

CRANFIELD UNIVERSITY

IOANNIS D. GEORGOUSIS

DEVELOPMENT OF A JOINT TQM&JIT IMPLEMENTATION  
MODEL

SCHOOL OF INDUSTRIAL AND MANUFACTURING SCIENCE

MPhil THESIS

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CRANFIELD UNIVERSITY

SCHOOL OF INDUSTRIAL AND MANUFACTURING SCIENCE

MPhil THESIS

Academic Year 1996-7

IOANNIS D. GEORGOUSIS

Development of a joint TQM&JIT implementation model

Supervisor: Professor J. M. Kay

February 1997

This thesis is submitted in partial fulfilment of the requirements  
for the degree of Master of Philosophy



**'Imagination is more important than knowledge'**

*Albert Einstein*

Dedicated to my grandfather, Demetrios Kioumousidis

# ABSTRACT

This study investigates the impact of the joint TQM and JIT approach on the performance of manufacturing organisations. The final objective is the development of a Joint TQM&JIT Implementation Model, based on the results of the investigation. The Model will contain a series of activities and operations that will lead to process and product improvement, based on the principles of the joint implementation approach.

Many studies and researches have been conducted in order to investigate and clarify the details and the potential benefits of each system. However, few studies looked at the operations that are necessary for a successful joint TQM and JIT approach; and even if they did it, they did not analyse the manufacturing process systematically. The present study attempts to give an answer to this problem and, moreover, to produce a systematic, analytical, and clear implementation plan.

The literature review and the industrial survey showed that there is a very close link between TQM and JIT; what is missing is a detailed implementation plan. The TQM&JIT Model tries to satisfy the *musts* and the *wants* of every manufacturing organisation which wishes to be competitive and world-class in the contemporary demanding markets, using the quality of the products and the low manufacturing cost as weapons. Furthermore, the Model details the sequence of the activities that should be followed in order to get completely beneficial results. It determines the production areas that should be improved, but also determines the role of everyone within the company towards that objective. The flowchart that presents the network of the activities is very simple and very clear, and this is perhaps the major advantage of the Joint TQM&JIT Implementation Model. A series of performance measures for each step of the Model has also been developed, in order to ensure the completion of each implementation stage.

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# TABLE OF CONTENTS

## CHAPTER ONE

### INTRODUCTION

|                                                  |   |
|--------------------------------------------------|---|
| 1.1 INTRODUCTION .....                           | 1 |
| 1.2 THE JOINT TQM AND JIT BUSINESS APPROACH..... | 2 |
| 1.3 OBJECTIVES OF THE RESEARCH .....             | 4 |
| 1.4 RESEARCH METHODOLOGY .....                   | 5 |

## CHAPTER TWO

### THE LITERATURE REVIEW

|                                                                  |    |
|------------------------------------------------------------------|----|
| 2.1 INTRODUCTION TO TOTAL QUALITY MANAGEMENT .....               | 7  |
| 2.2 KEY ELEMENTS OF TQM FOR A JOINT TQM&JIT IMPLEMENTATION.....  | 10 |
| 2.3 TOTAL QUALITY MANAGEMENT - A NEW MANAGEMENT MODEL .....      | 14 |
| 2.4 INTRODUCTION TO JUST-IN-TIME MANUFACTURING .....             | 15 |
| 2.5 KEY ELEMENTS OF JIT FOR A JOINT TQM&JIT IMPLEMENTATION ..... | 17 |
| 2.5.1 <i>Total Quality Management</i> .....                      | 17 |
| 2.5.2 <i>The elimination of waste</i> .....                      | 18 |
| 2.5.3 <i>People preparation</i> .....                            | 20 |
| 2.6 TOTAL QUALITY MANAGEMENT AND JUST-IN-TIME LINKAGE.....       | 24 |
| 2.7 TQM AND JIT JOINT IMPLEMENTATION APPROACH .....              | 28 |

## CHAPTER THREE

### THE RESEARCH ISSUE

|                                                                           |    |
|---------------------------------------------------------------------------|----|
| 3.1 INTRODUCTION .....                                                    | 31 |
| 3.2 TQM AND JIT: REQUIREMENTS FOR SUCCESS .....                           | 32 |
| 3.2.1 <i>The Total Quality Management framework</i> .....                 | 32 |
| 3.2.2 <i>Just-In-Time manufacturing</i> .....                             | 33 |
| 3.3 THE RESEARCH ISSUE .....                                              | 34 |
| 3.3.1 <i>Importance of TQM and JIT in terms of company strategy</i> ..... | 35 |
| 3.3.2 <i>Reasoning behind TQM and JIT implementation</i> .....            | 35 |
| 3.3.3 <i>Determination of TQM and JIT goals</i> .....                     | 35 |
| 3.3.4 <i>Practices for quality assurance</i> .....                        | 36 |

|                                                                             |    |
|-----------------------------------------------------------------------------|----|
| 3.3.5 Participation in the audit of quality .....                           | 36 |
| 3.3.6 JIT impact on the inventory and work-in-process (WIP) reduction ..... | 36 |
| 3.3.7 TQM and JIT impact on product quality and customer satisfaction.....  | 37 |
| 3.3.8 TQM and JIT impact on workforce .....                                 | 38 |
| 3.3.9 JIT impact on the production process .....                            | 38 |
| 3.3.10 TQM and JIT duration of implementation.....                          | 38 |
| 3.3.11 Education and training on TQM and JIT principles.....                | 39 |
| 3.3.12 Information on TQM and JIT problems within the company.....          | 39 |
| 3.3.13 JIT impact on the information flow .....                             | 40 |
| 3.3.14 Quality of the suppliers.....                                        | 40 |
| 3.3.15 Initiatives that improve company performance.....                    | 40 |

## CHAPTER FOUR

### DATA COLLECTION AND ANALYSIS

|                                                                  |    |
|------------------------------------------------------------------|----|
| 4.1 INTRODUCTION .....                                           | 42 |
| 4.2 THE INDUSTRIAL SURVEY .....                                  | 42 |
| 4.3 THE METHOD FOR DATA COLLECTION .....                         | 42 |
| 4.4 THE SAMPLE SIZE.....                                         | 44 |
| 4.5 THE STATISTICAL ANALYSIS .....                               | 44 |
| 4.6 THE STATISTICAL TESTS USED FOR THE ANALYSIS .....            | 45 |
| 4.7 THE PROFILE OF THE COMPANIES PARTICIPATED IN THE SURVEY..... | 46 |
| 4.7.1 Products .....                                             | 46 |
| 4.7.2 Number of employees - Company turnover.....                | 47 |
| 4.7.3 Type of manufacturing process .....                        | 48 |
| 4.7.4 Years of TQM and JIT industrial implementation .....       | 48 |
| 4.7.5 The experience of the managers with TQM and JIT .....      | 49 |

## CHAPTER FIVE

### RESULTS OF THE ANALYSIS AND CONCLUSIONS

|                                                                               |    |
|-------------------------------------------------------------------------------|----|
| 5.1 INTRODUCTION .....                                                        | 51 |
| 5.2 COMPARISON OF INDUSTRIAL FACTORS FOR A SUCCESSFUL JOINT IMPLEMENTATION    | 51 |
| 5.2.1 Importance of TQM and JIT in terms of company strategy (Quest. 6) ..... | 52 |
| 5.2.2 Reasoning behind TQM and JIT implementation (Quest. 7).....             | 54 |
| 5.2.3 Determination of TQM and JIT goals (Quest. 8).....                      | 57 |
| 5.2.4 Practices for quality assurance (Quest. 9).....                         | 59 |

|                                                                                        |    |
|----------------------------------------------------------------------------------------|----|
| 5.2.5 Participation in the audit of quality (Quest. 10).....                           | 61 |
| 5.2.6 JIT impact on the inventory and work in process reduction (Quest. 11).....       | 63 |
| 5.2.7 TQM and JIT impact on product quality and customer satisfaction (Quest. 12)..... | 66 |
| 5.2.8 TQM and JIT impact on workforce (Quest. 13).....                                 | 69 |
| 5.2.9 JIT impact on the production process (Quest. 14).....                            | 72 |
| 5.2.10 TQM and JIT duration of implementation (Quest. 15).....                         | 75 |
| 5.2.11 Education and training on TQM and JIT principles (Quest. 16).....               | 77 |
| 5.2.12 Information on TQM and JIT problems within the company (Quest. 17).....         | 80 |
| 5.2.13 JIT impact on the information flow (Quest. 18).....                             | 83 |
| 5.2.14 Quality of the suppliers (Quest. 19).....                                       | 86 |
| 5.2.15 Initiatives that improve company performance (Quest. 20).....                   | 88 |
| 5.3 A SUMMARY OF THE CONCLUSIONS.....                                                  | 91 |

## CHAPTER SIX

### DEVELOPMENT OF A JOINT TQM&JIT MODEL

|                                                                |    |
|----------------------------------------------------------------|----|
| 6.1 INTRODUCTION .....                                         | 93 |
| 6.2 THE NEED AND THE RATIONALE FOR A JOINT TQM&JIT MODEL ..... | 93 |
| 6.3 THE JOINT TQM&JIT IMPLEMENTATION MODEL.....                | 94 |
| 6.4 THE SEVEN STEPS OF THE JOINT TQM&JIT MODEL.....            | 97 |

## CHAPTER SEVEN

### THE TQM&JIT MODEL EVALUATION

|                                                               |     |
|---------------------------------------------------------------|-----|
| 7.1 INTRODUCTION .....                                        | 102 |
| 7.2 SELECTION OF THE COMPANIES FOR THE EVALUATION .....       | 102 |
| 7.3 THE TQM&JIT MODEL EVALUATION .....                        | 103 |
| 7.3.1 MAGNETI MARELLI LIGHTING.....                           | 103 |
| 7.3.2 DUTTON ENGINEERING.....                                 | 107 |
| 7.3.3 TROX (U.K) Ltd. ....                                    | 111 |
| 7.3.4 OXFORD AUTOMOTIVE COMPONENTS (UNIPART INDUSTRIES) ..... | 114 |
| 7.3.5 MAR-COM SYSTEMS.....                                    | 117 |
| 7.3.6 TADPOLE TECHNOLOGY .....                                | 120 |
| 7.4 KEY CHANGES INCLUDED IN THE REVISED MODEL.....            | 123 |

## **CHAPTER EIGHT**

### **GENERAL DISCUSSION AND FURTHER WORK**

|                                                                           |     |
|---------------------------------------------------------------------------|-----|
| 8.1 INTRODUCTION .....                                                    | 126 |
| 8.2 ACHIEVEMENT OF THE PROJECT AIMS .....                                 | 126 |
| 8.3 GENERAL EVALUATION OF THE IMPLEMENTATION METHODS CURRENTLY USED ..... | 128 |
| 8.4 FURTHER WORK .....                                                    | 129 |

|                  |     |
|------------------|-----|
| REFERENCES ..... | 131 |
|------------------|-----|

#### **APPENDIX A**

|                                      |     |
|--------------------------------------|-----|
| The Questionnaire of the survey..... | 135 |
|--------------------------------------|-----|

#### **APPENDIX B**

|                                                     |     |
|-----------------------------------------------------|-----|
| The initial Joint TQM&JIT Implementation Model..... | 139 |
|-----------------------------------------------------|-----|

#### **APPENDIX C**

|                                         |     |
|-----------------------------------------|-----|
| Performance measures for the Model..... | 140 |
|-----------------------------------------|-----|

#### **APPENDIX D**

|                                         |     |
|-----------------------------------------|-----|
| Questions for the Model evaluation..... | 148 |
|-----------------------------------------|-----|

#### **APPENDIX E**

|                                                             |     |
|-------------------------------------------------------------|-----|
| The final (revised) Joint TQM&JIT Implementation Model..... | 152 |
|-------------------------------------------------------------|-----|

# LIST OF FIGURES

## CHAPTER TWO

|                                                                             |    |
|-----------------------------------------------------------------------------|----|
| FIGURE 2. 1: THE NON-CONFORMANCE ICEBERG.....                               | 20 |
| FIGURE 2. 2:<br>DYNAMIC PRODUCTIVITY-ADJUSTED QUALITY CONTROL ANALYSIS..... | 26 |
| FIGURE 2. 3: TQM AND JIT JOINT IMPLEMENTATION APPROACH.....                 | 30 |

## CHAPTER FOUR

|                                                                   |    |
|-------------------------------------------------------------------|----|
| FIGURE 4. 1: YEARS OF TQM AND JIT INDUSTRIAL IMPLEMENTATION ..... | 49 |
| FIGURE 4. 2: EXPERIENCE OF THE MANAGERS WITH TQM AND JIT.....     | 50 |

## CHAPTER FIVE

|                                                                                       |    |
|---------------------------------------------------------------------------------------|----|
| FIGURE 5. 1: IMPORTANCE OF TQM AND JIT IN TERMS OF COMPANY STRATEGY .....             | 52 |
| FIGURE 5. 2: REASONING BEHIND TQM AND JIT IMPLEMENTATION .....                        | 54 |
| FIGURE 5. 3: DETERMINATION OF TQM AND JIT GOALS .....                                 | 57 |
| FIGURE 5. 4: JIT IMPACT ON THE INVENTORY AND WORK-IN-PROCESS REDUCTION .....          | 63 |
| FIGURE 5. 5: TQM AND JIT IMPACT ON PRODUCT QUALITY AND CUSTOMER<br>SATISFACTION ..... | 66 |
| FIGURE 5. 6: TQM AND JIT IMPACT ON WORKFORCE.....                                     | 69 |
| FIGURE 5. 7: JIT IMPACT ON THE PRODUCTION PROCESS.....                                | 72 |
| FIGURE 5. 8: TQM AND JIT DURATION OF IMPLEMENTATION.....                              | 75 |
| FIGURE 5. 9: EDUCATION AND TRAINING ON TQM AND JIT PRINCIPLES .....                   | 77 |
| FIGURE 5. 10: INFORMATION ON TQM AND JIT PROBLEMS WITHIN THE COMPANY .....            | 80 |
| FIGURE 5. 11: JIT IMPACT ON THE INFORMATION FLOW.....                                 | 83 |
| FIGURE 5. 12: INITIATIVES THAT IMPROVE COMPANY PERFORMANCE.....                       | 88 |

## CHAPTER SIX

|                                                                  |     |
|------------------------------------------------------------------|-----|
| FIGURE 6. 1: THE INITIAL JOINT TQM&JIT IMPLEMENTATION MODEL..... | 101 |
|------------------------------------------------------------------|-----|

## CHAPTER SEVEN

|                                                                             |     |
|-----------------------------------------------------------------------------|-----|
| FIGURE 7. 1:<br>THE FINAL (REVISED) JOINT TQM&JIT IMPLEMENTATION MODEL..... | 125 |
|-----------------------------------------------------------------------------|-----|

# LIST OF TABLES

## CHAPTER FOUR

|                                                                    |    |
|--------------------------------------------------------------------|----|
| TABLE 4. 1: FREQUENCY OF THE RESPONSES ACCORDING TO PRODUCTS ..... | 47 |
| TABLE 4. 2: NUMBER OF EMPLOYEES - COMPANY TURNOVER .....           | 47 |
| TABLE 4. 3: TYPE OF MANUFACTURING PROCESS .....                    | 48 |
| TABLE 4. 4: YEARS OF TQM AND JIT INDUSTRIAL IMPLEMENTATION .....   | 49 |
| TABLE 4. 5: EXPERIENCE OF THE MANAGERS WITH TQM AND JIT .....      | 50 |

## CHAPTER FIVE

|                                                                                       |    |
|---------------------------------------------------------------------------------------|----|
| TABLE 5. 1: IMPORTANCE OF TQM AND JIT IN TERMS OF COMPANY STRATEGY .....              | 52 |
| TABLE 5. 2: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 6.....                      | 53 |
| TABLE 5. 3: REASONING BEHIND TQM AND JIT IMPLEMENTATION .....                         | 54 |
| TABLE 5. 4: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 7.....                      | 55 |
| TABLE 5. 5: DETERMINATION OF TQM AND JIT GOALS .....                                  | 57 |
| TABLE 5. 6: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 8.....                      | 58 |
| TABLE 5. 7: PRACTICES FOR QUALITY ASSURANCE.....                                      | 59 |
| TABLE 5. 8: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 9.....                      | 59 |
| TABLE 5. 9: PARTICIPATION IN THE AUDIT OF QUALITY.....                                | 61 |
| TABLE 5. 10: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 10.....                    | 61 |
| TABLE 5. 11: JIT IMPACT ON THE INVENTORY AND WORK-IN-PROCESS REDUCTION.....           | 63 |
| TABLE 5. 12: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 11 .....                   | 64 |
| TABLE 5. 13: TQM AND JIT IMPACT ON PRODUCT QUALITY AND CUSTOMER<br>SATISFACTION ..... | 66 |
| TABLE 5. 14: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 12.....                    | 67 |
| TABLE 5. 15: TQM AND JIT IMPACT ON WORKFORCE.....                                     | 69 |
| TABLE 5. 16: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 13 .....                   | 70 |
| TABLE 5. 17: JIT IMPACT ON THE PRODUCTION PROCESS.....                                | 72 |
| TABLE 5. 18: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 14.....                    | 73 |
| TABLE 5. 19: TQM AND JIT DURATION OF IMPLEMENTATION .....                             | 75 |
| TABLE 5. 20: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 15.....                    | 76 |
| TABLE 5. 21: EDUCATION AND TRAINING ON TQM AND JIT PRINCIPLES .....                   | 77 |
| TABLE 5. 22: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 16.....                    | 78 |
| TABLE 5. 23: INFORMATION ON TQM AND JIT PROBLEMS WITHIN THE COMPANY .....             | 80 |
| TABLE 5. 24: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 17.....                    | 81 |

|                                                                    |    |
|--------------------------------------------------------------------|----|
| TABLE 5. 25: JIT IMPACT ON THE INFORMATION FLOW .....              | 83 |
| TABLE 5. 26: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 18..... | 84 |
| TABLE 5. 27: QUALITY OF THE SUPPLIERS .....                        | 86 |
| TABLE 5. 28: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 19..... | 86 |
| TABLE 5. 29: INITIATIVES THAT IMPROVE COMPANY PERFORMANCE.....     | 88 |
| TABLE 5. 30: RESULTS OF THE STATISTICAL ANALYSIS OF QUEST. 20..... | 89 |

# **CHAPTER ONE**

## ***INTRODUCTION***

# **INTRODUCTION**

## **1.1 Introduction**

This study is involved with the investigation of the joint TQM and JIT impact on the performance of manufacturing organisations. The final objective is the development of a Joint TQM&JIT Implementation Model, based on the results of that investigation. The Model will contain a series of activities and procedures that will lead to process and product improvement, based on the principles of a joint TQM and JIT implementation approach.

Total Quality Management (TQM) and Just-In-Time (JIT) are two production approaches which were used for the first time in the Japanese industry after the Second World War. In the West, serious efforts to adopt these two approaches began only at the beginning of the 1980s. Initially, manufacturing companies attempted to emulate the Japanese JIT practices, hoping that they would solve all the productivity problems that existed at the shopfloor. According to this view, the major quality and productivity problems that were identified in the process originated from the shopfloor. Nevertheless, a closer look at the genesis of the Japanese manufacturing excellence by many researchers and industrial practitioners in the early 1980s revealed that the secret of their success was their holistic approach to improving the efficiency and quality of the products and the processes. This was the beginning of the TQM revolution of the 1980s.

The Japanese had applied the principles of TQM since the 1950s and 1960s. Most of the Japanese companies, especially in repetitive manufacturing industries such as automotive and electronics, crossed a productivity and quality improvement path based on the gradual adoption of TQM philosophy, starting from the principles of quality control taught to them by the American gurus like Deming and Juran in 1950s. On the way, the economic necessities of the 1970s (the two oil crises) also gave way to evolution and implementation of JIT principles. Therefore, JIT was integrated by the Japanese

companies into an already developed framework of TQM philosophy. These strategies were read by the Western companies in a reverse sequence, first JIT and then TQM. Thus, organisations in the West started implementing JIT before TQM, considering this was the underlying framework for the Japanese manufacturing excellence. Since JIT was, and still is, noticed by many companies in the West as a collection of programs, its implementation has had mixed successes [Hall, 1987]. Those companies which have appropriately incorporated JIT elements into a broader TQM campaign have benefited significantly (i.e. Hewlett-Packard, Ford).

As it was described above, both philosophies are operating in the Western industry for the last 15 years. Many studies and researches have been conducted in order to investigate and clarify the details and the potential benefits of each system. However, few studies looked at the operations that are necessary for a successful joint TQM and JIT approach; and even if they did it, they did not analyse the manufacturing process systematically. The present study attempts to give an answer to this problem and, moreover, to produce a systematic, analytical and clear implementation plan, helping in such a way to achieve a Total Process Approach.

## **1.2 The joint TQM and JIT business approach**

In recent years, most companies have been looking for techniques to reduce the manufacturing costs, because the profit margins are becoming narrower. This is due to the increasing offer of goods and the great competition that exists between companies with the same products. Many of the Western manufacturing companies tried to emulate the very successive Japanese ones and they started to operate the Japanese management methods at their plants. TQM and JIT were the two most common methods, and after a not so successful implementation period (when they started operating first JIT and then TQM) they realised how and why these two philosophies can be jointly implemented with beneficial results (TQM revolution) [Schonberger, 1986]. The compatibility of TQM and JIT is due to the similar objectives that both have regarding the process

(although TQM is broader), and the procedures that they follow in order to accomplish them. Moreover, JIT will not work without quality processes, which means that TQM is the essential prerequisite for a successful JIT production. A joint TQM and JIT programme is usually based on the following concepts:

- An organisation relies on making profitable sales only if it produces output which conforms to the requirements of its customers. The organisation will be able to satisfy the customer requirements if it identifies them, and produces output which conforms to those requirements (TQM contribution to the process). JIT can make this happen, by defining the manner in which the manufacturing system should be managed in order to achieve the process demands.
- An organisation will be able to maximise profits only if it produces its output efficiently. In order to do this, the organisation must direct all its activities towards producing the necessary output at the minimum cost. This may be achieved by:
  - a) minimising inefficiencies when producing products, such as waste and rework. JIT can make this happen by reducing waste of overproduction, waste of transportation, waste of stocks, and waste of making defects. The techniques that are used are describing in chapter 2.
  - b) reviewing all activities to ensure they are directed to satisfying the requirements of external customers. JIT can also make this happen by devising systems to identify these problems and by developing mechanisms to solve them. A closer investigation of those is attempted in chapter 2.

Under this framework, a joint approach of Total Quality Management and Just-In-Time may help companies to move from the traditional market view to the today's one. This has one key focal point: *the customer*. Only businesses which focus on the requirements of their customers will survive into the future, and adopting a close customer focus may well emerge as the most successful strategy for remaining competitive. The new process concept based on a joint TQM and JIT programme is not difficult to understand, but it does requires a new focus of attention from anyone involved in it.

### **1.3 Objectives of the research**

As demonstrated in the previous paragraph, the concept of a TQM and JIT joint approach has much been developed, particularly in the literature, but little has been written regarding the process and even less about how to implement both to the process.

In industry, this problem appears to be enlarged because the companies usually do not have clear targets about the process improvement and the enhancement of the product quality. Also, the differences that exist between the several types of production processes make the things even more difficult, because the managers are not sure which of the TQM and JIT principles match their processes, what sequence should be followed, and how long it will take to implement it. The result is to miss some of the point of both the philosophies, which means that the benefits are not the ones they expected.

The objective of this thesis is to investigate the impact of a joint TQM and JIT approach on the performance of manufacturing organisations, and to develop a TQM&JIT Joint Implementation Model. This will include:

- The identification of the key factors of both systems, necessary for a successful joint implementation.
- The link between these key factors, their importance for the stages of the implementation, and their contribution to the final objective.
- The development of a Model which will be based on these factors, detailing the procedures that should be followed.
- The development of a series of financial and non-financial performance measures to support each step of the Model.
- The evaluation of the Model applicability on manufacturing industrial processes.

This research started from the need to find a way to reduce the manufacturing costs and at the same time to improve the quality of the product. That looks contradict at the first glance, but the joint implementation of Total Quality Management and Just-In-Time seemed ideal, because TQM would assure the quality of the product whilst the JIT would improve the production process. The results of the research should be tangible and applicable in a real process, because it was in the author's intentions to implement it in an industry in Greece.

## **1.4 Research methodology**

The methodology adopted in this study includes:

- A literature search in order to identify implemented and proposed approaches for a joint TQM and JIT programme. This will provide the identification and the classification of the important parameters for a successful implementation, as well as the clarification of the essential ones for the manufacturing industry.
- The conduct of an industrial survey in order to verify the identification of the important TQM and JIT factors and to investigate their impact on production performance.

This is achieved through the collection and statistical analysis of data from a number of companies that participate in the survey. The results of the analysis are used to draw conclusions about the effectiveness of a TQM and JIT joint programme, and to emerge the initiatives that are essential for the success of such an approach.

- A literature search to identify the approach that should be followed in order to link the TQM and JIT initiatives, and finally to develop them as a series of activities in the TQM&JIT Model. Also, the prerequisites that should be satisfied before proceeding from one to the next step at the Model.

- A literature search to identify the areas of the company production performance that are related to a joint implementation, in order to develop a set of financial and non-financial performance measures for every activity of the TQM&JIT Model.
- The evaluation of the Model accuracy and applicability through a number of industrial visits. The companies that will be chosen will have both systems in operation, they will have different type of manufacturing process, and they will produce different kind of products. This may help the Model to include as many TQM and JIT joint activities as possible, and to be broader and more systematic than others that have been developed.

## **CHAPTER TWO**

### ***THE LITERATURE REVIEW***

## **THE LITERATURE REVIEW**

### **2.1 Introduction to Total Quality Management**

The term Total Quality Management (TQM) was initially coined in the mid 1980s by the U.S. Naval Air Systems Command to describe its Japanese style management approach to quality improvement [Bemowski, 1992]. Since then TQM has taken on many interpretations.

In the Pera International Executive Briefing there is a definition of Total Quality Management attributed to the British Quality Association which states that [Hakes, 1991]:

‘Total Quality Management (TQM) is a corporate business management philosophy which recognises that customer needs and business goals are inseparable. It ensures maximum effectiveness and efficiency within a business and secures commercial leadership by putting in place processes and systems which will promote excellence and prevent errors. It also ensures that every aspect of the business is aligned to customer needs and advancement of business goals without duplication or waste of effort by releasing the full potential of all employees. The commitment of TQM originates at the chief executive level in business and is promoted in all human activities. The accomplishment of quality is thus achieved by personal involvement and accountability, devoted to a continuous improvement process, with measurable levels of performance by all concerned. It involves every department, function and process in a business and the active commitment of all employees to meeting customer needs. In this regard the ‘customers’ of each employee are separately and individually identified.’

Oakland (1995) defines Total Quality Management as ‘an approach to improving the competitiveness, effectiveness and flexibility of a whole organisation’. It is also a way of planning, organising and understanding each activity, and depends on each individual at

each level [Oakland, 1995]. If an organisation is really operating the TQM principles, then everyone within it must recognise that each person and each activity affects and it is affected by others and, moreover, that everyone must work with the others towards the same goals. Oakland (1995) argues that TQM is also a 'way of ridding people's lives of wasted effort by bringing everyone into the processes of improvement, so that results are achieved in less time'. The methods and techniques used in TQM can be applied throughout any organisation.

When the terms that make up the name are elucidated, then it is very clear that TQM is an integrated approach for gaining competitive advantage by continuously improving every aspect of an organisation's activities. Ho (1995) refers to this matter as follows:

|                   |                                                                                                                                 |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------|
| <b>Total</b>      | Everyone associated with the company is involved in continuous improvement (including its customers and suppliers if feasible). |
| <b>Quality</b>    | Expressed requirements of the customers are fully met.                                                                          |
| <b>Management</b> | Executives are fully committed.                                                                                                 |

Although the applied definitions vary, their essential elements are generally the same and they attempt to maximise the competitiveness of an organisation through the continual improvement of the quality of its products, services, people, processes and environments. The TQM approach has the following characteristics [Goetsch and Davis, 1994]:

- Customer focus (internal and external)
- Obsession with quality
- Scientific approach to decision making and problem solving
- Long-term commitment
- Teamwork
- Continual process improvement
- Education and training
- Freedom through control
- Employee involvement and empowerment

What has mentioned above confirms Oakland's (1995) point of view that 'the impact of TQM on an organisation is, firstly, to ensure that the management adopts a strategic overview of quality'. According to this opinion, the TQM approach must focus on developing a *problem-prevention* mentality, although it is easy to underestimate the effort that is required to change attitudes and approaches [Oakland, 1995]. It is very difficult to change the existent working attitudes, which resorts to the detection and inspection mode to solve problems, and people will need to undergo a complete change of their way of working. The managers must have a very clear vision about quality, because they have to put a lot of effort on the cultural changes of the workforce.

The correct quality vision may be achieved by looking at the sort of barriers that exist in key areas. Staff will need to be trained and shown how to reallocate their time and energy to studying their processes in teams, searching for causes of problems, and correcting the causes, not the symptoms, once and for all. This will require of management a positive, thrusting initiative to promote the right-first-time approach to work situations. If things are done correctly first time round, the usual problems that create the need for inspection for failure will disappear.

Also, in order to be successful in promoting business efficiency and effectiveness, TQM must be absolutely organisation-wide, and it must start at the top management level. Oakland (1995) describes the necessary management attitude as follows:

'The most senior directors and management must all demonstrate that they are serious about quality. The middle management will have a particularly important role to play, since they must not only grasp the principles of TQM, they must go to explain them to people for whom are responsible, and ensure that their own commitment is communicated. Only then will TQM spread effectively throughout the organisation. This level of management must also ensure that the efforts and achievements of their subordinates obtain the recognition, attention and reward that they deserve'.

Once the aims of the TQM approach have been defined, every organisation will set itself a series of objectives that they intend to achieve through TQM. These business objectives are effectively the benefits to be gained and, although they will vary from organisation to organisation, the most typical ones are [Hakes, 1991]:

- The improvement of profitability by increased operational efficiency
- Cultural and behavioural change
- The prevention of waste
- The improvement of customer satisfaction
- Maintaining or increasing market share
- The achievement of product and business excellence
- The releasing of organisation's people potential
- The improving of product or service quality, product safety and reliability
- Associated improvements in operational safety, occupational health and the environment
- Encouragement of each individual's personal improvement, innovation and creativity.

## **2.2 Key elements of TQM for a joint TQM&JIT implementation**

The Total Quality Management approach, as it was described in the previous paragraph, has two components: the *what* (what is TQM) and the *how* (how is it going to be achieved). Goetsch and Davis (1994) argue that 'what distinguishes Total Quality from other approaches to doing business is the *how* component of the definition'. This component has some critical elements, each of which is explained in this section.

### *Customer Focus*

In a Total Quality environment, the customer is the driver. This applies to both internal and external customers. External customers define the quality of the product or service delivered. Internal customers help define the quality of the people, processes and environments associated with the products or services. The TQM philosophy stresses a

systematic, integrated, consistent, organisation-wide perspective involving everyone and everything. It focuses primarily on total satisfaction for both the internal and external customers, within a management environment that seeks continuous improvement of all systems and processes.

### *Obsession with Quality*

In a TQM organisation, internal and external customers define quality. With quality defined, the organisation must then become obsessed with meeting or exceeding this definition. 'When an organisation is obsessed with quality, good enough is never good enough' [Goetsch and Davis, 1994]. Moreover, as quality is being improved, the production costs fall through reduction in failure and detection costs. The absence of quality problems also removes the need for dealing with failure and waste problems, and helps the delivery performance to benefit from increased output and higher productivity [Ho and Fung, 1994].

### *Scientific Approach*

People skills, involvement and empowerment are important in a Total Quality environment, but they represent only one part of the equation. Another important part of the equation is the use of the scientific approach in structuring work and in decision making and problem solving that relates to the work. This means that substantiated data and methodologies are used in establishing benchmarks, monitoring performance and making improvements.

### *Long-Term Commitment*

Many organisations try to implement management innovations, such as Total Quality Management, on a short-term basis and often fail in their initial attempt to adopt the TQM principles. This happens because they approach TQM as just another management innovation rather than as a whole new way of doing business which requires a whole new organisation's culture. There must be a new perception of the need for quality and the organisation's strategic imperatives. The long-term commitment is a crucial variable for the success of a TQM program and must definitely be backed by Top Management.

What usually occurs in practice is the very opposite and only few organisations begin the implementation of Total Quality Management with the long-term commitment to change what is necessary for success.

### *Teamwork*

In traditionally managed organisations, the best competitive efforts are often between departments within the organisation. Internal competition tends to use energy that should be focused on improving quality and external competitiveness. The TQM company fosters the teamwork between the departments and between the employees of every department and removes the barriers and the distrust that existed in the past. Now there is a common strive for meeting and exceeding customer's requirements and not separate struggles between departments. The new concept of Total Quality Management also is applied to the relationships with suppliers, developing in this way a totally innovative approach of doing business.

### *Continual Improvement of Systems*

In order to continually improve the quality of products or services, which is a fundamental goal in a TQM environment, it is necessary to continually improve systems. Quality improvement is linked to the establishment and operation of a series of performance measures. This relates to the above in providing a progressive structure against which improvement can be ensured. Peters (1994) argues that these can be the frequently process control measures, such as variations from a pre-set mean and steps taken to reduce them, but can also be the measurement of tangibles such as misplaced orders, reworks, warranty claims, scrap; or less tangible issues such as customer retention.

### *Education and Training*

Education and training are fundamental to Total Quality Management because 'they represent the best way to improve people on a continual basis' [Goetsch and Davis, 1994]. In a quality organisation everyone is constantly learning. TQM requires a heavy investment in training, development and learning. This investment may be in the form of

externally contracted help (i.e. courses, consultancy, business education) or internal time allocation (a number of hours per month on quality issues, multi-level and multi-functional improvement workshops and projects, etc.) or, most usually, both. Indeed, TQM emphasises use of all people, usually in multifunctional teams, to bring about improvement from within the organisation. Scholtes (1992) argues that management must encourage employees to constantly elevate their level of technical skills and professional expertise because 'that is how they can gain an ever-greater mastery of their jobs and learn to broaden their capabilities'. It is through education and training that people learn how to work smarter and not harder.

### *Freedom through Control*

One of the fundamental principles of Total Quality Management is to bring more minds on the decision-making process and at the same time to increase the ownership employees feel in decisions that are made [Goetsch and Davis, 1994]. TQM critics usually consider employee involvement as a loss of management control, when in fact control is fundamental in a TQM approach. The freedoms enjoyed in a TQM environment are actually the result of well-planned and executed controls. Scholtes (1992) explains that 'in quality leadership there is control, yet there is freedom'. There is control over the best-known methods for any of the production processes. Also, by standardising the processes and finding ways to ensure that everyone follows the standard procedures, employees can manage to reduce the variation in output by reducing variation in the way work is done. According to Scholtes (1992) if these changes take hold, employees are freer to spend time eliminating problems, to discover new markets and to gain mastery over processes.

### *Employee Involvement and Empowerment*

The reasoning for empowering employees and involving them in the decision-making process has two objectives. First, to increase the likelihood of a good decision, a better plan, or a more effective improvement by bringing more minds to bear on the situation, and particularly the minds of people who are closest to the work in question. Second, it promotes ownership of decisions by involving the people who will have to implement

them. According to Goetsch and Davis (1994), 'empowerment means not just involving people but involving them in ways that give them a real voice'. One of the ways that lead to real empowerment is by structuring work that allows employees to make decisions concerning the improvement of work processes within well-specified parameters [Goetsch and Davis, 1994].

### **2.3 Total Quality Management - A New Management Model**

To succeed in today's competitive marketplace a company must supply products and services in accordance to customer's requirements and at a minimum cost. To achieve this, the company must understand its role in the marketplace, organise itself to fulfil that role and ensure all employees understand, and are committed to fulfilling, the customer's requirements first time every time, whatever task is being performed.

TQM generally requires a change in how a company operates. It requires quality to be the first priority of every employee and for their efforts to be focused on the prevention of errors. It is no longer sufficient to rely on the detection and correction of errors because it is a costly and wasteful approach to assuring quality, and is now largely redundant. In a TQM organisation every department, every activity, and every employee at every level, starting at the top, must be wholly committed to the TQM philosophy.

Furthermore, TQM requires a change in the basic philosophy of everyone in the company, especially management. In the past, they generally followed the principles of management proposed by Taylor. According to those, the manager's role was to plan, organise, direct and solve problems and the worker's to carry out tasks as directed by the managers [Taylor, 1947].

The new management model requires the recognition of the contributions that every employee can make, but also requires to control the skills and the enthusiasm of everyone in the business. To achieve this, employees must be provided with the skills,

tools and authority to investigate problems and introduce improvements. Managers must demonstrate that they believe their employees can make an important contribution to managing the business and must create an open atmosphere to allow this happen. 'Teamwork will be the key to the successful businesses of the 1990s and beyond', according to Munro-Faure (1992). This is a radical change and it will only happen if it is actively and passionately led from the top and involves everyone. This radical change cannot happen overnight and it is likely to be painless, unless it is carefully managed.

## **2.4 Introduction to Just-In-Time Manufacturing**

Just-In-Time (JIT) is the manufacturing philosophy of eliminating waste in the total manufacturing process, from purchasing through distribution. Hay (1988) argues that 'if this philosophy is properly implemented, JIT enables a company to develop manufacturing into a strategic weapon'.

In a Just-In-Time environment, waste is defined as any activity that does not add value for the customer. It is the use of resources in excess of the theoretical minimum required (manpower, equipment, time, space, energy). Toyota, the originator of the JIT concept, defines waste as 'anything other than the minimum amount of equipment, materials, parts, and working time absolutely essential to production' [Japan Management Association, 1994].

Shingo (1995), one of the Japanese founding fathers of improved manufacturing methods, detailed what are known as his famous Seven Wastes. They are the following:

1. Waste of overproduction
2. Waste of waiting`
3. Waste of transportation
4. Waste of stocks
5. Waste of motion

6. Waste of making defects
7. Waste of processing itself (when the product should not be made or the process should not be used).

The basis of JIT manufacturing is to operate a simple and efficient manufacturing system capable of optimising the use of manufacturing resources such as capital, equipment, and labour. This results in the development of a production system capable of meeting a customer's quality and delivery demands at the lowest manufacturing price. Just-In-Time is also the philosophy of doing the simple things well, and gradually doing them better. In that way, the development of competence and simplification will squeeze out the wastes from every step of the production process.

Another objective of JIT is to continually optimise and integrate the manufacturing system, by removing excess inventory, rework, equipment, and labour, forcing the production-related problems to surface. JIT is used to rid the production line of production-related problems and to reduce overhead until the production system (quality, rate, and costs) has been balanced for quality and productivity levels. Lubben (1988) argues that the production process has been balanced when the further removal of overhead causes a loss of production quality. The result of this production balancing will be smoother, trouble-free production. It is only through a process of continual improvement that the manufacturing system can achieve its optimum level of productivity and reach its full profit potential.

Just-In-Time systems are designed to work constantly for the goal of improved performance. Sandras (1989) argues that 'One Less at a Time' is a constant, step-by-step methodology for making Just-In-Time work in any production environment. Integrating and optimising the manufacturing system are ongoing processes in a JIT approach, as the company evolves with the development of new markets, new products, and more efficient processes. The net result of operating a JIT system is reduced waste, and this may be the margin between a failing company and a successful company [Lubben, 1988]. Simply put, JIT is having just what is needed, just when it is needed and just in the

quantity that it is needed. Significant profits gained from the reduction of waste, and this can be directly translated to a great amount of money saved.

Many people think of JIT production as being only a technique of reducing inventory. However, reducing inventory helps expose hidden problems in the factory and by solving them it can take place a great reduction in the waste-related costs. Therefore, Monden (1993) argues that reducing inventory does tie in indirectly with cutting manufacturing costs. Another indispensable part of cutting manufacturing costs is reducing labour-hours needs. Thus, it is especially important to understand the labour-hours reduction techniques used in the JIT approach. According to Monden (1993), the reduction of the labour-hours costs is one of the most important parts of JIT production.

## **2.5 Key elements of JIT for a joint TQM&JIT implementation**

Three key elements of JIT are crucial to understanding the philosophy involved, each of which is explained in this paragraph.

### **2.5.1 Total Quality Management**

As it was described above, Just-In-Time is the manufacturing philosophy that requires only the right quantities to be produced at the right time, and that there is no waste. Anyone who perceives it purely as a material-control system, however, is bound to fail with JIT. 'JIT fits well under the TQM umbrella, for many of the ideas and techniques are very similar and, moreover, JIT will not work without TQM in operation' [Oakland, 1995]. Also, the sort of management commitment and organisation development necessary to obtain TQM provides a fertile breeding ground for JIT to follow in its wake. In practice, it is necessary to start with a basic overhaul of people motivation and discipline, starting off with doing the job correctly under management guidance, and going on to take pride in simple tasks like tidiness, organisation, cleaning, standardisation and discipline (known as the 5S). This is consistent with a basic theme of doing the simple things right, and gradually doing them better.

### **2.5.2 The elimination of waste**

Waste was defined as any activity that does not add value for the customer. As it was presented in a previous section, Shingo (1995) classified the wastes in seven major areas, known as his Seven Wastes. They are as follows:

#### *1. Waste of overproduction*

Producing more than it is needed by the next process is the greatest source of waste according to Toyota. It is 'safer' to have a comfortable buffer between one and the next operation, but this is the root of many evils [Shingo, 1995]. The overproduction causes scheduling problems, double handling, lead time delays, extra space requirements, and a lack of responsibility for quality as well as extra work-in-progress (WIP). Persuading people to think differently is not a simple task and depends on advances on the organisation development front, which is one reason why TQM is so important for JIT manufacturing.

#### *2. Waste of waiting*

People in industry have been very aware of waiting time as a source of waste. Machine efficiency and labour utilisation are two measures widely used in industry. It is quite difficult to expose the real amount of waiting time, because it is often disguised by operators who are kept busy producing WIP, which is not real productive time.

#### *3. Waste of transportation*

While transport clearly does not add value to the product, there are many processes that it has been build into like a standard operation. Double and triple handling of WIP from various storage points become the standard practice, and many employees as well as extra storage occupied for that purpose [Harrison, 1992]. So, layout improvements by bringing processes closer together, and in transport methods and workplace organisation, become important drivers for the reduction of waste.

#### *4. Waste of stocks*

Once the process have become converted to Just-In-Time principles, then inventory becomes an evil. Harrison (1992) argues that it is easy to distinguish the excellent company from the average one, because 'there simply is not much inventory around the place'. In an average company, inventory is used to hide production problems like equipment breakdowns, lengthy setup times and large batch sizes, and poor co-ordination between processes. Cushioning the company from the effects of such problems unconsciously ensures that these problems remain. It is only by tackling the causes that inventory can be reduced, as a consequence of the action taken.

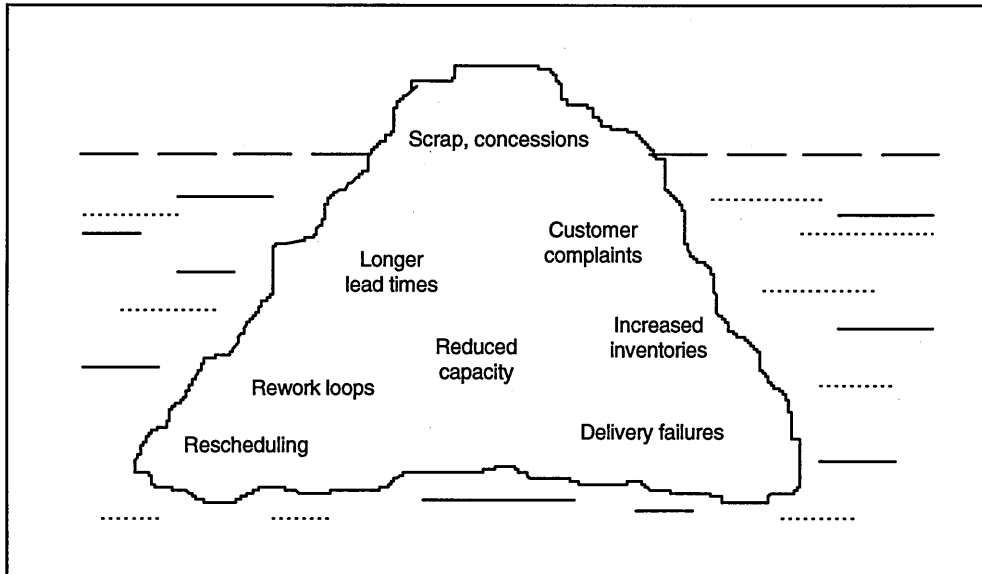
#### *5. Waste of motion*

In many occasions an operator may look busy because they are just looking for a missing box of parts, or going to the supervisor's office to collect another job card [Harrison, 1992]. The value added is actually non-existent. Simplification of work by improving the workplace layout and by operating the '5S principles' is a rich source of reduction in the waste of motion.

#### *6. Waste of making defects*

Harrison (1992) argues that 'the accounting systems are typically quite bad at telling what is the true cost of the waste of defective goods'. For example, what is the true cost of defects which get out into the market and which cause customers never to buy again? Does improved quality really lead to improved market share? Traditional accounting systems do not begin to address such difficult questions, and yet an understanding of them is very important to a company's competitive position.

Within the company, quality measures are often too limited. Scrap rates can indicate the material and maybe part of the labour cost involved but disruptions to the production control system, extra expediting actions and the failure to deliver as promised are invisible. While scrap costs and number of concession notes may be visible, most of the true costs are hidden below the water line [Figure 2.1].



**Figure 2.1: The non-conformance iceberg**

[Alan Harrison, Just-In-Time Manufacturing in Perspective, 1992]

Total costs of quality are much greater than traditionally has been considered, and it is correspondingly more important to attack the causes of such costs. The approximate percentage of 'total costs of quality' (in reality, the costs of non-quality) has been put at 15-30% of cost of sales [Crosby, 1979].

### *7. Waste of processing itself*

The process itself may become a source of waste as well. Many improvements over time can lead to considerable reductions in process time and to better delivered quality. This would be reflected in a reduction in what has been classified as value-added time of the process.

### **2.5.3 People preparation**

Making full use of people's capabilities is the starting point for this third element of JIT philosophy. It is desired for the companies to hire the whole person, and not waste the incalculable value of the person's brain, senses and potential. O'Toole (1973) criticised the American emphasis on relating work with pay. He proposed that work should be

redefined as 'an activity that produces something of value for other people' [O'Toole, 1973]. Behaviourists have been trying many ways to pinpoint how people in Western companies can be motivated. Some of the approaches that have determined are: involvement, recognition, responsibility and growth. Summarising the above, it is obvious that a new management response is needed, based on people preparation which includes the following aspects [Harrison, 1992]:

1. *Discipline*: Work standards which are critical for the safety of company members, as well as for the quality of the product, must be followed by everyone all the time. A company which allows such rules to be flouted will not survive in the long term, and its members will have no respect for the way in which the company is managed [Murata and Harrison, 1991]. Unnecessary and unfair rules should be abolished, so that only the critical ones are left. In this way, members will not overburdened with rules and will learn to respect the key standards which everyone follows. Discipline is the critical essence of a manufacturing company [Murata and Harrison, 1991].
2. *Flexibility*: It must be possible to expand responsibilities as much as people are capable. This applies equally to managers as it does to shop-floor personnel. Barriers to such flexibility, such as grading structures and restrictive practices, must be confronted and removed [Harrison, 1992]. True flexibility is only gained over time as a result of a consistent, long term program of training people in new skills. The benefits are greatly enhanced flexibility of the process as a whole.
3. *Equality*: Unfair and divisive personnel policies must be abandoned. Traditional companies have been divisive in terms of different privileges and facilities for different grades of personnel. The new management model wants all the barriers to be removed. For example, Japanese companies are taking the equality message to company uniforms, and to consistent pay structures which do not differentiate between full-time staff and hourly rated staff [Schonberger, 1986].

4. *Autonomy*: Another JIT principle is to delegate increasing responsibility to people involved in direct activities of the business. In a sense, management's task becomes one of supporting the shop-floor, so that organisation pyramid has fewer layers. Such autonomy is manifest in a company that operates TQM and JIT by such activities as the following [Sugimori et al., 1977]:

- *Line stop authority*: if a quality problem arises or the operator cannot keep up, an assembly line operative has the authority to stop the line. It is the line which is run by people, not the other way round.
- *Material scheduling*: parts are made to well-known rules, which means, do not produce more unless the customer needs more. Many routine aspects of material scheduling can thereby be delegated away from the central production control.
- *Data gathering*: data relevant to shop-floor performance monitoring is gathered and used by shop-floor personnel. Data extracted for the central finance system, which takes weeks to process and return to the foreman, is waste. By the time it gets back to the shop-floor, memories have become vague, and defensive positions have become established.
- *Problem solving*: shop-floor personnel get first crack at solving problems which affect the work they do. Only if they need help from experts should that help be sought and provided.

5. *Development of personnel*: Over time, the aim is to create more company members who can support the rigours of being an excellent company. Murata and Harrison (1991) distinguish three levels of quality of work:

- *Repair level*: reacts to problems, cannot foresee the future. Runs round with a bucket of water putting out fires. Asked to do something and simply does it.
- *Prevention level*: can foresee potential problems, or the requirements of other company members, and reacts in advance.
- *Improvement level*: not only foresees potential problems, but also proposes solutions so that the problems never recur.

The excellent company has a richer mix of people at the improvement level than the average company. Partly, this is achieved by long-term personal development of company members.

**6. Creativity:** This is one of the indispensable elements of motivation. In the past, improvement activities have been regarded as 'none of my business'. To compete nowadays, it is essential that everyone's contributions to solving problems and improving methods are harnessed [Harrison, 1992]. If only some of the company members are involved, then only some of the problems will be solved. Kondo (1989) proposes four steps for working more creatively:

- Work instructions should make it clear what is the aim of the job. More often, the focus is on the methods of carrying out the job, without making its purpose clear. Apart from the discipline of safety and quality standards, company members should be encouraged to devise their own methods to best achieve the aims of the job.
- Foster the development of people's sense of responsibility for what they do. People naturally tend to shirk such responsibility, blaming others. Managers can foster ownership of problems by refusing to accept excuses: help people to identify the key point of the problem.
- Give time for the creation of ideas. Often, an incubation period will help in the generation of fresh means to solve problems. It is necessary to encourage such periods, perhaps by allowing time for the team to meet.
- Let the ideas grow and come to fruition. Early in their life, new ideas are easily rubbished. Sensitivity is needed to help them to grow.

The positive feedback from the installed new ideas is a great source for motivation, helping to improve the self-confidence of the team. How does creativity fit in with the first point-discipline? Kondo (1989) argues that creativity and standardisation are not mutually exclusive, but on the contrary mutually complementary. By standardisation, he refers to the aim of the job, leaving company members free (other than for quality and

safety critical activities) to use their own ingenuity to develop improved methods [Kondo, 1989].

People are an investment which grows over time but the very process of continuous improvement invokes another powerful source for motivation, the Hawthorne effect. The extra motivation that results from paying attention to people has been called the *Hawthorne effect*, from the experiments that took place at the Hawthorne plant of the Western Electric Company. Schonberger (1986) argues that motivation comes from recognition and describes the Hawthorne studies at Western Electric as 'the second major event in the history of manufacturing management' (the first being scientific management and the third Just-In-Time and Total Quality Management). So the rewards of continuous improvement are highly geared: the company benefits not only from the improvement itself, but also from the boost in motivation which recognition brings. Yet achieving this energised state is not a quick and simple task. Many companies have greatly underestimated the time and the resources necessary to prepare management and workforce. So many things must be changed across a broad front. Harrison (1992) describes it as 'rebuilding the thought patterns of an old organisation'. Certainly it is not an easy task, and requires great determination and far-sightedness on the part of the top team.

## **2.6 Total Quality Management and Just-In-Time linkage**

The implementation of a joint TQM and JIT program has a very clear objective in terms of a company's strategy: to improve the quality of the product and the efficiency and effectiveness of the production process. This improvement of the efficiency and effectiveness of the system is nothing else but the improvement of productivity.

The traditional management view of the relationship between quality and productivity, for example through a joint TQM and JIT approach, has been that they are inversely related. This is, if a company wants to improve quality it is likely to pay a productivity

penalty as production lines are slowed down and more products are rejected and reworked. Until recently most managers seemed to believe that continuous improvement in quality and productivity was an attractive concept but likely to be uneconomic. Nowadays, the results from industrial surveys and academic research contradict this traditional management view. Mefford (1991) argues that there are three main reasons for the positive correlation between quality and productivity through the joint implementation of TQM and JIT.

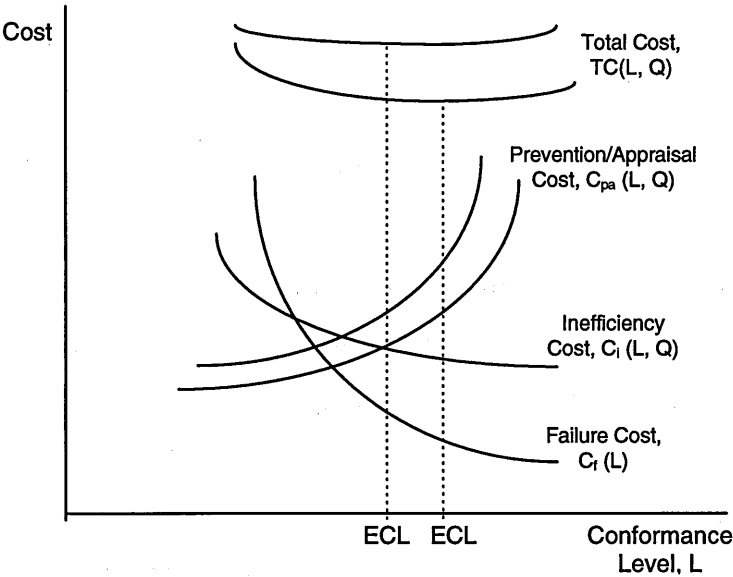
*a) The direct linkage*

The direct quality-productivity relationship results from the definition of productivity. Productivity is a measure of output divided by the inputs required to produce it. It does not make much sense to include the defective output that cannot or should not be sold. So, for every unit of defective output produced which must be scrapped or reworked, inputs are wasted. Labour hours, machine time, material and energy inputs are wasted on poor quality product, and a direct penalty is paid in terms of the profits that would have been gained if good quality output had been produced. A company with a lower percentage of defective output and the same amount of resource inputs will necessarily have higher productivity. Mefford (1991) argues that the direct quality-productivity consequences can be derived from quality improvement programs, like a TQM program. Making things right the first time can yield substantial direct productivity benefits. However, there are also some indirect productivity benefits of quality improvement programs.

*b) Indirect linkages*

One such indirect benefit for productivity, of quality enhancement efforts, is improvement in the design and operation of the production process. An effective joint TQM and JIT program requires a complete examination of the production process to identify all possible sources of defects. Product design, job flow, equipment selection and maintenance, worker selection and training, inventory procedures, customer requirements, as well as inspection procedures will all need to be looked at. In doing so, it is very likely that problems and potential improvements will be identified in all of these

problems. If these changes are implemented, productivity will almost certainly improve. For instance, if a smoother work flow with a shorter cycle time is achieved, productivity should increase as scheduling is improved and fewer bottlenecks occur. More preventive maintenance on machinery will likely lead to improved quality but will also reduce breakdowns and the productivity penalty these exact. The relationship is shown in the Figure 2.2.



**Figure 2.2: Dynamic productivity-adjusted quality control analysis**  
[R. Mefford, International Journal Of Production Economics, 1991]

The reduction in inefficiency in the process (i.e. improvement in productivity) is shown as the inefficiency curve which is negatively sloped. The lower the conformance level, the higher the cost. According to Mefford (1991), ‘as a company improves the quality of its products by increasing the conformance level (i.e. the percentage of product meeting quality standards), inefficiency in the process is reduced’. This occurs due to the direct and indirect effects described above: the improvement in productivity offsets to some extent the higher costs that are implied by the positively-sloped prevention and appraisal cost curve. There also may be improvement in the effectiveness of the prevention and appraisal activities which shift this cost curve downward. The prevention/appraisal and inefficiency cost curves are shown as functions of both the conformance level  $L$  and the order quantity  $Q$ , representing the improvements in quality that are likely to result from

efforts to reduce inventories with a Just-In-Time program. ECL represents the Economic Conformance Level, and as the diagram shows, the higher the conformance level of the products, the lower the total costs. Mefford (1991) argues that the overall result is a fall in total costs as the conformance level improves.

*c) Morale effects*

A third mechanism by which companies are able to simultaneously and cost-effectively improve productivity and quality, based on the joint implementation of TQM and JIT, is through morale effects. There is increasing evidence that improvements in quality and productivity have a salutary effect on employee morale [Mefford, 1991]. There are several reasons why this occurs. Effective TQM and JIT programs utilise employee involvement. By getting employees involved in quality circles, quality improvement teams and work teams, employees receive more satisfaction from their jobs and may feel more committed to the company. This is likely to lead to reduced absenteeism and labour turnover and a greater commitment on the part of the employee to do a good job.

Also many TQM and JIT programs involve financial rewards and bonuses to employees. This, of course, is to encourage effort on the part of the employee to the programme, but also may, if positive results are achieved, lead to feelings of accomplishment and personal growth by the employee and thus greater job satisfaction. Thus, linking employee reward to company performance, an integral part of many productivity/quality improvement programs, may also increase employee morale which in turn may lead to further improvements in productivity and quality.

A final mechanism by which moral effects may increase productivity and quality is through the increasing pride and commitment on the part of employees that results from working for a growing, successful company with a good quality reputation [Mefford, 1991]. This result is somewhat intangible, but Peters and Waterman (1982) believe it to be an important aspect of 'excellent' companies. The experience of companies using jointly TQM and JIT programs also seems to attest to the importance of this effect.

Again, improved morale and motivation of employees may translate into greater efforts on their part to improve productivity and quality.

Therefore, via the three mechanisms discussed, synergy and momentum can build between quality and productivity improvement efforts, through a TQM and JIT joint implementation program. It may also lead to beneficial results in both areas that overwhelm any negative tradeoffs, if these do exist. Although the indirect and motivational aspects of quality and productivity improvement are often intangible, they nevertheless seem to be quite potent and companies able to tap them are believers in the results [Mefford, 1991]. As Robert Galvin (1989), the Chairman of Motorola Corporation comments, 'superior quality is actually the lowest-cost way of doing things'.

## **2.7 TQM and JIT joint implementation approach**

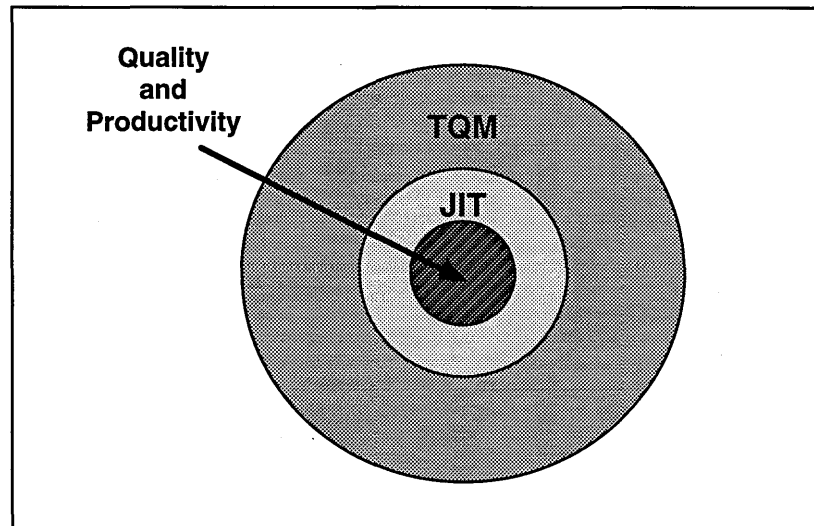
The two philosophies just discussed, Total Quality Management and Just-In-Time, are much more likely to be effective if implemented jointly rather than independently or sequentially. According to Mefford (1991), 'the experience of companies experimenting with new methods of achieving production improvement is demonstrating that there is a positive relationship between them'. The clarification of Just-In-Time principles indicates that JIT lays more emphasis on improving manufacturing efficiencies (minimising inventory, parts and components standardisation, quality circles, etc.). It seems that, on the whole, all the major elements of JIT are embedded in a more comprehensive TQM campaign, if properly implemented. In fact, TQM has a much broader focus on improving the overall effectiveness of an organisation. It defines the responsibility of the top management more clearly, and offers a clear, systematic road-map for improving the *quality and productivity*. TQM also makes the interactions of various functions (R&D, marketing, production, MIS, finance, purchasing and logistics) during the various phases of manufacturing cycle more lucid. It goes beyond the manufacturing focus of JIT and aims at continuous improvements in all activities directly and indirectly related to manufacturing.

Summarising the objectives and scope of a joint TQM and JIT implementation program, the following arguments emerge:

JIT philosophy is based on the premise that minimisation of inventory (raw material, work-in-process, and finished goods) can accrue benefits in terms of free capital. Therefore, all efforts should be focused on getting the right quality of raw material just when needed, and producing products just when needed. This necessitates setting operational objectives such as reducing the scrap and rework, and number of defects during manufacturing process. All techniques used in JIT are focused primarily on manufacturing efficiencies gained through focused layout, uniform plant loading, and use of Kanban, and comprehensive preventive maintenance. JIT conveys a focus on manufacturing activities.

On the other hand, TQM connotes a general philosophy of a concerted effort, which begins with clear goals defined by a committed top management, and proceeds with an organised development and deployment of quality improvement strategies. Owing to the complete and active involvement of the top management, an effective TQM implementation is facilitated through creation of supportive environment (for example, for interaction among functions, development and training, and reward systems) and supportive infrastructure (for example, quality information systems, benchmarking and customer feedback systems).

According to the theorisation expressed above, there should be a synergistic effect of coupling JIT approach with TQM philosophy. The traditional view of treating JIT and TQM as two separate approaches in which the only linkage is manufacturing quality control is rejected. Vuppalapati *et al.* (1995) argue that JIT should be viewed as a natural component of the overall TQM philosophy, which leads to overall organisational performance improvement. At the heart of the integrated business strategy are the manufacturing quality and productivity (Figure 2.3).



**Figure 2.3: TQM and JIT joint implementation approach**

Therefore, organisations on the threshold of implementing either JIT or TQM should consider implementing both the strategies concurrently. Rather, they should implement an integrated business strategy in which JIT is viewed as a natural component of overall TQM philosophy, which aims at overall organisational performance improvement. Doing this, they will improve the operational performance of the organisations much more than if they implement these strategies in isolation [Vuppalapati *et al.*, 1995].

## **CHAPTER THREE**

### ***THE RESEARCH ISSUE***

## **THE RESEARCH ISSUE**

### **3.1 Introduction**

The Total Quality Management and Just-In-Time literature strongly emphasise the benefits associated with the implementation of each philosophy, and the activities that must be undertaken in order to achieve them. Not much attention has been paid to the sequence that should be followed and to the constraints that exist before operating each system activity. In a joint TQM&JIT approach this problem seems to be wider, because the critical activities of each system should be determined at the beginning, and then they should be defined within the same context. The methodology that will support the whole process should be very systematic, the assumptions and hypotheses very mindful, and the conclusions of the analysis very accurate. The development and the successful implementation of a joint TQM&JIT model is very dependent on the fulfilment of the above preconditions.

It was argued in Chapter 2 that the joint approach should utilise the broad framework of TQM philosophy to assure the quality of the product and the quality of the procedures, whilst the JIT principles will focus on the manufacturing process (inventory minimisation, reduction of work-in-process (WIP), improvement of the flexibility of the output, etc.). The objective of this study is to investigate how that could happen, determine the critical factors for successful completion, and to develop a joint implementation plan which will be based on both academic and industrial experience. This chapter attempts:

- to identify the critical elements and implementation issues of a joint TQM&JIT approach, and provide a theoretical argument for recommending an appropriate manufacturing strategy to companies that wish to employ operations improvement programmes.

- to develop a theoretical argument for giving up the traditional view of treating TQM and JIT as isolated in favour of an integrated view in which JIT is considered as a component of TQM implementation.

### **3.2 TQM and JIT: Requirements for Success**

What attributes are required to successfully jointly implement TQM and JIT in British manufacturing companies? Total Quality Management is an integrative philosophy of management for continuously improving the quality of products and processes to achieve customer satisfaction. It is based on the premise that an organisation must build quality into its products and processes, and that everyone in the organisation has a responsibility in this effort. The customer is the focus of all the efforts to improve the product and process quality. On the other hand, Just-In-Time is based on two principles: (1) elimination of wastes and (2) respect for and full utilisation of the capabilities of people [Davy *et al.*, 1992]. The purpose of JIT is to remove the unnecessary wastes and improve the manufacturing performance objectives. The key to successful implementation of a joint TQM&JIT programme is to determine which factors are essential for making it work, and which factors are helpful in ensuring Just-In-Time production in the general context of Total Quality Management.

#### **3.2.1 The Total Quality Management framework**

The Malcolm Baldrige Award has identified seven broad dimensions along which any applicant organisation must excel in order to win the award [US Department of Commerce, 1992]. These are: leadership, information analysis, strategic quality planning, human resource management, quality assurance of products and processes, quality results, and customer satisfaction. An organisation must link these dimensions in a coherent, long-term campaign to reap the fruits of a sustained, continuous improvement in overall business performance reflected in better market shares, better financial performance, and better employee satisfaction and performance [US General Accounting Office, 1991].

An organisation must start the implementation by gaining the total and wholehearted support of its top management. Top management acts as a driver of TQM implementation by creating values, goals, and systems to satisfy customers' needs and improve organisation performance. The customer must be the focus of all quality improvement efforts. Therefore, the organisation must strategically plan and organise its technical, managerial, and human resources around the products and processes which will provide superior products to customers. Formulation of a strategy to build quality into products and processes, and organised deployment of this strategy into consistent human resource management and quality assurance activities are critical to successful TQM implementation. Human resource management assumes a strategic role of developing a highly motivated workforce with required multiple skills and the desire to contribute to quality efforts through participative management. It is also responsible for creating an infrastructure for this by appropriately orienting functions such as workforce planning, workforce training and development, and appraisal of the workforce performance towards the overall TQM framework developed by top management.

### **3.2.2 Just-In-Time manufacturing**

The Just-In-Time philosophy is based on the concept of delivering raw materials just when needed and producing products just when needed. The focus is on minimising raw material, work-in-process, and finished goods inventory with a view to cutting inventory costs and also helping to expose other more serious inefficiencies such as poor maintenance, defect products, poor equipment layout, etc. in the manufacturing cycle. JIT implementation elements are designed to eliminate these productivity problems. Activities such as reduction of setup times, multifunctional employees, uniform plant loading, Kanban systems, quality control, and quality of the suppliers are embodied in the general JIT context of the elimination of waste, and full utilisation of people, equipment, and materials. However, there are some implementation problems that can be attributed to the interactions between these different components of JIT. For example, a lack of understanding of the relationships between the above elements of JIT, and the view that implementing Just-In-Time as a set of programmes will be the solution for all productivity problems. Also, the emphasis on zero inventory and expectations of

employees to conform to tight schedules without appropriate supporting infrastructure are known to hurt the long-term productivity because of excessive stress [Klein, 1989]. Another parameter that should be evaluated is the suitability of JIT in terms of the type of the manufacturing process. JIT is not equally effective in all manufacturing environments. Since it attempts to recognise productivity benefits through the standardisation of the operations and the standardisation of the components of the products, and requires smooth production plans, JIT implementation is more effective for repetitive production with fairly stable demands. Application of JIT in other environments is also possible, but it is more demanding.

### **3.3 The research issue**

The previous section described TQM and JIT in terms of their philosophies, objectives, and scope of implementation. However, the development of a joint TQM&JIT implementation model, which is the final objective of this study, poses some questions regarding the elements of both that should be utilised. These questions could be expressed as:

- what practices and what activities from both the philosophies have been beneficial for the processes that they were used for?
- how can they interact and work under the same framework? Are there any of them in contradiction with each other?
- how can the critical ones be distinguished from the others?

This simple series of questions will help in the formulation of the research assumptions and will make the research issues clearer. The elements and the activities that will be investigated regarding Total Quality Management and Just-In-Time elements and activities have been selected after a thorough review of the previous works towards that direction. What can be pointed out is that only few academic or research attempts have been undertaken regarding a joint implementation of TQM and JIT. So, the basic effort

of this study was to focus on the selection of the proper components of each philosophy that will fit under the same context and will work together effectively. The following sections describe the investigated characteristics.

### **3.3.1 Importance of TQM and JIT in terms of company strategy**

The importance of TQM and JIT in terms of company strategy is indicative for the worth and usefulness of each system in terms of benefits for the company. In Britain, the industrial practitioners have typically five to ten years experience in both systems, so the transfer of this experience to the current research will be very helpful. A scale will be used for the comparison of the importance of each system. That will have three levels: (1) low importance, (2) middle importance, and (3) high importance in terms of company strategy.

### **3.3.2 Reasoning behind TQM and JIT implementation**

As it was described above, TQM and JIT differ in the implementation objectives and scope. It was necessary to find out the particular reasoning for the implementation of each system, because that will help in the accurate formulation of the joint TQM&JIT strategy. The possible reasons that were selected are the following: (1) marketing advantage, (2) improvement of efficiency and effectiveness of the process, (3) reduction of production cost, (4) improvement of product quality, (5) customers required it, (6) meshed with business strategy.

### **3.3.3 Determination of TQM and JIT goals**

The success of an implementation programme is very dependent on the determination and commitment to the programmes goals. That is why the total and wholehearted support of the top management is essential. The purpose of that part of the research is to investigate who determines the objectives and goals of each system. This may help to understand the contribution and the significance of each of the investigated factors in the determination of company strategy. These are: (1) top management, (2) middle management, and (3) main customers.

### **3.3.4 Practices for quality assurance**

Improving the quality of the products and the processes is one of the principal objectives of Total Quality Management and one of the major prerequisites of Just-In-Time. The practices that are currently employed in order to achieve quality of products and processes are investigated in this part of the study. These are the following: (1) a quality document (which describes company policy on quality and quality control), (2) a quality handbook (a written documentation of quality procedures), and (3) systems of regular audit in quality efforts and results.

### **3.3.5 Participation in the audit of quality**

Another important innovation that TQM and JIT bring to the manufacturing production process is the participation of everyone in the company in the audit of quality. People from all levels and all departments must participate in the audit of quality, because only then it can be said that the total quality assurance programme and the total quality control is properly implemented. Without total quality of the products and the processes it is impossible to operate JIT production, because the system will be very fragile. The components of a joint TQM&JIT approach that are investigated, in terms of quality assurance, are the following: (1) top management participation, (2) participation of the senior management of the department involved, (3) participation of the middle management of the department involved, (4) participation of managers from other departments, (5) participation of the management of Quality Control department, and (6) shop-floor employees.

### **3.3.6 JIT impact on the inventory and work-in-process (WIP) reduction**

Just-In-Time is based on the concept of inventory elimination. The term inventory includes the excessive quantities in three basic locations: stores, WIP, and finished goods. This means that 'inventory' is an excess of raw materials, an excess of materials and products within the production process, and an excess of finished goods. Many people consider that inventory and work-in-process are the same thing, so the clarification of both terms is necessary.

This area of the research is very important, because it investigates the impact of the JIT on major problems of the manufacturing industry, such as the inventory and the WIP. Five production parameters were selected to be investigated, because it is considered they are adequate to give an almost complete picture of the success of the implementation programme. The impact of JIT on each parameter will be estimated in a three-grade scale, Positive-None-Negative. The five parameters are the following: (1) inventory turnover, (2) inventory record accuracy, (3) tracking of inventory, (4) amount of finished goods, and (5) amount of work-in-process (WIP).

### **3.3.7 TQM and JIT impact on product quality and customer satisfaction**

An organisation must recognise that the purpose of all work and all efforts to make improvements is to serve the customers better. This means that it must know how well its outputs are performing, always according to the customer requirements. The ability to meet external customer requirements relies on a series of often complex internal supplier-customer links [Munro-Faure, 1992]. A breakdown in any of these internal chains may result in an error which will affect the service received by the external customer. Therefore, TQM must involve all the internal customer-supplier chains to ensure external customers only receive conforming goods and they are overall satisfied. It was decided to investigate the impact of each system separately on the five production parameters that were selected, because this may confirm one of the primary declarations: that TQM is a broad and integrative philosophy of management which attempts to improve the quality of products and processes in order to achieve a better customer satisfaction, whilst JIT is focusing on the minimisation of inventory (raw materials, WIP, and finished goods), and the full utilisation of the capabilities of employees. The five parameters that will be investigated are the following: (1) overall customer satisfaction, (2) number of customer complaints, (3) number of warranty claims, (4) amount of scrap, and (5) overall product quality.

### **3.3.8 TQM and JIT impact on workforce**

A joint Total Quality Management and Just-In-Time approach requires many cultural changes in employee way of working and probably is the most difficult stage of an implementation programme. Management quality leadership, integration of effort and teamwork, prevention of errors, detection of defects and error-proof devices (*poka-yoke*), ownership, and continuous improvement are only some of the new ideas that the innovative approach brings about. This study focuses on the human aspects of TQM and JIT impact on the workforce. The factors that will be investigated are: (1) employee job satisfaction, (2) absenteeism, (3) teamwork, (4) union relations, (5) labour turnover, (6) labour utilisation, and (7) employee motivation.

### **3.3.9 JIT impact on the production process**

The formulation of the joint TQM&JIT implementation strategy, and the education and training on TQM&JIT principles are the first two stages which aim to provide a fertile environment for the improvements in the process. If the manufacturing process is not changed, then it is extremely difficult to achieve JIT production [O'Grady, 1988]. This research attempts to investigate the impact of JIT on some of the most important production parameters, always under the context of a joint approach. The results of the research will test if the joint implementation is a successful approach. O'Grady, (1988) argues that by the term *successful* is meant an implementation that is professional, educated and determined, and which yields the greatest possible benefits for the company. The production parameters that will be investigated towards this direction are the following: (1) machine availability, (2) variance reduction, (3) setup time reduction, (4) throughput time reduction, (5) batch size reduction, (6) material handling costs, and (7) total manufacturing costs.

### **3.3.10 TQM and JIT duration of implementation**

Total Quality Management and Just-In-Time are two management philosophies that require a lot of patience and many efforts in order to get beneficial results. The new culture and the new practices cannot be implemented overnight. The role of management

is catalytic for the success of such a demanding programme as a continuous improvement programme, because it must have very clear targets about what is going to be done, it must spread it to the workforce, and it must find the appropriate way to lead them towards it. The average duration of TQM and JIT implementation is being investigated in this part of the research, seeking the time that is necessary to reap the first fruits. The implementation time is divided in four areas: (1) 6-12 months, (2) 12-18 months, (3) 18-24 months, and (4) more than 24 months.

### **3.3.11 Education and training on TQM and JIT principles**

The education and training on TQM and JIT principles differ from education and training for other manufacturing management approaches because of the fundamental changes in attitude and behaviour that are necessary. With TQM&JIT in operation, all employees have a greater role in helping the company to prosper, and that change in attitudes and behaviour demands a comprehensive educational/training programme. If the education and training are not thorough, then the implementation may have many difficulties and the primary objectives may not be achieved. The practices of the education and training on Total Quality Management and Just-In-Time will be investigated in this part of the research, seeking the commonest ones in manufacturing industry. These are the following: (1) courses outside the company, (2) courses in the company, and (3) studies in literature about TQM and JIT.

### **3.3.12 Information on TQM and JIT problems within the company**

A joint TQM&JIT approach apart from the new employee way of working is bringing new techniques and new procedures in obtaining information on the production problems. This information should reach all the levels, from shop-floor to top management, because quality and productivity are companywide matters and so their problems should be. It is management's responsibility to bring everyone dealing with these problems because everyone can contribute to solve them. The five approaches that will be investigated are the following: (1) suggestion system, (2) formal meetings, (3)

written reports, (4) informal collective discussion, and (5) informal face-to-face discussion.

### **3.3.13 JIT impact on the information flow**

The improvement in the information flow in a manufacturing process is strongly related to the employee involvement in the process, the teamwork and the job satisfaction, as well as the rearrangement of equipment layout in cells or work-centres. Also, as the organisation pyramid is getting fewer layers and more autonomy and authorisation is given to the employees, the information flow is becoming better and more integrated. This study investigates the information flow of three different production areas: (1) the information flow between management and shop-floor, (2) the information flow between each work area (e.g. cell), and (3) the information flow within each work area (e.g. cell).

### **3.3.14 Quality of the suppliers**

It was mentioned in the section of JIT impact on inventory and WIP, that one of the inventory areas is the stores or else the raw materials. This usually happens because companies are aware of the quite high percentage of non-conforming raw materials and components and they keep a safety stock. The TQM&JIT integration in the entire supply-chain management may need many years of effort and a contribution from the customer and the suppliers involved, but moreover needs monopolistic relation between the customer and the supplier. This study wishes only to touch this very wide subject, by investigating some of the techniques that the manufacturers use in order to check the quality of their suppliers. These are the following: (1) by lot inspection, (2) analysing control charts from the suppliers, (3) checking the process capability index from the suppliers, and (4) checking is done in customer's production process.

### **3.3.15 Initiatives that improve company performance**

The joint TQM&JIT implementation approach is only one of the modes that companies generally use in order to continuously improve their performance. It will be very useful for the study to identify other initiatives that are usually undertaken towards that

direction, because this could be an indirect comparison measure for the effectiveness of Total Quality Management and Just-In-Time programme. Some of the initiatives that will be investigated may be also included in TQM and JIT procedures. These are the following: (1) capital investment, (2) marketing, (3) performance measurements, (4) restructuring, (5) cost-cutting, (6) quality assurance, (7) training, and (8) total productive maintenance.

# **CHAPTER FOUR**

## ***DATA COLLECTION AND ANALYSIS***

## **DATA COLLECTION AND ANALYSIS**

### **4.1 Introduction**

In the previous chapter, the research issue was formulated as a series of questions requesting the impact of the joint TQM and JIT implementation on various production areas. In order to investigate the research issue this study conducted an industrial survey. This chapter describes: (1) the method for data collection that was used in the survey, and (2) the profile of the companies who participated in the survey.

### **4.2 The industrial survey**

In order to investigate the critical parameters of TQM and JIT implementation an industrial survey was conducted for this study. The manufacturing organisations that were chosen for this purpose were mainly from the automotive, electrical and electronics, machinery and aerospace equipment industries. The KELLY'S UK Directory 1996 and the FAME (1995) database were used, helping to find out the industries that would have operated Total Quality Management and Just-In-Time at their plants.

A postal questionnaire was used as a method for data collection. The following section describes its objectives and the general structure.

### **4.3 The method for data collection**

The objectives of the data collection were the following:

1. To obtain data that would allow the investigation and the classification of the procedures and the techniques that are used from TQM and JIT. The critical factors for their joint implementation will derive from the statistical analysis of the data.

2. To obtain data concerning the average impact of both systems on the workforce performance and on the quality of the products.
3. To obtain data that would give general information about some aspects of the current situation of the organisation, always related to the TQM and JIT objectives.

Therefore, the questions of the questionnaire were formulated in three different types. There were questions that were comparing TQM and JIT in some particular areas. Some others were measuring the average impact of TQM and JIT joint implementation on the process and workforce performance, and on the product quality. The third pattern of the questions was requesting the opinion of the managers about some given activities and initiatives that were undertaken to improve company performance. The complete questionnaire is contained in Appendix A.

In the development of the questionnaire, effort was made to include all the important parameters that are necessary for a successful joint approach. Many of these factors were described in the research issue, providing a comprehensive view of the TQM and JIT joint implementation. A broad view provides a clear identification of the differences that exist between TQM and JIT, but would also reveal the areas of their common action. On the other hand, effort was made to design a questionnaire that would be relatively easy for the respondents to complete in a short time, in order to ensure a good response rate. All questions referred to the principal elements of Total Quality Management and Just-In-Time, in order to ensure a common understanding of the research topic from potential respondents, and avoid vagueness in answers. The areas that were covered in the questionnaire included:

- the concept of quality, according to Total Quality Management and Just-In-Time principles and procedures
- the performance of the production process under the impact of TQM and JIT implementation
- the performance of the workforce under the innovative working principles that both systems bring about

- the overall performance of the organisation as a result of the joint implementation of TQM and JIT.

#### **4.4 The sample size**

Six hundred questionnaires were mailed to manufacturing companies from the automotive, electrical and electronics, machinery and aerospace equipment industries. The organisations that had been selected for the survey had two common characteristics; their turnover was over £15 million and they had more than 100 employees. These constraints had been established because Total Quality Management and Just-In-Time are commonly operated in UK in large sized organisations and, particularly, in repetitive manufacturing industry. Ninety-one (91) companies participated in the survey giving a response rate of 15.2%. Seventy-nine (79) were fully operating either TQM procedures or JIT systems but 60 of them thoroughly operated both systems simultaneously. This proportion is considered relatively high, because before the conduct of the survey there were not any details about the processes of the companies that had chosen. As it was mentioned above, the only criteria were the turnover and the number of employees. The responses of these 60 companies are the basis of the analysis.

#### **4.5 The statistical analysis**

The industrial implementation of TQM and JIT usually yields beneficial results to the companies, mainly from the improvement of numerous areas of the process. A statistical analysis is performed to distinguish the proper sequence of activities that should be followed, and to expose the key-areas that should be improved, based on the responses of the managers that have already completed a TQM and JIT joint implementation programme at their plants. To achieve that, the statistical analysis investigates and specifies the existence of statistically significant differences between TQM and JIT implementation practices, and the primary benefits of the joint approach. This analysis is based on the industrial implementation factors that have been described in Chapter 3.

#### 4.6 The statistical tests used for the analysis

The data that have been obtained from the responses of the questionnaire are divided in two different types: (i) data that have a nominal scale of measurement, and (ii) data that are naturally dichotomous, that is, the zero-one or success-failure type of data. The comparison of the key factors for a successful joint implementation takes the form of various tests, depending on the form of the question and the type of data. Every question can be expressed as a hypothesis, and the various statistical tests are used for the hypothesis testing. In each case, the hypothesis is tested on the basis of the evidence contained in the sample. The hypothesis is either *rejected*, meaning the evidence from the sample casts enough doubt on the hypothesis for one to say with some degree of confidence that the hypothesis is false, or else the hypothesis is *accepted*, simply meaning that is not rejected. The hypothesis to be tested is called *null hypothesis*. The *level of significance* is the maximum probability of rejecting a true null hypothesis [Conover, 1971].

The tests that have been performed in this study determine the existence of statistically significant differences between TQM and JIT or among the production measures that have been investigated. There is a statistically significant difference and the true null hypothesis is rejected, if the probability that has been calculated from a test is less than the level of significance. There is not a statistically significant difference and a true null hypothesis is accepted, if the probability that has been calculated from a test exceeds the level of significance. These tests are the following [SPSS User's Guide, 1993]:

1. *The paired-samples T test*. Tests the significance of a difference in means for paired samples. Both the variables are in the quantitative form.
2. *The Cochran's Q test for several related samples*. Tests the null hypothesis that the proportion of cases in a particular category is the same for several dichotomous variables. Cochran's Q statistic has approximately a chi-square distribution.

3. *The McNemar test for two related samples.* The McNemar test examines the cases with different values for two dichotomous variables, and it tests the hypothesis that both combinations of different values are equally likely.
4. *The repeated measures analysis of variance (ANOVA).* The same variable is measured on several occasions for each subject. The advantage of repeated measures design is that the variability due to differences between subjects can be eliminated from the experimental error.

#### **4.7 The profile of the companies participated in the survey**

In this paragraph, the companies that participated in the survey are classified according to the products they manufacture, the number of employees and the turnover, the type of manufacturing process they have, the time they are operating a TQM and JIT joint implementation program, and the experience of the managers that led this implementation.

##### **4.7.1 Products**

As it can be seen from the Table 4.1, the companies with automotive and electrical-electronics products seem to operate in a higher frequency joint Total Quality Management and Just-In-Time programmes. As it was mentioned above, both the systems are mainly employed in repetitive manufacturing environments, like automotive and electronics industries. Also, the percentage of 'other industries' that operated TQM and JIT is quite high, within which are companies manufacturing pumping and heating equipment, valves, telecommunication equipment and lifts.

|                          |    |
|--------------------------|----|
| Automotive               | 20 |
| Electrical & Electronics | 21 |
| Aerospace equipment      | 3  |
| Machinery                | 6  |
| Other                    | 17 |

**Table 4. 1: Frequency of the responses according to products**

#### **4.7.2 Number of employees - Company turnover**

The frequency of the responses in relation to the number of employees and the company turnover (in millions) are presented in the Table 4.2. The use of the T-test suggests that there is a statistically significant difference between them to the 5% significance level. That statistically significant difference in the distribution of the responses may indicate that the joint implementation of TQM and JIT yielded profits (if there is not any mistakes in the selection of scales). This means that the employees managed to be more productive, by using the TQM and JIT way of working, and the companies finally achieved a higher turnover.

| 100 - 500<br>(employees) | 500 - 2000<br>(employees) | 2000 -5000<br>(employees) | 5000 +<br>(employees) |
|--------------------------|---------------------------|---------------------------|-----------------------|
| 38                       | 20                        | 1                         | 0                     |
|                          |                           |                           |                       |
| £ 15 - 50<br>(millions)  | £ 50 - 100<br>(millions)  | £ 100 - 250<br>(millions) | £ 250 +<br>(millions) |
| 33                       | 17                        | 2                         | 5                     |

**Table 4. 2: Number of employees - Company turnover**

#### 4.7.3 Type of manufacturing process

Another piece of useful information that has been obtained from the analysis of the questionnaire is the type of manufacturing process that is usually operated in plants with TQM and JIT. According to the data, the higher percentage of the companies that jointly operating TQM and JIT manufacture their products in low volume batches or by using flow line. A closer examination of the questionnaires showed that several companies are operating multi-production or mixed-flow systems. For example, they used to have low volume batch and flow line production because that combination allow them being more flexible and more competitive. This explains what at the first glance looks contradictory, the manufacturing companies with repetitive processes to have 'Low Volume Batch' production as well. Another advantage of multi-production or mixed-flow processes is the ability to conform to the market needs and the customer requirements easier and more rapidly. So, they can produce what is needed, when it is needed and in the quantity that it is needed. Table 4.3 shows the frequency of the responses.

|                   |    |
|-------------------|----|
| Flow line         | 24 |
| High Volume Batch | 16 |
| Low Volume Batch  | 35 |
| Other             | 12 |

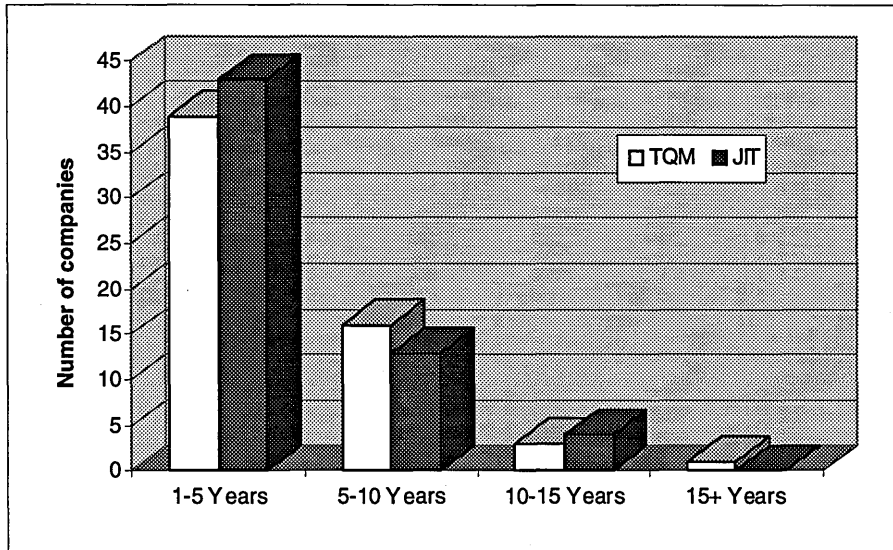
**Table 4. 3: Type of manufacturing process**

#### 4.7.4 Years of TQM and JIT industrial implementation

TQM procedures and JIT systems have been mostly used in British industries during the last one to five (1-5) years, although there are some that had started operating them five to ten (5-10) years ago. What is really worth observing is the frequency of the responses in the last two categories, ten to fifteen (10-15) and more than fifteen (15+) years of use. Only four out of sixty (6.7%) were using TQM and JIT before the mid 1980s, which means that they were adopted quite recently (comparing to the implementation of both systems in Japan) and they have had a great room for improvement. Table 4.4 and Fig. 4.1 show all the responses for every category.

|                | 1 - 5 yrs | 5 - 10 yrs | 10 - 15 yrs | 15 + yrs |
|----------------|-----------|------------|-------------|----------|
| TQM procedures | 39        | 16         | 3           | 1        |
| JIT systems    | 43        | 13         | 4           | 0        |

**Table 4. 4: Years of TQM and JIT industrial implementation**



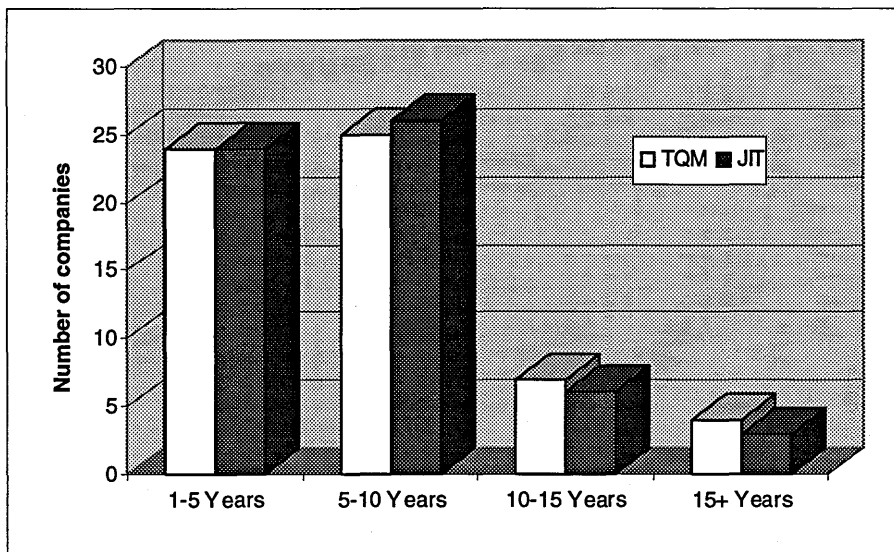
**Figure 4. 1: Years of TQM and JIT industrial implementation**

#### **4.7.5 The experience of the managers with TQM and JIT**

The experience of the managers with Total Quality Management and Just-In-Time (perhaps through literature review, seminars and courses, or visits to industries operating TQM and JIT in U.K. or in Japan) was a helpful factor for the proper and complete implementation of both philosophies. As it can be seen from the Table 4.5 and Fig. 4.2 below, the number of managers with experience of more than five years in TQM and JIT is a little higher than the one with only one to five years.

|                | 1 - 5 yrs | 5 - 10 yrs | 10 - 15 yrs | 15 + yrs |
|----------------|-----------|------------|-------------|----------|
| TQM procedures | 23        | 25         | 7           | 4        |
| JIT systems    | 24        | 25         | 6           | 3        |

**Table 4. 5: Experience of the managers with TQM and JIT**



**Figure 4. 2: Experience of the managers with TQM and JIT**

That means that the changes in the manufacturing process, and in the production activities, according to TQM and JIT principles, took place with the guidance and leadership of the management. Extending Dr. Deming's (1986) words that 'the management is responsible for the 94% of all quality problems' it could be said that the management (Top-Middle-Low) is responsible for the 94% of the successful efforts of TQM and JIT joint implementation programmes.

## **CHAPTER FIVE**

### ***RESULTS OF THE ANALYSIS AND CONCLUSIONS***

## **RESULTS OF THE ANALYSIS AND**

## **CONCLUSIONS**

### **5.1 Introduction**

Chapter four gave some details about the profile of the companies that participated in the survey, in which were included the type of products, number of employees and company turnover, type of manufacturing process, years of implementation, and experience of managers with TQM and JIT. The data regarding the profile of the companies came from the first five questions of the questionnaire. The other fifteen questions that investigated the impact of joint TQM and JIT implementation on the processes, the products, and the workforce are analysed in the following sections.

### **5.2 Comparison of industrial factors for a successful joint implementation**

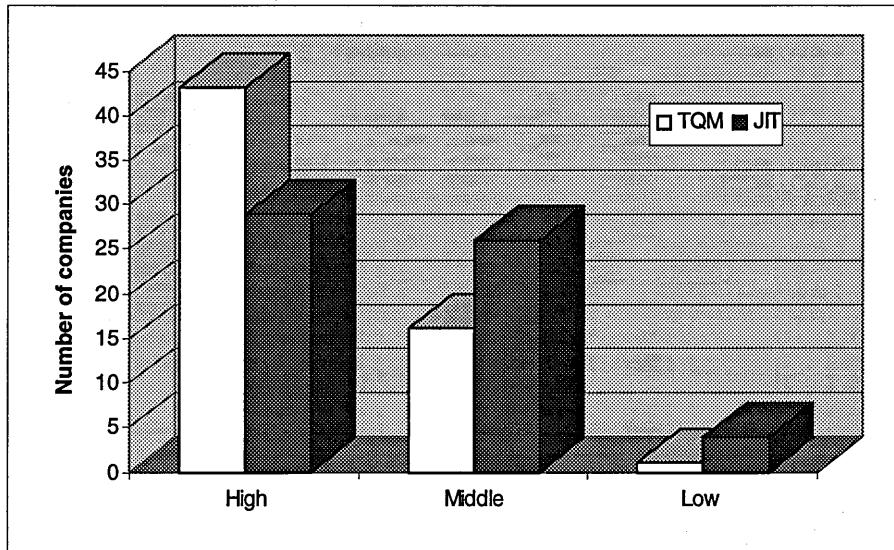
In order to provide a comprehensive view, the analytical frequency of the responses, the bar-chart diagram, and the results of the statistical analysis are presented for every one of the fifteen question that are analysed. The bar-chart diagram shows either the number of companies that responded, or the average impact of joint implementation to the specific options. The Tables with the results of the statistical analysis contain the statistically significant differences that obtained, depending on the form of the question and the test that has been performed. The conclusions that follow the results of the analysis are based on a possible explanation of the statistical significant differences. The author's intention was to draw realistic and unbiased conclusions from the results of the analysis, in order to be more accurate the development of the joint TQM&JIT Model.

### 5.2.1 Importance of TQM and JIT in terms of company strategy (Quest. 6)

The first factor that has been investigated in the survey is the managers' opinion of the importance of TQM and JIT in terms of company strategy. If this question is being associated with the one that investigated the determination of TQM and JIT goals, then it may give even more useful information about the perception that companies have for both the philosophies. Table 5.1 and Fig. 5.1 below appear the frequency of the responses.

|                | LOW | MIDDLE | HIGH |
|----------------|-----|--------|------|
| TQM procedures | 1   | 16     | 43   |
| JIT systems    | 4   | 26     | 29   |

**Table 5. 1: Importance of TQM and JIT in terms of company strategy**



**Figure 5. 1: Importance of TQM and JIT in terms of company strategy**

The mean values for TQM and JIT responses are 0.7000 and 0.4167 (1= High, 0= Middle, -1= Low) respectively. The use of the T-test suggests that there is a statistically significant difference between TQM and JIT to the 5% significance level. Table 5.2 contains the analytical results of the statistical analysis.

|     | Mean   | SD    | Correlation | t-value | 2-tail Sig. |
|-----|--------|-------|-------------|---------|-------------|
| TQM | 0.4167 | 0.619 | 0.138       | -2.97   | 0.004       |
| JIT | 0.7000 | 0.497 |             |         |             |

**Table 5. 2: Results of the statistical analysis of Quest. 6**

Given the results of the analysis, it could be pointed out that:

### ***Conclusion 1***

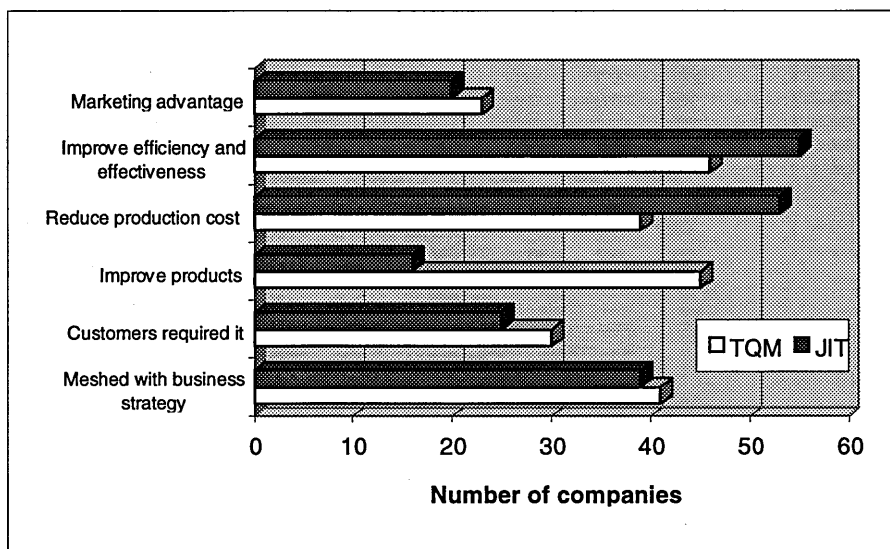
TQM has a higher importance in terms of company strategy than JIT. The frequency of the responses showed that TQM lies more close to the High area of importance, whilst JIT more close to the Middle one. One possible explanation is that: Total Quality Management is a broad business philosophy which affects many areas and many levels of an organisation. The benefits of a successful TQM programme may improve the performance of an organisation as a whole, so its implementation is very important and it has a high ranking in company strategy. On the other hand, JIT is focusing on the production process of an organisation and is localised only in this area. It is a management philosophy very useful for the manufacturing organisations, but it does not have the companywideness of Total Quality Management. JIT is the manufacturing tool that can yield benefits and profits for the company, if it is properly used under the TQM business framework.

### 5.2.2 Reasoning behind TQM and JIT implementation (Quest. 7)

One of the principal areas for investigation was the reasoning behind the implementation of Total Quality Management and Just-In-Time principles into the manufacturing process. The aim of that question was to find out what actually prompted the British companies to implement the Japanese management methods in their processes, and what they expected to achieve. Table 5.3 and Fig. 5.2 show some of the possible reasons that led companies to adopt them.

|                                      | TQM | JIT |
|--------------------------------------|-----|-----|
| Marketing advantage                  | 23  | 20  |
| Improve efficiency and effectiveness | 46  | 55  |
| Reduce production cost               | 39  | 53  |
| Improve products                     | 45  | 16  |
| Customers required it                | 30  | 25  |
| Meshed with business strategy        | 41  | 39  |
| Other                                | 5   | 7   |

**Table 5. 3: Reasoning behind TQM and JIT implementation**



**Figure 5. 2: Reasoning behind TQM and JIT implementation**

The use of the McNemar test suggests that there are statistically significant differences between the TQM and JIT reasoning to the 5% significance level in some of the options. The options that produced statistically significant differences are: the second (Improve efficiency and effectiveness) where TQM has 46 and JIT 55, the third (Reduce production cost) where TQM has 39 and JIT 53, and the fourth (Improve products) where TQM has 45 and JIT 16 responses. Table 5.4 and Fig. 5.3 contain the analytical results of the statistical analysis.

|                                      |                                                |
|--------------------------------------|------------------------------------------------|
| Meshed with business strategy        | 0.7905 (2-Tailed P)<br>(Binomial)              |
| Customers required it                | 0.4049 (2-Tailed P)<br>(Binomial)              |
| Improve products                     | 0.0000 (Significance)<br>(Chi-Square: 25.2903) |
| Reduce production cost               | 0.0066 (2-Tailed P)<br>(Binomial)              |
| Improve efficiency and effectiveness | 0.0352 (2-Tailed P)<br>(Binomial)              |
| Marketing advantage                  | 0.6291 (2-Tailed P)<br>(Binomial)              |
| Other (Please indicate):             | 0.7266 (2-Tailed P)<br>(Binomial)              |

**Table 5. 4: Results of the statistical analysis of Quest. 7**

Given the results of the analysis, it could be pointed out that:

### **Conclusion 2**

This study revealed some important targets that Total Quality Management and Just-In-Time programmes have. According to the responses of the managers and the above

analysis, companies primarily implement TQM because they want to improve the products. That means to improve: product quality, product design, product manufacturability, product functionality, product safety, etc. TQM has the appropriate procedures and the appropriate tools to achieve all the above, and make the product to conform to customer requirements. On the other hand, JIT is operated to improve the efficiency and effectiveness of the process, and to reduce the production costs. JIT is trying to achieve this through the minimisation or elimination of inventory. Standard operations, production levelling, and Kanban are some of the techniques that JIT production uses to eliminate the inventory. The concept of quality is the critical factor for a successful JIT implementation, because it can assure that it will produced only what it is needed, when it is needed, and in the quantity that is needed. Without quality products and processes JIT is very fragile and almost inapplicable.

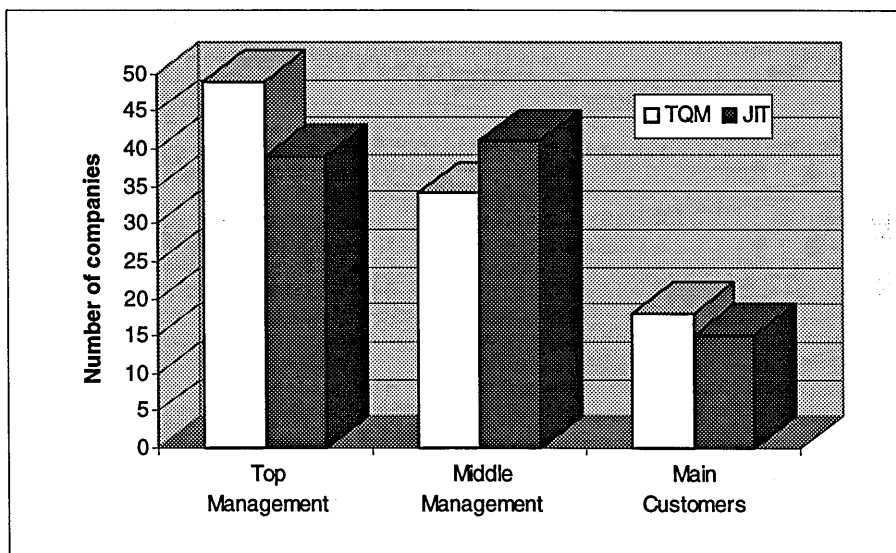
Furthermore, the frequency of the responses showed that both systems meshed with business strategy in a quite high rate. However, each system has a different rank in the business strategy, as can be seen in the previous section. Customers required the implementation of TQM and JIT was thought to be of medium importance, whilst there were companies who thought that Total Quality Management and Just-In-Time was a marketing advantage.

### 5.2.3 Determination of TQM and JIT goals (Quest. 8)

The determination of TQM and JIT goals is an important factor for the success of a joint programme. As it was clearly explained in Chapter 2, top management's wholeheartedly support is essential for such process improvement initiatives. The opinion of the managers regarding this subject is shown in the following Table 5.5.

|                      | TQM | JIT |
|----------------------|-----|-----|
| 1. Top management    | 49  | 39  |
| 2. Middle management | 34  | 41  |
| 3. Main customers    | 18  | 15  |

**Table 5. 5: Determination of TQM and JIT goals**



**Figure 5. 3: Determination of TQM and JIT goals**

The use of the McNemar test suggests that there is a statistically significant difference between TQM and JIT answers only in 'Top management' (TQM 49 and JIT 39) option to the 5% significance level. Table 5.6 contains the analytical results of the statistical analysis.

|                      |                                   |
|----------------------|-----------------------------------|
| 1. Top management    | 0.0414 (2-Tailed P)<br>(Binomial) |
| 2. Middle management | 0.1185 (2-Tailed P)<br>(Binomial) |
| 3. Main customers    | 0.5811 (2-Tailed P)<br>(Binomial) |

**Table 5. 6: Results of the statistical analysis of Quest. 8**

Given the results of the analysis, it could be pointed out that:

### ***Conclusion 3***

The TQM goals are mostly determined by the top management of an organisation, because they have high importance in terms of company strategy. This conclusion could be drawn from the combination of this section with the one above that described the importance of TQM and JIT in terms of company strategy. The support and the commitment of top management on the quality concept is the essential factor for the success of a joint implementation programme. Many business improvement initiatives have failed because they did not have the support of the top. The role of middle management is to translate the objectives and the goals of top management to the equivalent ones that can be understood from the lower levels of the organisation. A more careful look at the frequency of the responses will show that middle management was responsible for the determination of JIT goals in many companies participated in the survey. No evidence was found to suggest that JIT than TQM goals are mostly determined by middle management, because of the role that middle management has in the company hierarchy and which it was previous described. The participation of main customers in determination of TQM and JIT goals is considered relatively low, although it was expected to be higher in companies that were supposed to be customer-oriented.

5.2.4 Practices for quality assurance (Quest. 9)

Almost all the companies in the survey had a quality document [which describes company policy on quality and quality control], a quality handbook [a written documentation of quality procedures] and systems of regular audit in quality control efforts and results. The frequency of the responses is presented in the Table 5.7 below.

|                                                                                    |    |
|------------------------------------------------------------------------------------|----|
| A quality document [which describes company policy on quality and quality control] | 59 |
| A quality handbook [a written documentation of quality procedures]                 | 54 |
| Systems of regular audit in quality control efforts and results                    | 56 |

Table 5. 7: Practices for quality assurance

The use of the Cochran’s Q test suggests that there is not a statistically significant difference between the above quality assurance practices to the 5% significance level. Table 5.8 contains the analytical results of the statistical analysis.

|       |           |              |
|-------|-----------|--------------|
| Cases | Cochran Q | Significance |
| 60    | 4.7500    | 0.0930       |

Table 5. 8: Results of the statistical analysis of Quest. 9

Given the results of the analysis, it could be pointed out that:

Conclusion 4

The three investigated practices that were used for the quality assurance of the products and the processes had a very high rate of responses. Fifty nine out of sixty companies had a quality document, which describes company policy on quality and quality control. This document represents the ‘constitution’ of the organisation on quality policy and it is very important for the success of an implementation programme. What is worth mentioning concerns the experience that the author had during the industrial visits for the model

evaluation. In some companies, the quality document was changing after the completion of a TQM programme; new objectives and new visions were included, according to the new targets that the new continuous improvement programme has.

Also, the systems for regular audit in quality control efforts and results, and the quality handbook (a written documentation of quality procedures) are practices that are commonly known and used in British industry. Both are necessary for the quality documentation of ISO 9000 series or BS5750 certification. The certification in most of the cases can assure the quality of products and processes, but it cannot guarantee that products meet customer requirements. The certification can be a useful tool, but not the panacea for all the quality problems.

### 5.2.5 Participation in the audit of quality (Quest. 10)

One of the most important factors for the successful joint implementation of TQM and JIT is everyone's participation in the audit of quality. The managers were asked about that subject and their responses are presented in the Table 5.9 below.

|                                              |    |
|----------------------------------------------|----|
| Top management                               | 39 |
| Senior Management of the department involved | 52 |
| Middle management of the department involved | 51 |
| Managers from other departments              | 48 |
| Management of Quality Control department     | 53 |
| Shop-floor employees                         | 43 |

**Table 5. 9: Participation in the audit of quality**

The use of the Cochran's Q test suggests that there is a statistically significant difference between the above six options to the 5% significance level. But if the test is run only with the second (52 responses), the third (51), the fourth (48), and the fifth (53) options, then there is not a statistically significant difference. This means that the first (39) and the last (43) cause that difference, and so the six options can be divided into two groups. One group contains 'top management' and 'shop-floor employees' options, and the other the four rest. The grouping of the above options will help arriving at the right conclusions. Table 5.10 contains the analytical results of the statistical analysis.

| Cases | Cochran Q | Significance |
|-------|-----------|--------------|
| 60    | 20.4386   | 0.0010       |

**Table 5. 10: Results of the statistical analysis of Quest. 10**

Given the results of the analysis, it could be pointed out that:

***Conclusion 5***

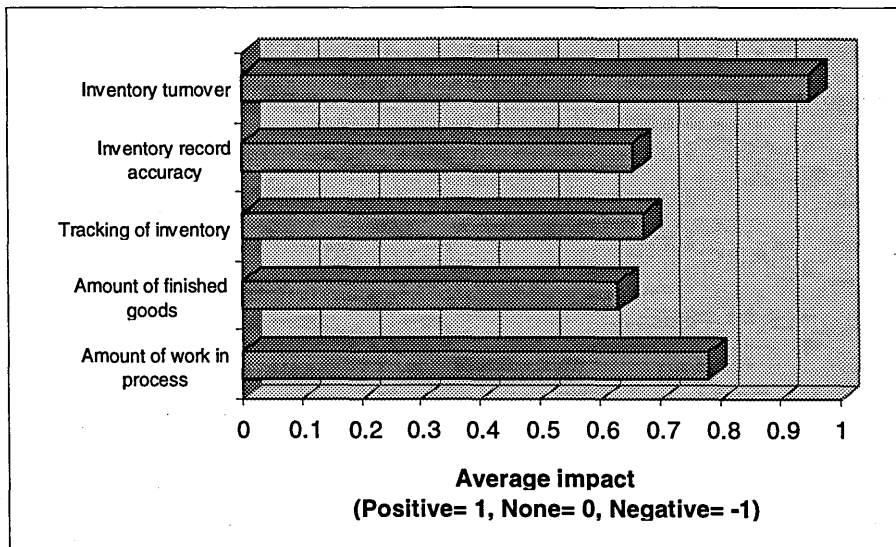
The statistical analysis revealed that senior management and middle management of the department involved, managers from other departments, and management of Quality Control department had approximately the same participation and contribution in the audit of quality. The high response rates perhaps indicate the important contribution of those four in the audit of quality. The frequency of the responses regarding the shop-floor employees is considered relatively high, but it was lower than the above four. This fact may indicate that the management had not given to employees the autonomy and the authorisation that is necessary for the new management model. Also, it may indicate that employees did not have the proper education and training to undertake such an initiative. The involvement and the empowerment of employees in all the business levels, from decision-making to audit of quality, may improve the processes and the systems. This is of major importance in a quality company, but the industrial survey did not verify it. There is a lot of work to be done in order to reach the desired levels, in terms of employee autonomy, that Total Quality Management and Just-In-Time propose.

### 5.2.6 JIT impact on the inventory and work in process reduction (Quest. 11)

Just-In-Time is the production philosophy of the elimination of waste. Two of the major production wastes are the inventory and the work in process (WIP). The survey investigated the managers opinion regarding the impact of JIT systems on these production aspects, and the frequency of the responses is presented in the Table 5.11 and Fig. 5.4 below.

|                           | POSITIVE | NONE | NEGATIVE |
|---------------------------|----------|------|----------|
| Inventory turnover        | 56       | 3    | 0        |
| Inventory record accuracy | 40       | 16   | 2        |
| Tracking of inventory     | 40       | 17   | 1        |
| Amount of finished goods  | 38       | 17   | 2        |
| Amount of work in process | 50       | 5    | 4        |

**Table 5. 11: JIT impact on the inventory and work-in-process reduction**



**Figure 5. 4: JIT impact on the inventory and work-in-process reduction**

The use of the ANOVA test suggests that there is a statistically significant difference between the mean values of the five options to the 5% significance level. The use of the

ANOVA test between the mean values of the second (inventory record accuracy), the third (tracking of inventory), the fourth (amount of finished goods), and the fifth (amount of work in process) options suggests that there is not a statistically significant difference to the 5% significance level. So, what caused the statistically significant difference that initially recorded was the 'inventory turnover' option. That observation may help arriving at more accurate conclusions. Table 5.12 contains the analytical results of the statistical analysis.

|                               | SS    | DF  | MS   | F    | Sig. of F |
|-------------------------------|-------|-----|------|------|-----------|
| Within+Residual               | 48.39 | 220 | 0.22 | -    | -         |
| Factor<br>(Benefits from JIT) | 4.01  | 4   | 1.00 | 4.56 | 0.001     |

**Table 5. 12: Results of the statistical analysis of Quest. 11**

Given the results of the analysis, it could be pointed out that:

### **Conclusion 6**

The inventory turnover was the area that Just-In-Time implementation had the most positive impact on. Fifty six out of sixty companies answered that there was a positive impact, with zero claiming a negative one. As was described in Chapter 3, 'inventory' is a term that contains three sub-elements: raw materials inventory, WIP inventory, and finished goods inventory. A reduction in the inventory turnover can mean a considerable financial benefit for the company.

Quite high but not as it was expected was the JIT impact on the four other inventory elements. There were many cases that JIT implementation had no impact at all on the inventory record accuracy, tracking of inventory, amount of finished goods, and amount of work-in-process (WIP). It is considered quite high the proportion of seventeen out of sixty companies that noticed no impact on the amount of finished goods. Also, it is surprising the percentage of four out of sixty companies that noticed negative impact of

Just-In-Time on the amount of work-in-process. These facts may indicate an inappropriate implementation plan and/or a lack of clear implementation targets. The understanding of implementation objectives, an analysis of the benefits, the commitment of everyone within the company towards this direction, and the existence of a thorough implementation plan, are only some of the principal preconditions for the success of the JIT process improvement approach.

5.2.7 TQM and JIT impact on product quality and customer satisfaction (Quest. 12)

The benefits of the joint TQM and JIT programme in relation to the product quality and customer satisfaction has also been investigated from the questionnaire. The gathered data are indicative for each system. The frequency of the responses is shown in the following Table 5.13 and Fig. 5.5.

|                               | TQM | JIT |
|-------------------------------|-----|-----|
| Overall customer satisfaction | 38  | 27  |
| Number of customer complaints | 40  | 13  |
| Number of warranty claims     | 32  | 8   |
| Amount of scrap               | 47  | 26  |
| Overall product quality       | 56  | 22  |

Table 5. 13: TQM and JIT impact on product quality and customer satisfaction

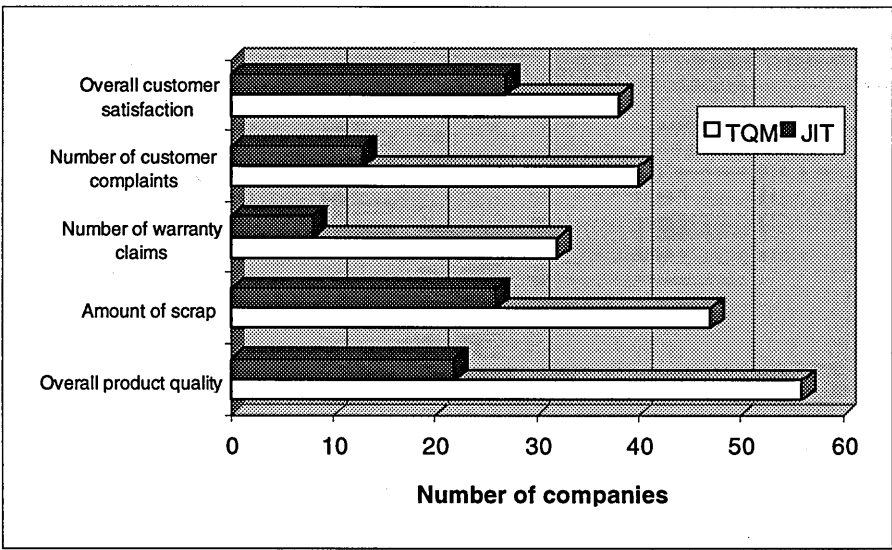


Figure 5. 5: TQM and JIT impact on product quality and customer satisfaction

The use of the McNemar test suggests that there is a statistical significant difference between TQM and JIT in all the parameters that were investigated to the 5% significance level. Table 5.14 contains the analytical results of the statistical analysis.

|                               |                                                |
|-------------------------------|------------------------------------------------|
| Overall product quality       | 0.0000 (Significance)<br>(Chi-Square: 32.0294) |
| Amount of scrap               | 0.0002 (Significance)<br>(Chi-Square: 13.7931) |
| Number of warranty claims     | 0.0000 (Significance)<br>(Chi-Square: 18.8929) |
| Number of customer complaints | 0.0000 (Significance)<br>(Chi-Square: 20.4848) |
| Overall customer satisfaction | 0.0192 (2-Tailed P)<br>(Binomial)              |

**Table 5. 14: Results of the statistical analysis of Quest. 12**

Given the results of the analysis, it could be pointed out that:

#### **Conclusion 7**

The scope of this investigated area was to confirm that, under a joint TQM&JIT working framework the role of Total Quality Management remains the same, which is to improve the product quality and to assure the customer satisfaction. Many times in this study it has been said that TQM is the broad business management philosophy, within which fits the JIT production process management philosophy. This question confirms the most of what has been said, but not all.

The overall product quality was the area with the greater improvement and the most responses, fifty six out of sixty for TQM. The improvement of the overall product quality results in the reduction of the amount of scrap products. Forty seven out of sixty companies replied that the TQM implementation was beneficial for that production parameter. Moreover, the number of customer complaints and the number of warranty claims, which are measuring the customer satisfaction, appear quite high proportions as well. What is quite high, but was expected to be even higher, is the proportion of

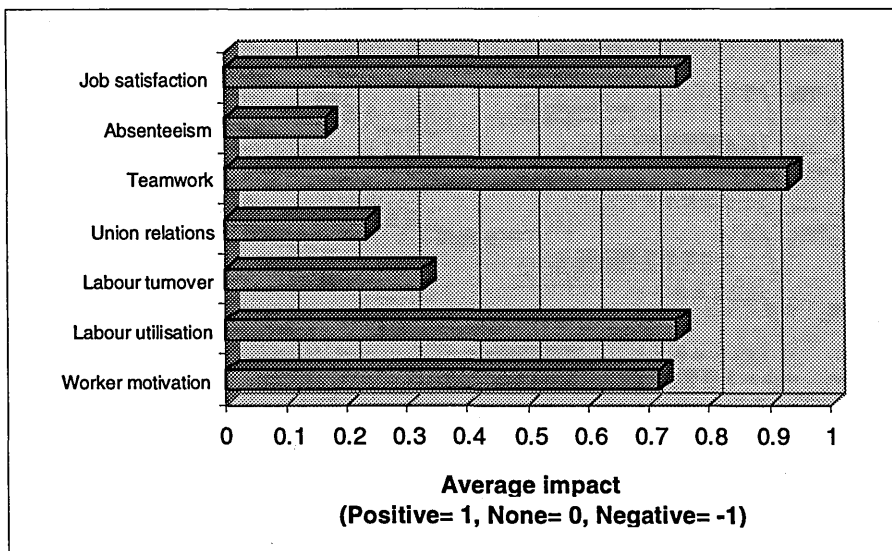
companies who replied that TQM improved the overall customer satisfaction. There were thirty eight out of sixty that gave a positive answer, but there were still twenty two that they had not seen any improvement in this area. This fact, in combination with the conclusion about JIT impact on inventory and WIP, may become the beginning of a rethinking process concerning the TQM and JIT joint approach. Both systems are continuous improvement systems, so their scope and their objectives need continuous re-treatment.

### 5.2.8 TQM and JIT impact on workforce (Quest. 13)

TQM and JIT are bringing new ideas and new methods in the employee way of working. These new ideas and methods are dealing with the personal improvement and performance of employees and their contribution towards to overall production performance. Both the philosophies are paying much attention to the human aspect of work, trying to relate the job with the personal satisfaction. The Table 5.15 and Fig. 5.6 show the frequency of the responses.

|                    | POSITIVE | NONE | NEGATIVE |
|--------------------|----------|------|----------|
| Job satisfaction   | 46       | 13   | 1        |
| Absenteeism        | 11       | 41   | 2        |
| Teamwork           | 56       | 4    | 0        |
| Union relations    | 14       | 30   | 3        |
| Labour turnover    | 19       | 35   | 1        |
| Labour utilisation | 47       | 9    | 3        |
| Worker motivation  | 46       | 11   | 3        |

**Table 5. 15: TQM and JIT impact on workforce**



**Figure 5. 6: TQM and JIT impact on workforce**

The use of the ANOVA test suggests that there is a statistically significant difference between the production factors that were investigated, regarding the impact of TQM and JIT on them, to the 5% significance level. An attempt to group the options by running repeated statistical tests was not successful, because the statistical differences between the responses are very strong. That can also be seen from the bar-chart of Figure 5.6. Table 5.16 contains the analytical results of the statistical analysis.

|                                   | SS    | DF  | MS   | F     | Sig. of F |
|-----------------------------------|-------|-----|------|-------|-----------|
| Within+Residual                   | 47.42 | 270 | 0.18 | -     | -         |
| Factor<br>(Benefits from TQM&JIT) | 23.73 | 6   | 3.95 | 22.52 | 0.000     |

**Table 5. 16: Results of the statistical analysis of Quest. 13**

Given the results of the analysis, it could be pointed out that:

**Conclusion 8**

A joint TQM&JIT implementation requires the full utilisation of the workforce potential in order to improve the processes and the systems. The means, that both philosophies employ to achieve potential utilisation, are focusing to the human aspect of the employee. The involvement in many of the business procedures (i.e. from decision-making and problem solving to audit of quality), the expansion if responsibilities and flexibility, the autonomy and authorisation to undertake initiatives concerning their working area and the way of working, are only some of the new principles that TQM and JIT introduce towards to utilisation of employee capabilities. All these new things brought positive results in the morale and performance of the workforce, but there still is a great room for improvement. Teamwork had the greater improvement; fifty six out of sixty companies replied that the TQM&JIT joint approach improved the teamwork of their workforce. Labour utilisation, worker motivation, and job satisfaction were areas with high frequency of responses, but they were not absolutely satisfactory. Twelve,

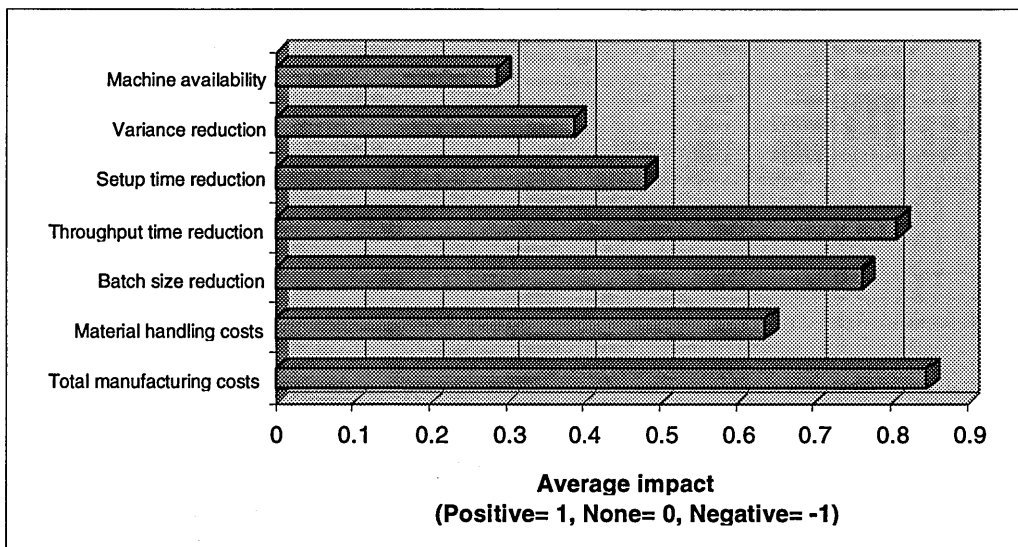
fourteen, and fourteen companies respectively answered that the impact of a joint approach was not positive. Almost fourteen out of sixty companies did not achieve any change to employee behaviour, and, moreover, did not achieve any improvement of the morale or the performance of their workforce. The education and training of employees is the 'make or break issue', and the whole success of the implementation programme depends on it. It should be always borne in mind that, the successful implementation is the one which yields the greatest possible benefits for the company.

### 5.2.9 JIT impact on the production process (Quest. 14)

A JIT system is considered as a successfully implemented system if it has managed to improve the production process. The frequency of the responses for some of the most important production parameters, regarding the beneficial impact of JIT on them, is presented in the following Table 5.17 and Fig. 5.7.

|                           | POSITIVE | NONE | NEGATIVE |
|---------------------------|----------|------|----------|
| Machine availability      | 21       | 25   | 6        |
| Variance reduction        | 22       | 31   | 1        |
| Setup time reduction      | 28       | 24   | 2        |
| Throughput time reduction | 48       | 7    | 2        |
| Batch size reduction      | 43       | 11   | 1        |
| Material handling costs   | 43       | 9    | 6        |
| Total manufacturing costs | 52       | 5    | 2        |

**Table 5. 17: JIT impact on the production process**



**Figure 5. 7: JIT impact on the production process**

The use of the ANOVA test suggests that there is a statistically significant difference between the average impact of JIT on the selected production factors to the 5% significance level. The use of the ANOVA test suggest that there is not a statistically significant difference between the fourth (throughput time reduction), the fifth (batch size reduction), and the seventh (total manufacturing costs) options. That grouping may help arriving at more precise conclusions, and it was achieved by running repeated statistical tests. Table 5.18 contains the analytical results of the statistical analysis.

|                               | SS    | DF  | MS   | F     | Sig. of F |
|-------------------------------|-------|-----|------|-------|-----------|
| Within+Residual               | 68.62 | 294 | 0.23 | -     | -         |
| Factor<br>(Benefits from JIT) | 16.23 | 6   | 2.71 | 11.59 | 0.000     |

**Table 5. 18: Results of the statistical analysis of Quest. 14**

Given the results of the analysis, it could be pointed out that:

### **Conclusion 9**

In the previous section it was discussed the JIT impact on the human factors of the process. This one describes the impact on the actual production process. It must clarified that it has been tested the impact of JIT on the process, always under the operation of a joint TQM and JIT framework.

The reduction of total manufacturing costs, the reduction of throughput time, and the reduction of batch size were the areas that obtained the more benefits from the Just-In-Time implementation. The average positive impact is considered quite high, especially in total manufacturing costs and throughput time respectively. Another production parameter that had been improved was the material handling costs (they reduced), although there were fifteen companies that did not notice a positive impact from the JIT implementation. However, there were some other areas like setup reduction, variance reduction, and machine availability, in which better results were expected. Setup time

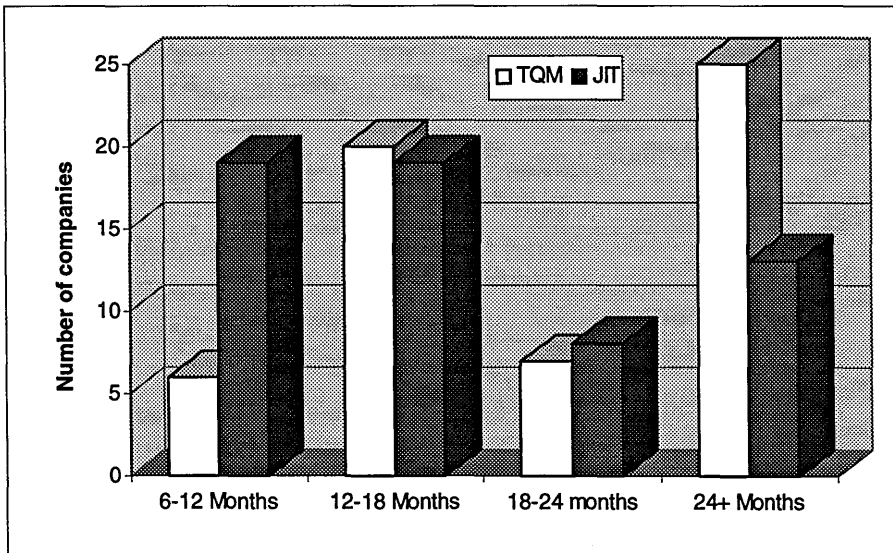
and component variance are some of the principal factors that should be improved in order to obtain JIT production. Without short setup times and small variance of components, it cannot successfully operate production levelling techniques and mixed-flow production, affecting in that way the flexibility of the output system. Only 50 per cent of the companies who participated in the survey had a reduction in setup times, and only 40 per cent in component variance. The relatively low proportions in setup time reduction and variance reduction also affected the improvement of machine availability, which depends on the setup time, the number (variety) of the incoming components, and the batch size. The low average impact of JIT on the three latter production factors confirms the part of conclusion 6 referring to the amount of finished goods, but it does not confirm the very positive impact on the amount of work in process. Perhaps the participating companies did not have the proper performance measures for the work-in-process (WIP) inventory, or possibly they defined the WIP differently. Although the entire production process has been improved, from the implementation of a joint TQM&JIT programme, there are still some areas that need more attention, more effort, and more frequent performance measurements.

#### 5.2.10 TQM and JIT duration of implementation (Quest. 15)

One of the major demands of Total Quality Management and Just-In-Time is the length of time within which the implementation will be considered complete and the benefits will be expected. TQM and JIT are broad philosophies with significant cultural changes and usually their procedures take time. The managers' opinion about the duration of the implementation of TQM and JIT is presented in the Table 5.19 and Fig. 5.8 [each period is counted in MONTHS].

|                | 6 - 12 | 12 - 18 | 18 - 24 | 24 + |
|----------------|--------|---------|---------|------|
| TQM procedures | 6      | 20      | 7       | 25   |
| JIT systems    | 19     | 19      | 8       | 12   |

**Table 5. 19: TQM and JIT duration of implementation**



**Figure 5. 8: TQM and JIT duration of implementation**

The mean values for TQM and JIT are 2.8793 and 2.2586 (1= 6-12 Months, 2= 12-18 Months, 3= 18-24 Months, 4= 24+ Months). The use of the T-test suggests that there is a statistically significant difference between TQM and JIT, regarding the implementation

time, to the 5% significance level. Table 5.20 contains the analytical results of the statistical analysis.

|     | Mean   | SD    | Correlation | t-value | 2-tail Sig. |
|-----|--------|-------|-------------|---------|-------------|
| TQM | 2.2586 | 1.148 | 0.598       | -4.70   | 0.000       |
| JIT | 2.8793 | 1.093 |             |         |             |

**Table 5. 20: Results of the statistical analysis of Quest. 15**

Given the results of the analysis, it could be pointed out that:

***Conclusion 10***

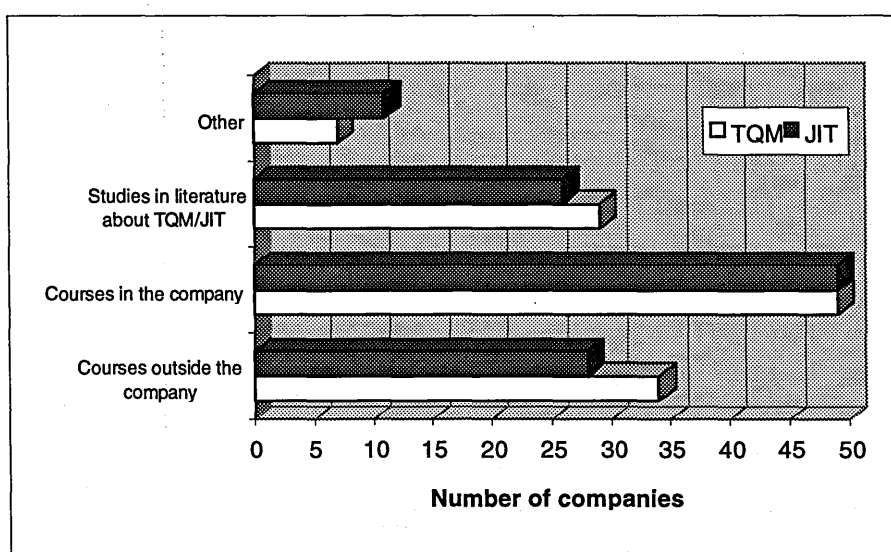
The average implementation time for a Total Quality Management programme was found to be approximately 18-24 months. For a Just-In-Time programme it was found to be approximately 12-18 months. This difference in the implementation time reflects the difference that exist between the two philosophies, in terms of the actions and initiatives that must undertaken, the cultural changes that should be taken place, the working attitudes that should be modified, and the business processes that should be improved. The implementation time of the TQM part of an integrated TQM&JIT joint model must last more than the JIT part, because it will lay the foundations for the new management style. Once the cultural changes that TQM brings have been established, JIT is ready to carry out the process improvements and the control improvements. Twenty five companies answered that their TQM programme lasted more than twenty four months, which is a significant amount of time. It takes time to change working attitudes of employees with many years of experience, but if that happens, there is fertile ground for the changes that Just-In-Time production system brings. TQM and JIT can perfectly work under the same framework, as long as the role of each system is clearly defined and patience is the main counsellor in every stage of this attempt.

### 5.2.11 Education and training on TQM and JIT principles (Quest. 16)

The cultural changes that are required for the proper implementation of both systems can be obtained only through an overall and systematic education and training on TQM and JIT principles. Table 5.21 and Fig. 5.9 presenting some of the education/training methods that are employed and the frequency of managers' responses.

|                                       | TQM | JIT |
|---------------------------------------|-----|-----|
| Courses outside the company           | 34  | 28  |
| Courses in the company                | 49  | 49  |
| Studies in literature about TQM / JIT | 29  | 26  |
| Other                                 | 7   | 11  |

**Table 5. 21: Education and training on TQM and JIT principles**



**Figure 5. 9: Education and training on TQM and JIT principles**

The use of the McNemar test suggests that there is not a statistically significant difference between TQM and JIT, regarding the education/training methods, to the 5% significance level. Table 5.22 contains the analytical results of the statistical analysis.

|                                       |                                   |
|---------------------------------------|-----------------------------------|
| Courses outside the company           | 0.1094 (2-Tailed P)<br>(Binomial) |
| Courses in the company                | 1.0000 (2-Tailed P)<br>(Binomial) |
| Studies in literature about TQM / JIT | 0.3750 (2-Tailed P)<br>(Binomial) |
| Other (Please indicate):              | 0.1250 (2-Tailed P)<br>(Binomial) |

**Table 5. 22: Results of the statistical analysis of Quest. 16**

Given the results of the analysis, it could be pointed out that:

### ***Conclusion 11***

The courses in the company is the commonest method for education and training on both TQM and JIT principles. The frequency of the responses is indicative: forty nine responses in the 'courses in the company' option for TQM, forty nine for JIT as well. The proportion is considered quite high, and it was surely a first good attempt to employ the Japanese management and working methods in the western industry. The leadership of the educational and training programme belonged to the managers of the company, especially the top ones. A more careful examination of the questionnaires showed that, companies with chief executives and top management committed to quality had more beneficial results from the joint implementation. Perhaps it was the chief executives and the top managers with their vision that led the employees through the difficulties of such a continuous improvement plan, and now these companies are well-known as quality companies. During the industrial visits for the Model evaluation, the author had the luck and the honour to meet some of those. What really impressed the author was their excellent knowledge of TQM and JIT principles, and their deep trust of them. The commitment of top management is the 'specific distinction' between a partial and a completely successful implementation. By the time that top management is getting the

concept of a joint TQM&JIT approach over to the employees, through the educational and training programme, the trust that top managers have is passed over to the employees as well. That is why the top management commitment to the programme is so important.

The frequency of the responses in the two other options was lower, but it indicates a trend for more scientific and professional approach to the education and training subject. Furthermore, companies utilised other practices to educate and train the workforce. The advice and help from consultants, and visits to other plants that already operated TQM and JIT systems were the commonest other approaches.

5.2.12 Information on TQM and JIT problems within the company (Quest. 17)

Within the companies the information on TQM and JIT problems is obtained by using some particular procedures. Five of them were investigated in the survey and the results are presented in the Table 5.23 and Fig. 5.10 below.

|                                  | TQM | JIT |
|----------------------------------|-----|-----|
| Suggestion system                | 24  | 15  |
| Formal meetings                  | 45  | 38  |
| Written reports                  | 38  | 27  |
| Informal collective discussion   | 40  | 40  |
| Informal face-to-face discussion | 46  | 43  |

Table 5. 23: Information on TQM and JIT problems within the company

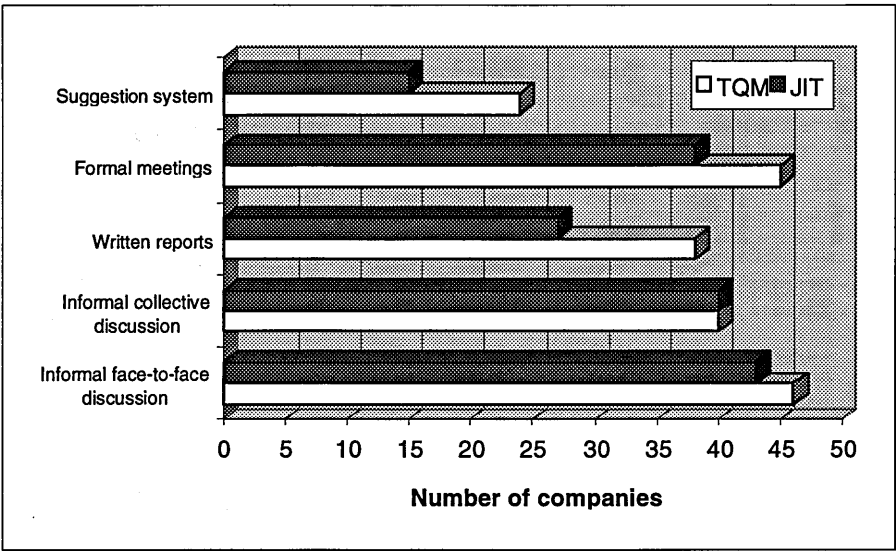


Figure 5. 10: Information on TQM and JIT problems within the company

The use of the McNemar test suggests that there is a statistically significant difference between TQM and JIT only in ‘Written reports’ (TQM 38 and JIT 27) and ‘Suggestion system’ (TQM 24 and JIT 15) options to the 5% significance level. Table 5.24 contains the analytical results of the statistical analysis.

|                                  |                                   |
|----------------------------------|-----------------------------------|
| Informal face-to-face discussion | 0.5078 (2-Tailed P)<br>(Binomial) |
| Informal collective discussion   | 1.0000 (2-Tailed P)<br>(Binomial) |
| Written reports                  | 0.0034 (2-Tailed P)<br>(Binomial) |
| Formal meetings                  | 0.0923 (2-Tailed P)<br>(Binomial) |
| Suggestion system                | 0.0117 (2-Tailed P)<br>(Binomial) |

**Table 5. 24: Results of the statistical analysis of Quest. 17**

Given the results of the analysis, it could be pointed out that:

### ***Conclusion 12***

The two practices with the higher response rates were the informal face-to-face discussion and the formal meetings respectively. This may look contradictory at the first glance, but the author believes that there is a rationale behind it. The informal information on TQM and JIT problems is working sufficiently, because of the personal contact and the short time that it takes. If the problem is not major, the solution may arise from the personal discussion and the interchange of ideas between employees or between employees and managers. The solution can be achieved quickly, without causing any problems or any delays to the process. If the problem is major, people from various departments and various levels are gathering, and they are not going until a solution is obtained. Brainstorming techniques, Pareto diagrams, cause and effect diagrams, weighting techniques, etc. are some of the tools commonly used. These formal meetings may have a name like 'Quality teams' or 'Quality improvement teams' and they are found in most of the plants. The importance of these meetings is great, because they are bringing many minds from different departments and with different specialisation

together, and so the solution to the problem is more accurate and more complete. Formal meetings or Quality improvement teams are also operating from companies that do not have a TQM framework. A typical example is Marks&Spencer.

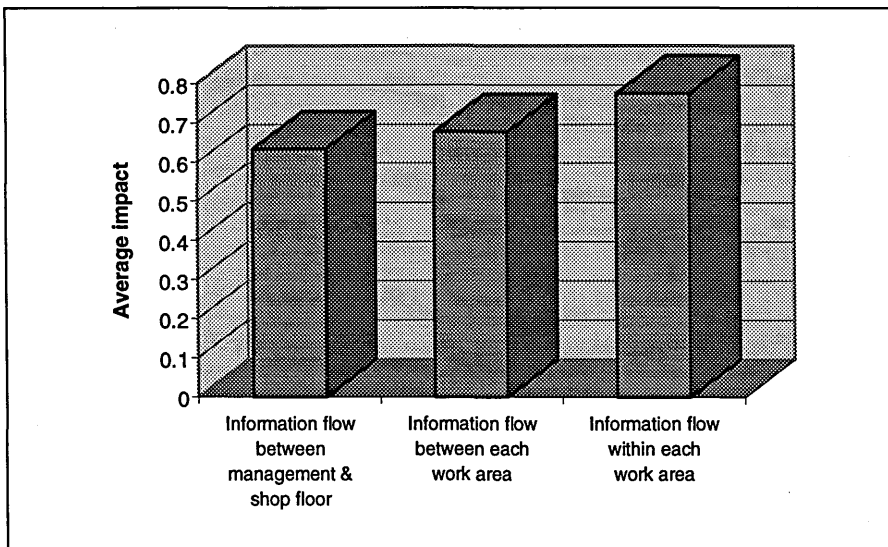
The written reports are mainly used for information on quality problems, because these reports often reach the top levels and they should be more official. Another method for obtaining information on TQM problems is a suggestion system, but it is not so widely spread. Also, informal collective discussion is a useful technique for detecting and analysing problems for both the systems.

### 5.2.13 JIT impact on the information flow (Quest. 18)

One of the areas that JIT has strong impact on is the flow of information within the company. The JIT implementation affected the route of information flow, and the opinion of the managers about that subject is presented in the Table 5.25 and Fig. 5.11.

|                                                     | POSITIVE | NONE | NEGATIVE |
|-----------------------------------------------------|----------|------|----------|
| Information flow between management & shop floor    | 41       | 16   | 3        |
| Information flow between each work area [e.g. cell] | 41       | 17   | 1        |
| Information flow within each work area [e.g. cell]  | 45       | 13   | 0        |

**Table 5. 25: JIT impact on the information flow**



**Figure 5. 11: JIT impact on the information flow**

The mean values for the above three options are 0.6333 for the first (information flow between management & shop floor), and 0.6779 and 0.7758 respectively for the other two. The use of the ANOVA test suggests that there is not a statistically significant

difference between the average impact of JIT on the three areas that were investigated to the 5% significance level. Table 5.26 contains the analytical results of the statistical analysis.

|                               | SS    | DF  | MS   | F    | Sig. of F |
|-------------------------------|-------|-----|------|------|-----------|
| Within+Residual               | 19.39 | 112 | 0.17 | -    | -         |
| Factor<br>(Benefits from JIT) | 0.61  | 2   | 0.30 | 1.76 | 0.177     |

**Table 5. 26: Results of the statistical analysis of Quest. 18**

Given the results of the analysis, it could be pointed out that:

### ***Conclusion 13***

The impact of Just-In-Time on the information flow is generally considered as positive. However, there were about fifteen companies that had not noticed a positive impact in any of the investigated areas. This is really surprising, particularly in the information flow within each work area, and may indicate that not all the companies have turned their shop-floor layout into cells. Cells are not indispensable for JIT, but they could be considered as very useful. One of the major advantages of the cell production is the very good information flow, because of the small amount of people occupied in and the better sequence of the operations within the cell area. The forty five positive responses concerning the 'information flow within each work area (e.g. cell)' is a good evidence of this view. Furthermore, in the information flow between each work area, and between management and shop-floor, the forty one out of sixty responses is considered a quite high proportion. The breakdown of the barriers between departments through the teamwork and the cell layout, and, moreover, the breakdown of the barriers between management and employees through the principles of the new TQM&JIT management model, were perhaps the two main reasons for the positive impact of JIT on the information flow. Although the signs were positive, there is a lot of work to be done towards this direction, in order to get even more beneficial results. Thirty per cent of the

companies who participated in the survey did not get benefits from JIT implementation in the above two areas, which means that the efforts need to be harder and continuous.

#### 5.2.14 Quality of the suppliers (Quest. 19)

The quality of the suppliers is one of the primary preconditions for a successful and trouble free JIT production. Some of the approaches that are followed for the checking of quality of the suppliers are presented in the Table 5.27 below. The frequency of the responses shows the trends that currently exist within the supplier-customer chain.

|                                                           |    |
|-----------------------------------------------------------|----|
| By lot inspection                                         | 36 |
| Analysing control charts from your suppliers              | 20 |
| Checking the process capability index from your suppliers | 26 |
| Checking is done in your production process               | 32 |
| Other                                                     | 18 |

**Table 5. 27: Quality of the suppliers**

The use of the Cochran's Q test suggests that there is a statistically significant difference between the ways that companies followed to check their suppliers to the 5% significance level. The use of repeated statistical tests showed that the statistically significant difference is mainly caused from the second (20 responses) and the last (18 responses) options. Table 5.28 contains the analytical results of the statistical analysis.

| Cases | Cochran Q | Significance |
|-------|-----------|--------------|
| 60    | 17.0435   | 0.0019       |

**Table 5. 28: Results of the statistical analysis of Quest. 19**

Given the results of the analysis, it could be pointed out that:

#### **Conclusion 14**

Quality raw materials means less raw materials; and less raw material means inventory reduction. The checking of the quality of the suppliers is an important procedure,

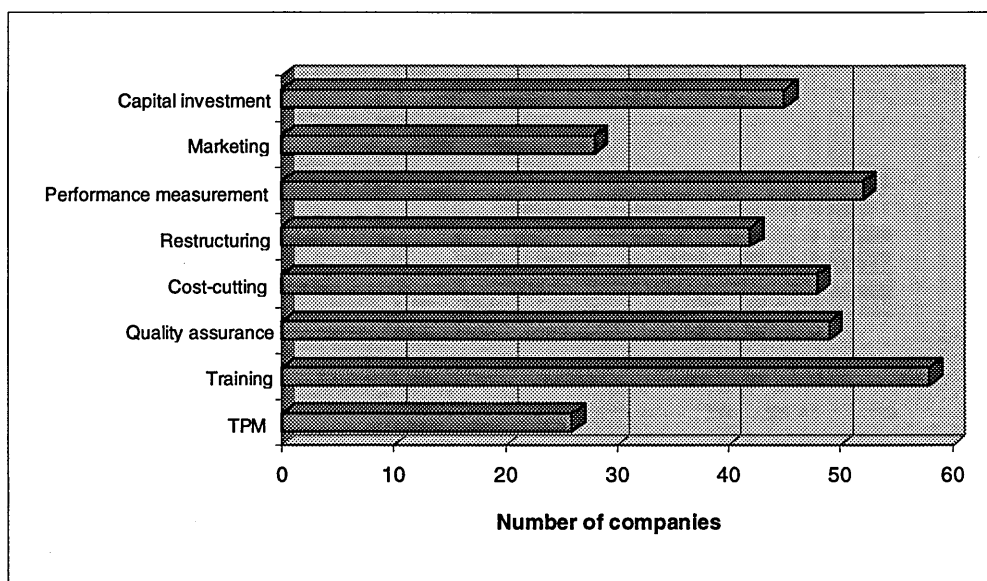
because it contributes to the improvement of the products and the processes. The lot inspection, as well as the checking in customer's process were the two commonest practices. What is really notable is the high percentage of other methods used for raw materials quality assurance. The statistical quality assurance (SQA) and visits to the sites of suppliers were some of the practices that customers employed. The relations between suppliers and customers is a very thorny subject in the manufacturing industry. The truth is that the quality of raw materials can help the implementation of a joint TQM&JIT programme, in terms of inventory reduction and improvement of product quality. Also, the systems can be more stable, and the time for process and control improvements shorter. Likely ideas to improve the quality of raw materials can be the ISO 9000 series or BS5750 certification of the suppliers, and, moreover, the establishment of continuous improvement programmes between the customer and the suppliers.

### 5.2.15 Initiatives that improve company performance (Quest. 20)

Finally, the managers were asked about the initiatives that were undertaken to improve the performance of their company. The frequency of the responses, shown in the Table 5.29 and Fig. 5.12, can give valuable information about the companies' approach to the concept of continuous business improvement. The low percentage at the Total Productive Maintenance option reveals that there are still some areas of the process that managers have not paid much attention to and may be can do that in the future.

|                              |    |
|------------------------------|----|
| Capital investment           | 45 |
| Marketing                    | 28 |
| Performance measurement      | 52 |
| Restructuring                | 42 |
| Cost-cutting                 | 48 |
| Quality assurance            | 49 |
| Training                     | 58 |
| Total Productive Maintenance | 26 |

**Table 5. 29: Initiatives that improve company performance**



**Figure 5. 12: Initiatives that improve company performance**

The use of the Cochran's Q test suggests that there is a statistically significant difference between the initiatives that are undertaken to the 5% significance level. The use of repeated statistical tests showed that four of the options can be treated as a group, because they do not produce statistically significant difference to the 5% significance level. The four options are: the first (capital investment), the third (performance measurement), the fifth (cost-cutting), and the sixth (quality assurance). This observation may help drawing more accurate conclusions. Table 5.30 contains the analytical results of the statistical analysis.

| Cases | Cochran Q | Significance |
|-------|-----------|--------------|
| 60    | 89.6812   | 0.0000       |

**Table 5. 30: Results of the statistical analysis of Quest. 20**

Given the results of the analysis, it could be pointed out that:

### **Conclusion 15**

The continuous training of employees was the initiative with the highest frequency of the responses (fifty eight out of sixty). This means that companies had realised the importance of training for the success of a continuous improvement programme and worked on it. Performance measurements, quality assurance, cost-cutting, and capital investment were initiatives with approximately equivalent proportions. Quality assurance and cost-cutting are two of the principal targets of a joint programme, while the capital investment could contain the training expenses, new machines, consultancy, new personnel, etc. necessary for the continuous improvement of the business. The performance measures are the means of estimating the success of such a programme, and it is very important to choose the appropriate ones.

What was really surprising was the very low percentage of Total Productive Maintenance (TPM), actually the lowest of all. TPM is productive maintenance carried

out by all employees through small group activities, and more specific is the equipment maintenance performed on a companywide basis [Nakajima, 1988]. Perhaps TPM is not an initiative that can solely improve the performance of an organisation, but it can help to improve many areas of the process. Improvement of labour productivity, reduction of breakdowns, reduction of defects in process, reduction in maintenance costs, zero accidents and zero pollution are only some of the production parameters that can be improved. Prevention is better than cure, and, in terms of maintenance, TPM is also cheaper than total productive 'cure'. It is a challenge of the future for the British manufacturing companies to operate TPM, because that is how they can implement the concepts of total quality control and total employee involvement in the maintenance area.

### **5.3 A Summary of the Conclusions**

Summarising the conclusions that were drawn above, it could be pointed out that:

- TQM has a higher importance in terms of company strategy than JIT. Just-In-Time is a management philosophy very useful for the manufacturing organisations, but it does not have the companywideness of Total Quality Management.
- The manufacturers implement TQM because they want to improve the overall quality of their products. On the other hand, they operate JIT because they want to improve the efficiency and the effectiveness of the process, and to reduce the production costs.
- The TQM goals are mostly determined by the top management of an organisation.
- Most companies of the survey had established practices for the assurance of quality (i.e. quality policy, written documentation of quality procedures, etc.)
- The inventory turnover was the area that JIT implementation had the most positive impact on.
- The joint TQM and JIT implementation had a positive impact on the workforce performance. The teamwork had a great improvement, while the job satisfaction, the labour utilisation, and the worker motivation were also well-improved.
- The reduction of total manufacturing costs, the reduction of throughput time, and the reduction of batch size were the principal benefits from the JIT implementation (always under the operation of a joint TQM and JIT framework).
- The implementation time of the TQM part of an integrated joint TQM&JIT model must last more than the JIT part, because it will lay the foundations for the new management style. Once the cultural changes that TQM brings have been established, JIT is ready to carry out the process improvements and the control improvements.

The leadership of the educational and training programmes belonged to the managers of the company, especially the top ones. A more careful examination of the questionnaires showed that, companies with chief executives and top management committed to quality had more beneficial results from the joint implementation.

The informal information on TQM and JIT problems is working sufficiently in manufacturing industry, because of the personal contact and the short time that it

takes. If the problem is not major, the solution may arise from the personal discussion and the interchange of ideas between employees or between employees and managers.

- The lot inspection and the checking in customer's process were the two commonest practices for the assurance of the quality of the suppliers.
- The continuous training of employees was the initiative that almost all the companies undertook to improve their performance. It seems that manufacturing organisations had realised the importance of training for the success of a continuous improvement programme and worked on it.

## **CHAPTER SIX**

### ***DEVELOPMENT OF A JOINT TQM&JIT IMPLEMENTATION MODEL***

## **DEVELOPMENT OF A JOINT TQM&JIT IMPLEMENTATION MODEL**

### **6.1 Introduction**

In order to develop a TQM&JIT joint implementation plan, which was the prime objective of this study, two procedures were necessary: first, the development of the theoretical background on which the Model will be based, and, second, the development of the network of the activities that Model will follow. The development of the theoretical background for a joint TQM&JIT approach was detailed in the literature review in Chapter 2. The development of the network of the activities was mainly based on the industrial survey.

The data gathered from the industrial survey was the single source of this study concerning the industrial implementation of TQM and JIT. The analysis of the data was intended to utilise the information on TQM and JIT given from the industrial research, and to evaluate the important factors for a successful joint implementation plan. These factors are contained in the conclusions that have been drawn from the analysis in Chapter 5. The analysis of the results and the consideration of the conclusions from the literature review, assisted the Model development to be more accurate and more detailed. In the following sections there is a thorough description of the Joint TQM&JIT Implementation Model.

### **6.2 The need and the rationale for a joint TQM&JIT model**

As it was described in the first chapter, the initial question of this study was to find out a way to reduce the production costs and, at the same time, to improve the quality of the product. This is a problem that many manufacturing organisations have faced nowadays, because of the immense offer of products and the relatively low demand. The joint

implementation of a TQM and JIT programme seemed ideal, because TQM would assure the quality of products and processes, whilst JIT would improve the production process and reduce the production costs. The literature review and the industrial survey showed that there is a very close link between TQM and JIT; what was missing was a detailed implementation plan. The industrial survey showed that some attempts for improvement had not completely succeeded, because of the lack of clear implementation targets. There were cases where the TQM&JIT joint implementation had negative instead of positive results in some production areas.

The TQM&JIT Model tries to satisfy the *musts* and the *wants* of every manufacturing organisation which wishes to be competitive and world-class in the contemporary demanding markets, using the quality of the products and the low manufacturing cost as weapons. Furthermore, the Model details the sequence of the activities that should be followed in order to get completely beneficial results. It determines the production areas that should be improved, but also determines the role of everyone within the company towards that objective. The flowchart that presents the network of the activities is very simple and very clear, and this is perhaps the major advantage of the TQM&JIT Model (Appendix B). A series of performance measures for each step of the Model has also been developed (Appendix C), in order to ensure the completion of each implementation stage.

### **6.3 The Joint TQM&JIT Implementation Model**

The Joint TQM&JIT Implementation Model is a seven-step approach to improve the quality of products and processes and to reduce the production costs. This is achieved through the achievement of three subgoals: (1) reduction of inventory, (2) reduction of excess labour-hours, and (3) total quality control.

In order to have an inventory reduction, an organisation must change the process from push into a pull system (the responses of Questions 7, 11 and 14, and the Conclusions 2,

6 and 9 contain some useful information regarding this statement). Only the right quantity of products, in the right time should be produced. A flexible production output system, Kanban and production levelling techniques, and quality assurance of the products are the prerequisites for the inventory reduction [Monden, 1993]. Furthermore, the use of Kanban and production levelling requires short lead times [Hay, 1988]. This could be achieved via small lot production or with one piece flow production or both, depending on the type of the process. The reduction of setup and changeover times, and the good condition of machines and tools through a total productive maintenance (TPM) programme could be very helpful to the proper flow of the process (this could be identified from the responses of Question 14 and the Conclusion 9). The establishment of standard operations can also have a positive contribution to achieve one-piece production and to shorten the lead times [Monden, 1993], [Hay, 1988].

The reduction of excess labour-hours could be achieved with the establishment of flexible work assignments for the employees. This means transfer of employees from one line to another or from one process to another, depending on the work load [Harrison, 1992]. However, this may require multi-skilled employees from various departments, a rearrangement of equipment layout, in order to have better access to the process activities, and the establishment of standard operations, as it was described above. All the changes in process that have mentioned and analysed could not happen without the required education and training on TQM and JIT principles (this could be identified from the responses of Question 20 and the Conclusion 15). Practices like the 5 S (organisation, neatness, cleaning, standardisation, discipline), and the breakdown of the barriers between departments could be implemented only after the cultural changes that the educational programme brings (the beneficial results of the cultural changes could be seen at the responses of Question 13 and the Conclusion 8) [Deming, 1986].

The third subgoal is the total quality control of products and processes. It is the principal issue of the TQM implementation and a precondition of success of the JIT [Monden, 1993], [Hay, 1988], [Oakland, 1995], [Harrison, 1992]. It requires many cultural and attitude changes, and a lot of effort and support on the part of management (this could

be identified from the responses of Questions 6, 8, and 10, and the Conclusions 1, 3, and 5). Through education and training the employee should learn to work smarter, which means to understand what exactly they are doing and why [Deming, 1986]. This may lead them to invent new and more simple practices to do the job, increasing at the same time their productivity. The involvement in the audit of quality and the participation in quality control circles increases the employee contribution to the quality assurance matter, but also increases the job satisfaction and the job motivation which are very important for the new management model (this could be identified from the responses of Questions 10 and 13, and the Conclusions 6 and 9). The establishment of employee quality assurance standards, like 'Zero Defects', could be beneficial, because it will place a common performance measure for all the employees [Juran, 1988]. The cautious use of such a measure is essential, otherwise it could have undesirable results (discouragement, low morale, unsatisfied personal targets, etc.). Another tool that could help the quality assurance of the products is the statistical quality control (SQC) (this could be identified from the responses of Question 19 and the Conclusion 14) [Munro-Faure, 1992]. SQC may indicate the improvement-conformity of the product quality, but it can also be an index of the success of the joint approach (this could also be identified from the responses of Question 20 and the Conclusion 15).

Two indispensable parameters to the success of the joint TQM&JIT implementation model are the support and commitment of the management (in particular, of the top management) (the responses of the Questions 6, 8, 9, and 10, and the Conclusions 1, 3, 4, and 5 could verify that), and the performance measurements after every step and before proceeding to the next one (this could be identified from the responses of Question 20 and the Conclusion 15). Top management's commitment is the main cause of a complete success, a partial success, or no success [Deming, 1986], [Oakland, 1995]. Although it is very important, sometimes it is overlooked. Quality at the top brings quality throughout the organisation, it brings quality to the products, but it also brings quality in the way of thinking (this could also be identified from the responses of Questions 7 and 12, and the Conclusions 2 and 7) [Deming, 1986].

## **6.4 The seven steps of the Joint TQM&JIT Model**

Every step consists of activities that attempt to improve a particular production area. The completion of every step is a precondition for proceeding to the next one. A description of the targets of each step, and the activities and procedures that are employed to achieve them are presented below, whilst the performance measures for each step of the Model are presented in Appendix D.

### **STEP I**

#### *Definition and commitment on quality*

In this first step, it is necessary to define quality according to customer requirements. It should be clear that, quality is a relative concept and it depends on what a customer really wants. Depending on the products, quality is considered as reliability, as functionality, as durability, as appearance, or all the above together. A company must be able to understand customer needs and produce only according to those requirements.

Top management's commitment on quality is the next action that should be undertaken. Top management must have a clear vision about the objectives and the targets of the joint implementation, because a lack of understanding could have negative results. Also, top management should be well informed about the techniques and the methods that both philosophies use to improve quality and productivity and to reduce the manufacturing costs. Perhaps some seminars and visits to other plants would be useful.

### **STEP II**

#### *Cultural changes: implementation of TQM&JIT principles in employee way of working*

The second step of the joint implementation plan is perhaps the most critical for the success of the programme. The cultural changes that should happen are many and difficult to achieve, because the working attributes and practices cannot change

overnight. The education and training of employees via small groups and pilot programmes is a good start. Employee involvement in the audit of quality, modification in the way of working (smarter, not harder), quality control circles, multi-skills training, 5 S, breakdown of the barriers between departments, as well as implementation of a certification system (ISO 9000 series), are some of the initiatives that the educational programme could implement.

### **STEP III**

#### *Workforce flexibility and quality performance*

The improvements in workforce flexibility and quality performance come after the completion of the education and training programme and the assimilation of TQM&JIT principles from employees. The establishment of employees performance standards (zero defects), the establishment of standard operations, and the optimisation of equipment layout are the actions that should be undertaken in the first phase, while the establishment of flexible work assignments should follow. The standard operations include the standardisation of all operations that each employee must perform, in order to operate a series of activities within the cycle time. Cycle time is defined as the amount of time needed to produce each product, to meet the required daily output.

### **STEP IV**

#### *Production maintenance and equipment flexibility*

The foundations of total productive maintenance (TPM) are laid in the new employee culture of the new management model. Each employee is responsible for the good operation of the machines and the tools that they are working with, and so they are responsible for their maintenance as well. A successful TPM programme could be the first stage of the reduction of changeover times, because it could ensure the reliability of the machines. The increase of external changeover time and the decrease of the internal

one could be another initiative that reduces the total changeover times. The external changeover operations are the ones that could happen while the machine is working. The internal changeover operations require the machine to be stopped. If the appropriate activities are undertaken while the machine is in operation, the internal changeover time will be reduced, and the reduction in the total changeover time would be significant.

## **STEP V**

### *Process capability and schedule adherence*

The capability to produce the products in small lots or by using one-piece flow, depending of the type of the process, greatly helps to shorten the process lead time. Perhaps the most important benefit of smaller and smaller lot sizes is that it lay the groundwork for level-by-level balance and flow, by producing every product as smoothly and predictably as possible. Just-In-Time production relies on small lot production and short lead times, but it also relies on the quality of the products that should have been assured with the quality initiatives. Given the improvement of these production parameters, the improvement on schedule adherence would be noticeable.

## **STEP VI**

### *Quality assurance, flexibility of production output system, and total quality control*

Once the process improvements have taken place in the previous steps, it is time for control improvements. Production levelling could help to increase the efficiency of the systems and to reduce the inventory, by smoothing the peaks and the valleys of the production process. Statistical quality control (SQC) is used to measure the conformity of the products according to customer requirements, and it can contribute to the quality assurance. In order to be firm and effective, a Kanban system requires, high quality of the products moving within the process, and production levelling according to customer orders. In extreme, if one product is required every day, one product should be

produced. The good operation of the Kanban system and the high level of quality assurance may lead to a flexible production output system and to total quality control.

## **STEP VII**

### *Reduction of inventory and excess labour-hours*

A flexible and quality output system indicates low level in work-in-process (WIP) and finished goods inventory. This means that an inventory reduction has been achieved. The flexible work assignments (Step III), in relation to reduction of the rework levels, reduction of WIP, and improvement of product quality, could lead to the reduction of excess labour-hours. Once the targets for total quality control, inventory reduction, and excess labour-hours reduction have been achieved, the process should run better, the production costs should be reduced and the product quality should be improved. This means that the joint TQM&JIT implementation approach has finished and the prime objective for process improvement has been achieved. TQM and JIT are continuous improvement systems, so the end of an implementation programme denotes the beginning of a new one.

A condensed flowchart of the Joint TQM&JIT Implementation Model, which includes the step by step, and the activity by activity implementation approach, is presented in Fig. 6.1 in the next page. The full size flowchart of the Model is contained in Appendix B.

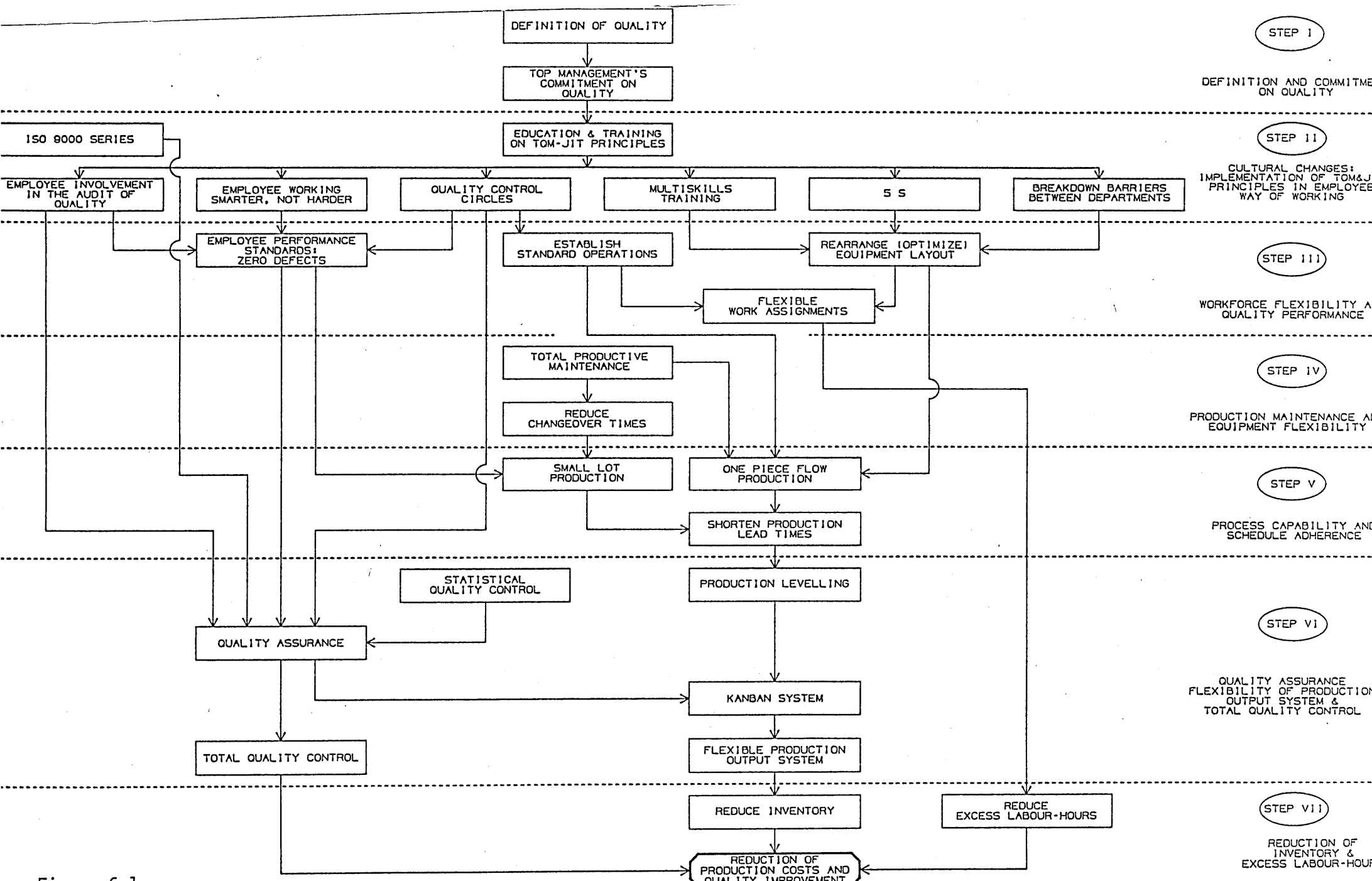


Figure 6.1  
THE TOM & JIT JOINT IMPLEMENTATION MODEL

## **CHAPTER SEVEN**

### ***THE TQM&JIT MODEL EVALUATION***

## **THE TQM&JIT MODEL EVALUATION**

### **7.1 Introduction**

The development of the Joint TQM&JIT Model was based on: (1) the data gathered from the survey, and (2) a literature search on the methodology that should be followed in order to link TQM and JIT under a joint framework. The activities and the initiatives that the Model employs, are currently operating in many manufacturing organisations. In the TQM&JIT Model, they are operating under the same joint context, trying to achieve an improvement of business performance. Emphasis was placed on the Model to be as simple and as clear as possible. The achievement of these objectives will be investigated with the evaluation of the Model. This chapter describes the TQM&JIT Model evaluation in six manufacturing companies.

### **7.2 Selection of the companies for the evaluation**

Six companies were selected for the evaluation, with different profile, different products, and different level of implementation success. The author visited the six plants and spent four to five hours in each one, discussing with the managers the Model applicability, and observing many of the things that the Model proposes working in practice. A series of questions was developed, regarding every step and every activity of the Model, and the production area that it tries to improve (the series of questions is included in Appendix D). Managers were called upon to answer these questions, according to their own experience and the implementation of both philosophies at their plants. The interchange of ideas and opinions, as well as the close observation of TQM and JIT in operation were invaluable, both for the author's experience and the Model's accuracy. Some details during the Model development were not taken into account, and the industrial visits helped their significance to be revealed. The knowledge that was obtained from the industrial visits, and their contribution to the Model improvement, are presented in the following sections.

### **7.3 The TQM&JIT Model evaluation**

The results of the evaluation and the recommendations of the managers are described in the following paragraphs. The Joint TQM&JIT Implementation Model was developed in seven steps in Chapter 6. The same procedure was kept at the last stage of the research, evaluating the accuracy and the applicability of each step of the Model.

#### **7.3.1 MAGNETI MARELLI LIGHTING**

The first industrial visit was at MAGNETI MARELLI LIGHTING, a company that manufactures lights for cars. MAGNETI MARELLI LIGHTING mainly supplies Toyota and Rover in U.K, and companies like Chrysler and Cadillac in the U.S.

##### **STEP I**

###### *Definition and commitment on quality*

The definition of quality, according to MAGNETI MARELLI, is to meet and exceed the customer requirements. The definition of the Model is approximately the same (to meet the requirements of every single customer).

Top management had very clear targets about quality, the defects parts per million (PPM). For example, 20 PPM means that there should be no more than twenty defective products in one million products that are manufactured. The assimilation of such clear targets (as the parts per million or something equivalent) could make the commitment of top management on the quality concept easier. The TQM&JIT Model has gained a means to determine the commitment of top management on quality.

##### **STEP II**

###### *Cultural changes: implementation of TQM&JIT principles in employee way of working*

MAGNETI MARELLI currently operates ISO 9001, and QS 9000, which is the quality certification system launched by Ford, General Motors, and Chrysler. The Model proposes an ISO 9000 series certification.

They employed a top-to-bottom education and training programme, started from top management and moving downwards. This is something that the TQM&JIT Model did not pay attention to.

They have quality improvement teams, consisting of 10 people each, while multiskilled teams are employed for new products or for specific problems. Each employee has been trained to participate in the audit of quality at the cells, and a *poka-yoke* (fool-proof) system is employed in the final assembly. MAGNETI MARELLI employs the 5 S (organisation, neatness, cleaning, standardisation, discipline), with special attention to the managers discipline. Also, they measure employee performance using the ratio of products made per hours on the clock. Feedback with face-to-face discussions, lead times, stock levels, and parts per person per hour, are some other measures that used to indicate the assimilation of TQM and JIT principles by employees. All the activities that the Model proposes in the second step of the cultural changes were included in the implementation plan of MAGNETI MARELLI. The Model has gained more details for each one of the activities that should be undertaken.

### **STEP III**

#### *Workforce flexibility and quality performance*

MAGNETI MARELLI utilises standard operations in the assembly department, while they have rearranged the equipment layout to fit in the needs of the joint programme. The Model requirements are satisfied in this third step of the joint implementation approach.

### **STEP IV**

#### *Production maintenance and equipment flexibility*

MAGNETI MARELLI does not operate a complete TPM programme, as the Model proposes. However, they managed a remarkable reduction in the breakdowns and the downtime hours, while the changeover times in the moulding machines are today the lowest in Europe (4.28 min).

## **STEP V**

### *Process capability and schedule adherence*

The reduction of batch-size by 80%, and the reduction of lead time by 50% could be a good sign about the effectiveness of the initiatives that were undertaken in the previous stages. The transfer of the industrial results to the Model implementation plan may indicate that, the cultural changes and the process improvements that Model proposes are applicable, and could yield beneficial results. The factory manager made a suggestion regarding the schedule adherence of the Model, to be as frequent as the customer wants. In the extreme, if the customer requirements are changing every day, the schedule it should be capable of meeting them on time. MAGNETI MARELLI LIGHTING supplies Toyota plant at Derby every two hours.

## **STEP VI**

### *Quality assurance, flexibility of production output system, and total quality control*

MAGNETI MARELLI operates production levelling and Kanban systems, as the Model also proposes. They measure the quality of the products using customer PPM, assembly rejects, and individual measurements. The performance measures for the TQM&JIT Model are approximately the same.

The Statistical Process Control is a useful tool for the checking of the rejected items in the final inspection, and it is equivalent to the Statistical Quality Control that Model employs.

## **STEP VII**

### *Reduction of inventory and excess labour-hours*

The inventory reduction, through the implementation of a joint TQM&JIT programme, was 50%, while the excess labour-hours reduction was 40%. These numbers are coming from an industrial implemented plan, but they could be typical for the TQM&JIT Model as well. The joint implementation has built up a more effective and more efficient process, and the numbers of produced parts per hour at MAGNETI MARELLI plant can

prove that. The performance measures of the joint TQM&JIT Model could also help towards this direction.

Furthermore, there was a great reduction in the warehousing costs, which used to be £850,000 per year in the past, and today have been eliminated (there is stock only within the plant). This may indicate that a joint implementation of TQM and JIT, like the one that Model proposes, could be beneficial, as long as the people in the company are committed on that.

More recommendations from the Factory manager, concerning the Joint TQM&JIT Implementation Model, are:

- It should be clear that TQM and JIT implementation will start separately. Employees should learn how to work under the new management model and the new working conditions (TQM-cultural changes), while JIT is more tangible and should prompt employees to implement what they have learned in their work.
- Quality comes out from the standardisation and the intensive labour.
- Creating stress in the manufacturing system makes a problem evident much more quickly.

### **7.3.2 DUTTON ENGINEERING**

The second industrial visit was at DUTTON ENGINEERING, a company that manufactures metal box covers. DUTTON ENGINEERING is the third most visited company in U.K., and it is well-known for the excellent implementation of a joint TQM and JIT programme.

#### **STEP I**

##### *Definition and commitment on quality*

The definition of quality, according to DUTTON ENGINEERING, is to achieve business excellence. Quality is a matter that should be well-defined across the whole customers-suppliers-employees. 'Top management is much committed to quality, because it is one of the vital parts for the success of TQM and JIT', according to business manager. Inventory reduction and customer focus are two of the prime targets of top management at DUTTON, while there is also the pioneer target of 'fun at work'. In DUTTON they want the employees satisfied from their job and they are doing the best to achieve that. The definition of quality and the top management's commitment on that are much broader in DUTTON than in TQM&JIT Model. Initiatives-statements, like definition and commitment on quality, which were much theoretical at the TQM&JIT Model, are now clearer and more practical.

#### **STEP II**

##### *Cultural changes: implementation of TQM&JIT principles in employee way of working*

The education and training of employees started with videos and seminars about the new principles, and it was continued with a LEGO 'simulation' game in an effort to understand what the new philosophies were bringing about. Visits to other companies that had already implemented TQM and JIT, as well as the step by step implementation of the new techniques in jobs, helped the employees to improve their own performance. The management's role in all that effort was guidance, support, and freedom to employees. In DUTTON, they operated cross-function training very simply; the employees trained each other. There was a 'championship', and the employee who learnt to perform the most operations was the champion. Today, they have three multi-function

teams, and each team is working for a specific customer and on a specific product (in cells). Employees have a self-inspection system, and corrective actions are taken only if a whole batch or an entire order goes wrong. They do not employ quality control circles or the 5 S, although they intend to do so. In DUTTON, they measure the performance of employees with the achievement of the personal and company targets. They operate a becoming popular working system which is called 'annual hours'. According to this, all employees must work the same hours in a year, something around 980 hours. If an employee has worked less than the others in a year, they can transfer the remaining hours for the next year. If one has worked more than 980 hours in a year, they can work less hours next year. All the employees are getting the same money every year. As it was described above, not all the actions that the Model proposes are employed from DUTTON. The great benefit for the Model is the many different practices that could be followed, in order to implement the proposed initiatives. The TQM&JIT Model has gained more details for each one of the activities that should be undertaken.

### **STEP III**

#### *Workforce flexibility and quality performance*

DUTTON does not employ standard operations, one of the initiatives that Model proposes. They have rearranged the equipment layout several times, and each time it has occupied less space.

### **STEP IV**

#### *Production maintenance and equipment flexibility*

DUTTON does not employ a TPM programme, as the Model proposes. They have few machine breakdowns per year because they do not load the machines, they load the people. However, the reduction on the changeover times was very high, about 75%.

### **STEP V**

#### *Process capability and schedule adherence*

The reduction of the batch-size was 87.5% for the repeated manufacturing products, and 5% for the other ones. Also, the reduction on lead times was impressive; from 6-8

weeks to 1 day for repeated manufacturing products, and from 6-8 weeks to 2-3 weeks for non repeated. The implementation of a joint TQM and JIT programme in DUTTON had impressive results in many of the important production parameters. The TQM&JIT Model should include many of the details that were observed in its own implementation approach.

## **STEP VI**

*Quality assurance, flexibility of production output system, and total quality control*

DUTTON operates production levelling and Kanban system, as the Model proposes. They have an ISO 9002 certification, but they do not have statistical quality control.

The implementation of a joint TQM&JIT programme improved the quality of the products, because the employees were getting closer to customer requirements. Quality is a different concept for every customer (i.e. some want good polishing, others good packaging, etc.), and TQM and JIT helped employee not only to satisfy, but to delight their customers. The broad definition of the quality concept in DUTTON contributed very positively to the TQM&JIT Model definition.

## **STEP VII**

*Reduction of inventory and excess labour-hours*

The inventory reduction was about 70%, the reduction of excess labour hours 20%, and the reduction on manufacturing costs was 10%. They frequently measure the performance of the process, and they have a good series of performance measures (i.e. direct and indirect added value time, the WIP, working according to schedule, etc.). 'The key for the success of the performance measures is to be adjusted to the workforce', according to the business manager. This is a very good advice for the performance measures that support the TQM&JIT Model.

The joint approach helped the company to improve customer satisfaction and to get better and bigger contracts. Customer satisfaction is measured with frequent customer

surveys, which are conducted at every level of the customer's organisation, from the CEO to the operators.

As a general evaluation of the Joint TQM&JIT Implementation Model, the business manager of DUTTON ENGINEERING declared:

'I find your research and conclusions very interesting, and I feel that your model is a very good 'journey plan'. We would like to display your model in our training room, as we believe that it will give to our visitors an insight into how and where to start their own quality journey, what to do first, and so on'. The Model is now on display at DUTTON.

### **7.3.3 TROX (U.K) Ltd.**

Another industrial visit was at TROX (U.K) Ltd., a company that manufactures components for ventilation and air conditioning plants. TROX was the only company of the Model evaluation that the series of question was not followed. The discussion with the Quality Assurance manager enlarged upon many subjects of the Model applicability, and the formal completion of the questionnaire seemed non-practical.

TROX started operating a business improvement programme, in which was included a joint TQM and JIT implementation. The originator of the programme was the new CEO (he has changed in the recent years), who has experience in such initiatives. They started the improvement programme, because they faced problems in terms of meeting customer requirements and deliver on time (lead times). The new CEO extended the current Quality Policy, by putting new principles and new concepts that should be employed, in order to make the company competitive again. The CEO spread his vision to the top managers, and they jointly determined the new policy of the company. The top management is now committed to quality, it is committed to meet customer requirements, and it is committed to do it on time. All the above initiatives seem to confirm the important role of top management commitment to quality that TQM&JIT Model proposes.

The first thing that TROX changed was the order process. In the past, the sales department was the only responsible for the orders they were coming in. The salesmen promised everything that customer wanted, without considering if this is feasible. Now, the order must be also approved from the product manager of the department involved, in order to ensure that the customer requirements could be met within the right time. This is something that Model did not take into account.

Moreover, TROX rearranged the shop-floor layout into cells. Although it was quite early to estimate the results of this initiative, the first signs were quite positive. The Model proposal for rearrangement (optimisation) of the equipment layout seem to be confirmed.

The quality assurance programme was 90 per cent effective, because they investigated the quality of products after the completion of the whole process and for a whole batch, and not after every single process and for every single part. The author suggested to the manager the investigation of the product quality after the completion of each process, so only quality products continue in the next processes. This means less working and reworking time, better products at the end, and schedule adherence according to the order due date. This procedure was used only for some sophisticated products, but now it will expand everywhere in the process. The author's suggestions are coming from the Model proposals about the employee involvement in the audit of quality and the 'Zero Defects' as employee performance standards.

The rearrangement of shop-floor layout into cells requested multi-skill employees. The teamwork between the employees of each cell, but also between cells helped the breakdown of the barriers between departments and the improvement of employee performance. This confirms what Model proposes; before starting the rearrangement of the equipment or shop-floor layout, it should have finished the multiskills training of employees. However, it also indicates that the breakdown of the barriers is not only an objective of the educational programme; the struggle for teamwork is continuous and it takes place in various levels.

In the past, there was a bonus system for the employees, if company managed to achieve the production or turnover targets. This system did not work effectively, because the employees paid attention only in the number of the products that they produced and not in the quality. According to TQM&JIT Model, employee should learn to work smarter and not harder. This fact, in combination with the employee involvement in the audit of quality and the quality control circles, could contribute to the improvement of quality assurance. The bonus system caused at TROX increased the number of warranty claims and customer complaints. Now, there is no bonus system, but the wages are better.

TROX includes all the changes in the process into a combined medium-term and long term continuous improvement programme that they implement. The reduction of

inventory by 30%, the reduction of warranty claims by 50%, the increase of cross margin, etc. are only some of the business objectives that TROX has. The implementation of a complete Total Productive Maintenance (TPM) programme, a new series of performance measures, the visual production control, and the ISO 9001 certification (they currently have 9002), which includes also the design, were some of the initiatives that TROX will employ in order to achieve its objectives. A joint TQM and JIT programme is currently implemented, but the company has not gained all the benefits yet. Many of the targets that TROX has are identical to the ones of the TQM&JIT Model. This may indicate that the applicability of the Model is quite high, because a manufacturing company follows approximately the same route to solve many of the process and quality problems.

Some more recommendations of the Quality Assurance manager, concerning the Joint TQM&JIT Implementation Model, are the following:

- The definition of quality according to customer requirements should be after the top management's commitment on quality. This is the sequence that TROX followed and the result was positive.
- The ISO 9000 series certification should be closer to the production process, and it should not have so companywide role. In terms of the flowchart, it should be in one of the lower levels.
- More attention should be paid to teamwork improvement, because teamwork could breakdown the barriers between departments. The barriers that exist between the departments are one of the major enemies of the new management model.
- It was pointed out that 'Zero Defects' could have negative results in the effort for improvement of employee performance (discouragement, low morale, unsatisfied personal targets, etc.).

### **7.3.4 OXFORD AUTOMOTIVE COMPONENTS (UNIPART INDUSTRIES)**

OXFORD AUTOMOTIVE COMPONENTS (OAC) is a company of Unipart Industries. It designs and manufactures steel fuel tank systems, pressed components, high performance air coolers, and produces exhaust components and exhaust systems. Customers of OAC include Rover, Honda, IBC Bedford, Leyland DAF Vans and Jaguar/Ford.

#### **STEP I**

##### *Definition and commitment on quality*

The definition of quality, according to OAC, is to be a first class partner for the automotive manufacturing industry, committed to continuous improvement. A total approach of the business and long-term profitable relationships are also included in the above statement. The OAC definition of quality is different from the Model's one. The Model defines quality as 'meeting the exact requirements of the customer'.

The top management is committed to quality, in terms of providing good guiding strategy. The Model requires guidance and leadership from top management, but sometimes it is more effective to have clearer targets.

#### **STEP II**

##### *Cultural changes: implementation of TQM&JIT principles in employee way of working*

The training of employees on TQM and JIT principles is part of an established programme of the company, called Unipart U (stands for University). This programme includes TQM and JIT, Kaizen (continuous improvement), environmental issues, etc. It lasts 10 days per year, and it is conducted every year. They do not employ quality control teams, as the Model proposes, but they have circles for improvement of quality and productivity. Employees participate in the audit of quality, as the Model proposes, but they have also a feedback system; if three scrap parts are manufactured, the line stops. They employ 5 S, but not as good as they could do. The performance of employees is measured in four different areas: (1) Productivity: parts per man hour, (2) Quality: scrap rates, (3) Attendance: absenteeism, and (4) Contribution to Improvement: participation

in two circles per year. All these four measures, and some more, are included to the ones that the TQM&JIT Model proposes for the second step of implementation. OAC has an ISO 9001 certification, as the Model proposes.

### **STEP III**

#### *Workforce flexibility and quality performance*

OAC employs standard operations, but they are in the early stages. There was a rearrangement (optimisation) of equipment particularly in assembly areas, in order to fit new business in the plant. The Model requirements are satisfied in this step, but not in the maximum rate.

### **STEP IV**

#### *Production maintenance and equipment flexibility*

OAC employs TPM, but they are in the level one. The downtime hours due to breakdowns are considered relatively low, between 3% - 8%, depending on the machine. The reduction of the changeover times in the press shop was 75%, from 40min to 10min.

### **STEP V**

#### *Process capability and schedule adherence*

The reduction of batch-size by 85%, and the reduction of lead time by 70% could be a good sign about the effectiveness of the initiatives that were undertaken in the previous stages. The transfer of the industrial results to the Model implementation plan may indicate that, the cultural changes and the process improvements that Model proposes are applicable, and could yield beneficial results. One piece flow is operated in the moulding, and flow line in the assembly. The Model requirements are fully satisfied.

### **STEP VI**

#### *Quality assurance, flexibility of production output system, and total quality control*

OAC successfully operates production levelling and Kanban systems in the production process, as the TQM&JIT Model proposes. The measurement of the product quality is conducted with three different ways: Finish products to order products, feedback from

the customer, and with defect parts per million. They employ SQC, as the Model proposes, particularly on high precision works (oil pumps, exhaust components, etc.).

## **STEP VII**

### *Reduction of inventory and excess labour-hours*

The inventory reduction was significant from the implementation of a joint TQM&JIT programme. In the last five years, the inventory space has been reduced 50% - 60%. The manufacturing costs have also been reduced, whilst there was not noticeable reduction in the excess labour hours (the latter fact does not satisfy the Model's expectations). The customer satisfaction has been improved, in terms of product quality, delivery achievement, and delivery performance.

As a general evaluation of the Joint TQM&JIT Implementation Model, the manufacturing manager of OXFORD AUTOMOTIVE COMPONENTS declared that 'it is a very clear and comprehensive implementation plan, with start, middle and end. It would be very useful, particularly to the employees'.

### **7.3.5 MAR-COM SYSTEMS**

MAR-COM GROUP of companies comprises individual organisations dedicated to visual communication needs of industry, business, education, and government. MAR-COM SYSTEMS is one of them, and provides complete multimedia solutions for several applications. This encompasses supplying hardware, training courseware and providing full support material and technical back-up.

#### **STEP I**

##### *Definition and commitment on quality*

The definition of quality, according to MAR-COM, is to meet customer requirements. This is starting from the very top, from the CEO. The Model requirements for the definition and commitment on quality are fully satisfied in MAR-COM.

#### **STEP II**

##### *Cultural changes: implementation of TQM&JIT principles in employee way of working*

The training on TQM and JIT principles in MAR-COM was on job training, mainly focusing to the practical approach. It is a continuous learning process and it has never stopped from the day that it started. MAR-COM operates multiskills training, as the Model proposes, because of the wide product range and the very often changing of broadcasting industry. MAR-COM is not a pure manufacturing company, and it is not operating quality control circles as the Model proposes. However, it has brainstorming and troubleshooting teams. Each employee is aware of quality, because quality is also an individual matter. They do not operate 5 S, but they are working hard to do it. They do not have official measurements for the employee performance, as the Model proposes, but they use the customer complaints as a measure. Most of the work is done in the customer's site or place (i.e. installation, connection, and operation of multimedia), so they use customer feedback and customer satisfaction to estimate if they have assimilated the TQM and JIT principles. MAR-COM has an ISO 9001 certification.

### **STEP III**

#### *Workforce flexibility and quality performance*

They do not employ standard operations because they do not have a manufacturing line. They did not rearrange the equipment layout, because that facility does not exist.

### **STEP IV**

#### *Production maintenance and equipment flexibility*

MAR-COM provides maintenance for its products, and the engineers are based on the customer's site. They have a TPM programme, as the Model proposes. The reduction in changeover times is not valid, because the products are multimedia systems.

### **STEP V**

#### *Process capability and schedule adherence*

MAR-COM is not a pure manufacturing company, so concepts like batch-size reduction, lead time reduction, and one piece flow do not have a practical meaning.

### **STEP VI**

#### *Quality assurance, flexibility of production output system, and total quality control*

They measure the quality of the products with the product reliability, and the feedback from the customers. MAR-COM employs Statistical Quality Control in their products, while the reject rate is very low, around 0.5%.

### **STEP VII**

#### *Reduction of inventory and excess labour-hours*

The implementation of a joint TQM and JIT programme reduced the inventory and the excess labour hours, and the quality of the products has been improved. People are now aware of quality, because they want to have everything in perfect today and no work for tomorrow. The customer satisfaction has also improved very much, and new business with the same satisfied customers is a proof of that. Although the MAR-COM was not a manufacturing organisation like the above ones, the requirements and the expectations of the TQM&JIT Model are much satisfied. This may indicate that the appropriate

modification of the Model, in order to fit to the needs of different organisations, could make it applicable and functional in different business areas. MAR-COM is an example of that.

### 7.3.6 TADPOLE TECHNOLOGY

TADPOLE TECHNOLOGY is a leading designer, developer and manufacturer of workstation-class portable computers based on the industry's most advanced, highly integrated CPU architectures. In December 1995, TADPOLE TECHNOLOGY broke new ground with the introduction of the world's first 233MHz Alpha notebook, the ALPHAbook™ 1. TADPOLE TECHNOLOGY is continuing to advance workstation-class computing to new levels with the SPARCbook 3GX, the latest generation SPARCbook.

In addition, TADPOLE TECHNOLOGY designs, develops and manufactures high-performance embedded controllers for such industry-leading companies as Polaroid, Xerox, Amdahl, Texas Instruments, General Electric and Martin Marietta.

#### **STEP I**

##### *Definition and commitment on quality*

The definition of quality, according to TADPOLE, is the customer satisfaction through quality of design, product, and service. This definition is very close to the one of TQM&JIT Model, to understand and satisfy customer needs and produce only according to those requirements. Top management is committed to quality, and the aim is to develop an environment based on Continuous Improvement.

#### **STEP II**

##### *Cultural changes: implementation of TQM&JIT principles in employee way of working*

In TADPOLE, there has been no formal training of employees on TQM and JIT principles. Any progress has been based around management of employee relationships, where managers are committed to TQM and JIT principles. However, there has been recent moves to provide formal problem solving training, i.e. Pareto analysis, Ishikawa diagrams, etc. TADPOLE also employed cross-function training. Shop-floor skills have been developed across multiple disciplines. This has been done on a staff to staff basis, with the assistance of documented procedures where applicable. The overall cross-function training methods could benefit from more normalisation. They operate quality

control circles, and there are around 4 to 5 staff per circle. Moreover, they do not employ multifunction teams in a significant extent, and the employees do not participate in the audit of quality because no training has been provided for this. The basic principles of 5 S are being conveyed to staff at the moment. Also, there is a reasonably good appraisal system about employee performance that employs good metrics, but it is only wheeled out on a yearly basis. The intention of TADPOLE is to make it more dynamic.

### **STEP III**

#### *Workforce flexibility and quality performance*

TADPOLE is currently employing standard operations in some extent, but there is much work to be done towards that direction. The equipment layout is constantly being reviewed in line with TQM and JIT.

### **STEP IV**

#### *Production maintenance and equipment flexibility*

In TADPOLE, there are maintenance programmes in place but not in line with the Total Productive Maintenance concept. The implementation of a joint TQM and JIT programme reduced the changeover times significantly.

### **STEP V**

#### *Process capability and schedule adherence*

TADPOLE proceeded to lot-size (batch-size) reduction, as the TQM&JIT Model proposes. Some lot sizes, depending on product, are around 12% of previous batch sizes. They do not have flow line production. The lead time of assembly has reduced significantly, as the Model assumes from the joint TQM and JIT implementation, but the lead time of material acquisition has remained the same.

### **STEP VI**

#### *Quality assurance, flexibility of production output system, and total quality control*

They do not currently employ production levelling and Kanban systems, as the Model proposes, but they intend to do so in the near future. They also have an ISO 9001

certification and the employ Statistical Quality Control as the Model proposes. The quality assurance methods are effective, but there is also enough room for further improvement.

## **STEP VII**

### *Reduction of inventory and excess labour-hours*

The implementation of a joint TQM and JIT programme at TADPOLE improved the quality of the products, reduced the inventory, and reduced the excess labour hours as well. This means that the three subgoals of the TQM&JIT Model are fully satisfied. The manufacturing costs have been reduced 10-15%. There is no formal mechanism to measure customer satisfaction and there is no reward system for the operators in place. Reduced scrap, improvement in failure rate in production, increase in capacity within certain areas due to higher yields, and reduced cycle times are some of the benefits from the joint TQM and JIT implementation.

#### **7.4 Key changes included in the revised Model**

A revised version of the Joint TQM&JIT Implementation Model is presented in Fig. 7.1 in a condensed flowchart. The full size flowchart of the revised version is contained in Appendix E. The key changes which are included in the revised version of the Model follow.

- In the initial Joint TQM&JIT Model 'Definition of Quality' was the first activity taken and it was followed by the 'Top Management's commitment on Quality'. After the industrial visits it became clear that, at first it is necessary the commitment of top management on quality and then, always according to each single customer requirements and needs, the definition of quality.
- The 'Quality Control Circles' was one of the initiatives of the initial Joint TQM&JIT Model to assure and improve quality, by implementing the principles of TQM and JIT. The 'Quality Control Circles' are usually constituted of 8 to 10 members who do similar tasks and agree to meet in a regular basis to discuss work and quality problems. In the revised version of the Model, the 'Quality Control Circles' have been replaced with 'Quality Improvement Teams'. The 'Quality Improvement Teams' are constituted of members from various departments and with various tasks and agree to meet only when a serious work or quality problem arises. In such a way, the workforce is more flexible, because it is not overloaded with duties and tasks that are not so important on a regular basis. The informal face-to-face discussion and the informal collective discussion could be two methods for tackling with less serious work and quality problems (this could be identified from the responses of Question 17 and the Conclusion 12).
- In the initial Joint TQM&JIT Model, the application of ISO 9000 series was considered as a 'map' which would help employees to orient their new working attitudes towards to quality improvement objective. After the industrial visits, this view has been revised, because many industries could have an ISO certification without having changed the working attitudes of the employees. An ISO 9000 series

certification could be a good indicator of the product quality, but it cannot lead the orientation of the cultural changes. It could exist companies without ISO certification but with TQM in operation. That is why the 'ISO 9000 series' box has been transferred from the second step of the Model to the sixth.

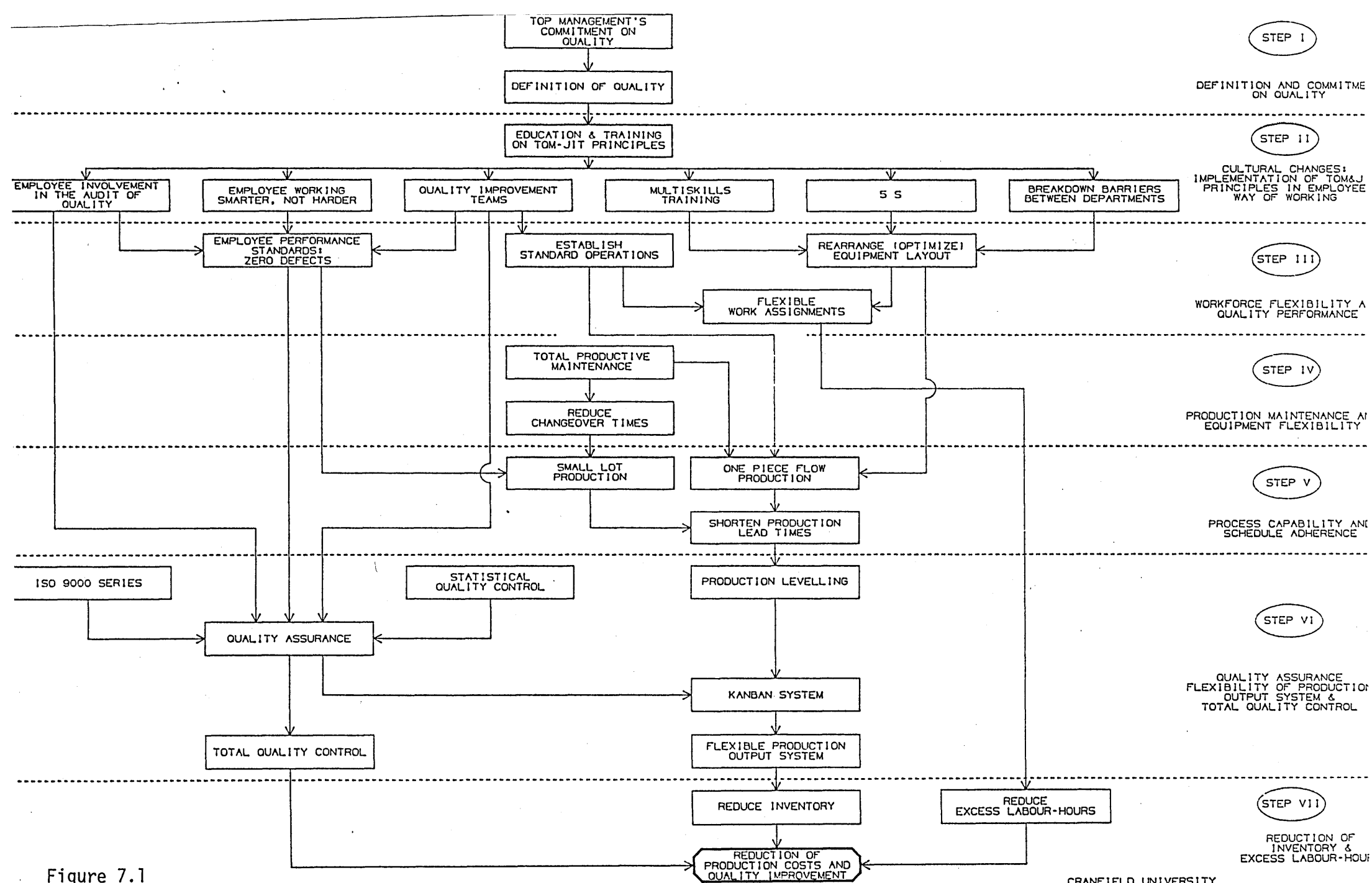


Figure 7.1  
THE TOM & JIT JOINT IMPLEMENTATION MODEL

## **CHAPTER EIGHT**

### ***GENERAL DISCUSSION AND FURTHER WORK***

## **GENERAL DISCUSSION AND FURTHER WORK**

### **8.1 Introduction**

The objective of this study has been the investigation of the impact of a joint TQM and JIT approach on the performance of manufacturing organisations, and the development of a Joint TQM&JIT Implementation Model. In particular, this study has concentrated on the identification of the key factors of both systems, necessary for a successful joint implementation, the link between these key factors, their importance for the stages of the implementation, and their contribution to the improvement of product quality and the reduction of production costs. Moreover, this study has included the development of an implementation model which will be based on these factors, detailing the procedures that should be followed. The development of a series of financial and non-financial performance measures to support each step of the Model is also a part of this thesis, as well as the evaluation of the Model applicability on manufacturing industrial processes.

In the following sections, the findings of this study are summarised and an attempt is made to draw general conclusions from these findings.

### **2 Achievement of the project aims**

All the project aims that were described in the previous paragraph have been achieved in this study. The satisfaction of each one of the individual targets brought in the achievement of the primary and general objective, which was the development of a joint TQM&JIT implementation model. More specifically, the statistical analysis of the responses of the survey showed the key factors of both systems, necessary for a successful joint implementation approach. The analytical and well documented statistical analysis, as well as the conclusions that were drawn from that, were the cornerstones for the Model development.

Each question was trying to investigate a specific production area and the impact of the joint approach. The identification of the key factors for each area also helped to reveal the possible links between them, and their importance for the implementation stages. A literature search, concerning the particular role of each activity and its position in the process hierarchy, was also a useful tool.

The development of the Model activities was based on the important factors that came up from the industrial survey, and on the literature review of the works that have been done previous on this research area. The author's industrial and academic experience with both systems also helped significantly to the Model development. The new concept that Model brings is a detailed series of activities and procedures that are linked to each other, and they cover all the process areas that are essential to the implementation of TQM and JIT principles.

The development of the series of the financial and non-financial performance measures relied on a review of the previous work on that specific research area, as well as on the industrial evaluation of the Model. The appraisal of the performance measures that were developed in the research, from the practitioners of the visited companies, is considered positive. However, in practice, there are also some other useful measures, depending on the type of the process (i.e. the measure of the defective parts per million that is used mainly in the automotive industry).

The industrial evaluation of the Model, in six leading manufacturing companies, was perhaps one of the most interesting parts of the research. The observation of both systems in operation, and the recommendations of the experienced managers concerning the Model applicability, were invaluable. Also, the author had the opportunity to clarify some of the Model activities and their location at the implementation plan, resulting in a revised version of the Model. Also, the details that were gained for each one of the implementation stages, made the Model richer and more accurate towards the

achievement of its objectives. The analytical (following the seven steps of the Model) presentation of each industrial visit helped the evaluation to be easier and more specific.

### **8.3 General evaluation of the implementation methods currently used**

The responses of the sixty companies that participated in the survey gave useful information and many details about the current industrial situation of TQM and JIT joint implementation. The conclusions of the analysis, for each one factor that was investigated, were presented in Chapter five. An attempt to summarise all these conclusions could give a cumulative picture of the methods currently used.

Most of the companies operate most of the TQM and JIT principles in a good way but not in the best one. For example, there were companies that declared they have TQM and JIT procedures without having the top management's support, and without being customer-oriented. Almost all the companies had a quality certification system, because they thought this is the safer and easier way to assure the quality of the products. They did not keep in mind that quality is to meet the exact customer requirements, and not to have only a documented product.

The participation of shop-floor employees in the audit of product quality and in the quality assurance procedure is considered relatively low for companies with TQM and JIT in operation. The involvement and empowerment of employees in all the business levels, from decision-making to audit of quality, did not happen in total extent. It could be said that not all the principles of TQM and JIT are well matured in the conscience of manufacturing managers.

Furthermore, it was found that 50% of the companies participated in the survey had no reduction in setup times, although there were JIT systems in operation. It is something that needs consideration, because the reduction in setup times affects many other

important activities (i.e. production levelling, Kanban systems, flexibility of output system, etc.).

Despite the weaknesses of the current methods that were found, there were also many benefits that companies gained from the joint TQM and JIT implementation. The reduction of the inventory of the finished goods and of the work in process, the improvement of overall product quality, the reduction of amount of scrap, and the improvement of labour utilisation are only some of the benefits gained. The joint TQM and JIT implementation in British manufacturing companies is considered successful, but always there is some room for improvement.

The Joint TQM&JIT Implementation Model that has been developed from this study could contribute towards this direction, because it is an analytical and sequential implementation plan, which tries to include all the positive elements that were identified, and to improve all the weaknesses that were observed.

## **8.4 Further work**

The Joint TQM&JIT Implementation Model is like an overall schedule, which could be adapted and operate with beneficial results in every manufacturing process. It provides the methodology and the series of steps that should be taken in order to achieve the principal objective, the improvement of the product quality and the reduction of production costs. Every step of the Model tries to improve a particular field of the production process, starting from the commitment of Top Management and the training of employees, and extending to production levelling, Kanban systems, Statistical Quality Control, Total Productive Maintenance (TPM), Zero Defects etc. So, the overall plan does exist; what is necessary is the testing of the Model by implementing it in a real manufacturing process.

The aim of a further work (research) could be an integrated approach of a joint TQM and JIT implementation, in terms of detailed methodologies, sequence of activities, and manufacturing and financial performance measures. This could include:

- The mathematical modelling of the TQM and JIT joint implementation, by developing the network of the activities, defining the critical ones and the critical path, by using critical path analysis and PERT techniques. Estimation of the optimum solution.
- The development of a mathematical model of the performance measures, which will convert the performance measures to mathematical variables, so that they can employed for repetitive measurements, and a cumulative formula.
- The development of the Cost Analysis Model, which will include the optimisation of the duration period and the cost benefits of the TQM and JIT joint implementation.

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## **APPENDIX A**

### ***THE QUESTIONNAIRE OF THE SURVEY***

**JOINT IMPLEMENTATION OF TQM AND JIT SYSTEMS**  
**A SURVEY [1996]**

RESPONDENT'S NAME \_\_\_\_\_ POSITION \_\_\_\_\_

COMPANY NAME \_\_\_\_\_

DEPARTMENT \_\_\_\_\_

LOCATION \_\_\_\_\_

NUMBER OF EMPLOYEES AT YOUR PLANT [PLEASE TICK]

|           |            |            |        |
|-----------|------------|------------|--------|
| 100 - 500 | 500 - 2000 | 2000 -5000 | 5000 + |
|           |            |            |        |

COMPANY TURNOVER BAND IN MILLIONS [PLEASE TICK]

|           |            |             |         |
|-----------|------------|-------------|---------|
| £ 15 - 50 | £ 50 - 100 | £ 100 - 250 | £ 250 + |
|           |            |             |         |

**1. Are there any TQM procedures and/or JIT systems operating in your plant?**  
(Please tick one box in each row)

|                | YES | NO |
|----------------|-----|----|
| TQM procedures |     |    |
| JIT systems    |     |    |

**2. How many years have they been used in your plant?**  
(Please tick one box in each row)

|                | 1 - 5 yrs | 5 - 10 yrs | 10 - 15 yrs | 15 + yrs |
|----------------|-----------|------------|-------------|----------|
| TQM procedures |           |            |             |          |
| JIT systems    |           |            |             |          |

**3. How many years of experience do you personally have with TQM and JIT?**  
(Please tick one box in each row)

|                | 1 - 5 yrs | 5 - 10 yrs | 10 - 15 yrs | 15 + yrs |
|----------------|-----------|------------|-------------|----------|
| TQM procedures |           |            |             |          |
| JIT systems    |           |            |             |          |

**4. What type of products are made under TQM and JIT systems in your plant?**

|                          |  |                   |  |
|--------------------------|--|-------------------|--|
| Automotive               |  | Machinery         |  |
| Electrical & Electronics |  | Office equipment  |  |
| Aerospace equipment      |  | Other (indicate): |  |

**5. What type of manufacturing process do you have at your plant?**

|                   |  |                   |  |
|-------------------|--|-------------------|--|
| Flow line         |  | Low Volume Batch  |  |
| High Volume Batch |  | Other (indicate): |  |

**6. In terms of company strategy, please rate the importance of TQM and JIT for your company.** (Please tick one box in each row)

|                | LOW | MIDDLE | HIGH |
|----------------|-----|--------|------|
| TQM procedures |     |        |      |
| JIT systems    |     |        |      |

**7. What was the reasoning behind the implementation of TQM and JIT ?**

(Please tick everything that applies to your company in each column)

|                                      | TQM | JIT |
|--------------------------------------|-----|-----|
| Meshed with business strategy        |     |     |
| Customers required it                |     |     |
| Improve products                     |     |     |
| Reduce production cost               |     |     |
| Improve efficiency and effectiveness |     |     |
| Marketing advantage                  |     |     |
| Other (Please indicate):             |     |     |

**8. Who determines the company's TQM and JIT goals?**

(Please tick everything that applies to your company in each column)

|                      | TQM | JIT |
|----------------------|-----|-----|
| 1. Top management    |     |     |
| 2. Middle management |     |     |
| 3. Main customers    |     |     |

**9. Please indicate if your company has:**

(Please tick everything that applies to your company)

|                                                                                         |  |
|-----------------------------------------------------------------------------------------|--|
| A quality document [which describes company's policy about quality and quality control] |  |
| A quality handbook [a written documentation of quality procedures]                      |  |
| Systems of regular audit in quality control efforts and results                         |  |

**10. Who participates in the audit of quality in your plant?**

(Please tick everything that applies to your company)

|                                              |  |
|----------------------------------------------|--|
| Top management                               |  |
| Senior Management of the department involved |  |
| Middle management of the department involved |  |
| Managers from other departments              |  |
| Management of Quality Control department     |  |
| Shop-floor employees                         |  |

**11. What impact has the implementation of JIT systems on the following?**  
(Please tick one box in each row)

|                           | POSITIVE | NONE | NEGATIVE |
|---------------------------|----------|------|----------|
| Amount of work in process |          |      |          |
| Amount of finished goods  |          |      |          |
| Tracking of inventory     |          |      |          |
| Inventory record accuracy |          |      |          |
| Inventory turnover        |          |      |          |

**12. Have you seen any benefits from the implementation of TQM and JIT on the following?** (Please tick everything that applies to your company in each column)

|                               | TQM | JIT |
|-------------------------------|-----|-----|
| Overall product quality       |     |     |
| Amount of scrap               |     |     |
| Number of warranty claims     |     |     |
| Number of customer complaints |     |     |
| Overall customer satisfaction |     |     |

**13. Please rate how you think TQM and JIT systems have affected the following:**  
(Please tick one box in each row)

|                    | POSITIVE | NONE | NEGATIVE |
|--------------------|----------|------|----------|
| Worker motivation  |          |      |          |
| Labour utilisation |          |      |          |
| Labour turnover    |          |      |          |
| Union relations    |          |      |          |
| Teamwork           |          |      |          |
| Absenteeism        |          |      |          |
| Job satisfaction   |          |      |          |

**14. What is the impact of JIT systems on the following?**  
(Please tick one box in each row)

|                           | POSITIVE | NONE | NEGATIVE |
|---------------------------|----------|------|----------|
| Total manufacturing costs |          |      |          |
| Material handling costs   |          |      |          |
| Batch size reduction      |          |      |          |
| Throughput time reduction |          |      |          |
| Setup time reduction      |          |      |          |
| Variance reduction        |          |      |          |
| Machine availability      |          |      |          |
| Other (Please indicate):  |          |      |          |

**15. How long did it take to you (in MONTHS) for the implementation of TQM and JIT systems?** (Please tick one box in each row)

|                | 6 - 12 | 12 - 18 | 18 - 24 | 24 + |
|----------------|--------|---------|---------|------|
| TQM procedures |        |         |         |      |
| JIT systems    |        |         |         |      |

**16. How did you train/educate your staff on the principles of TQM and JIT?**  
(Please tick everything that applies to your company in each column)

|                                       | TQM | JIT |
|---------------------------------------|-----|-----|
| Courses outside the company           |     |     |
| Courses in the company                |     |     |
| Studies in literature about TQM / JIT |     |     |
| Other (Please indicate):              |     |     |

**17. How is information on TQM - JIT problems obtained in your company?**  
(Please tick everything that applies to your company in each column)

|                                  | TQM | JIT |
|----------------------------------|-----|-----|
| Informal face-to-face discussion |     |     |
| Informal collective discussion   |     |     |
| Written reports                  |     |     |
| Formal meetings                  |     |     |
| Suggestion system                |     |     |

**18. What impact has the Implementation of JIT systems on the following?**  
(Please tick one box in each row)

|                                                     | POSITIVE | NONE | NEGATIVE |
|-----------------------------------------------------|----------|------|----------|
| Information flow between management & shop floor    |          |      |          |
| Information flow between each work area [e.g. cell] |          |      |          |
| Information flow within each work area [e.g. cell]  |          |      |          |

**19. Please indicate how you check the quality of your suppliers. Leave blank if you do not check them.** (Please tick everything that applies to your company)

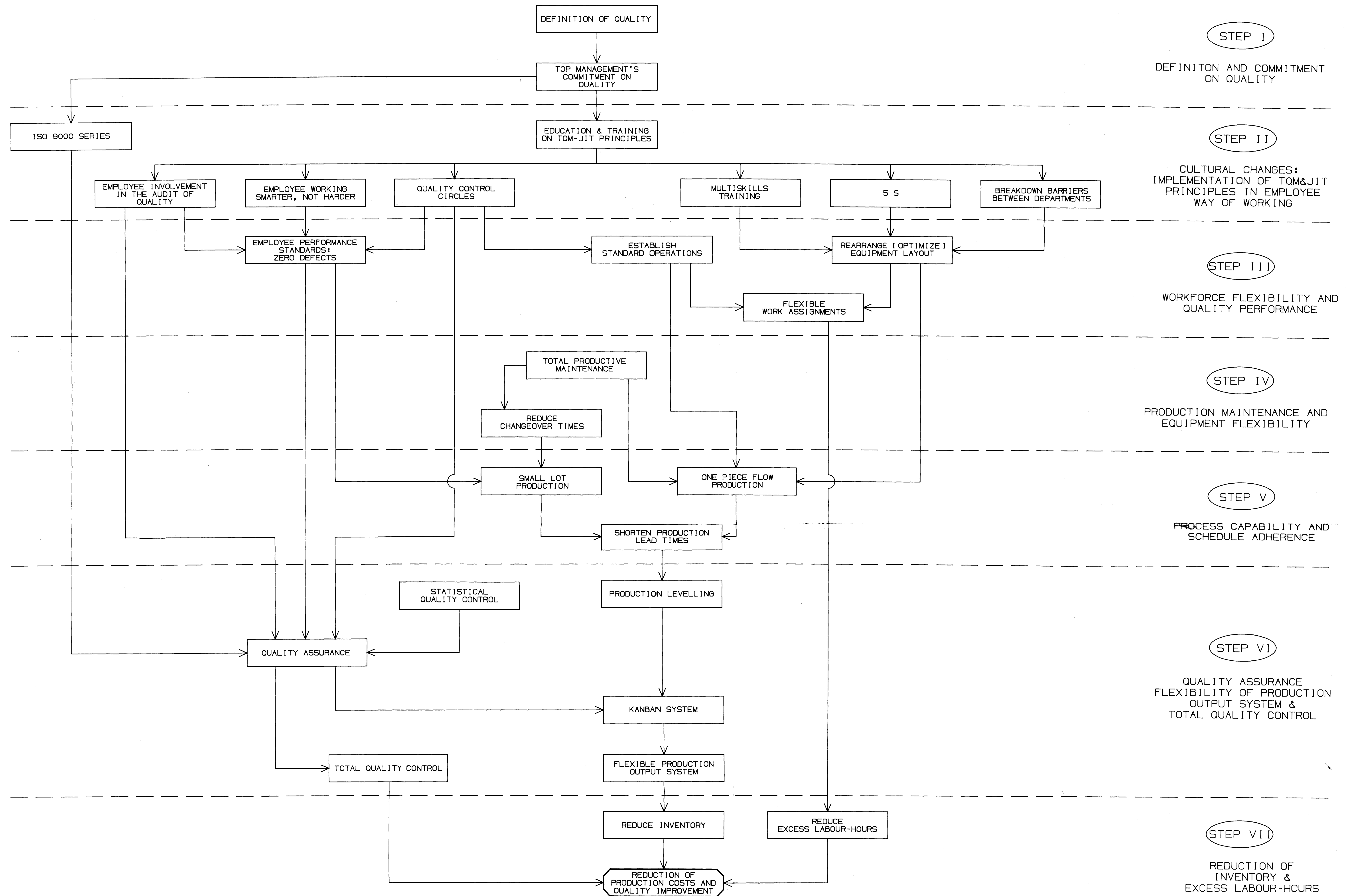
|                                                           |  |
|-----------------------------------------------------------|--|
| By lot inspection                                         |  |
| Analysing control charts from your suppliers              |  |
| Checking the process capability index from your suppliers |  |
| Checking is done in your production process               |  |
| Other (Please indicate):                                  |  |

**20. Please indicate if you undertake any initiatives to improve your company's performance. Leave blank if you do not undertake any.**  
(Please tick everything that applies to your company)

|                              |  |
|------------------------------|--|
| Total Productive Maintenance |  |
| Training                     |  |
| Quality assurance            |  |
| Cost-cutting                 |  |
| Restructuring                |  |
| Performance measurement      |  |
| Marketing                    |  |
| Capital investment           |  |
| Other (Please indicate):     |  |

## **APPENDIX B**

### ***THE INITIAL JOINT TQM&JIT IMPLEMENTATION MODEL***



## **APPENDIX C**

### ***PERFORMANCE MEASURES FOR THE MODEL***

## **PERFORMANCE MEASURES FOR THE TQM&JIT MODEL**

### **STEP II**

#### **Workforce Quality Circles**

They are usually constituted of 8 to 10 members who do similar tasks and agree to meet in a regular basis to discuss work and quality problems. The group analyses the causes of problems and recommends solutions to the management. They also can assist in the implementation of the recommended solutions [Feigenbaum, 1983].

The possible performance measures regarding these issues are:

- Number of circles in operation
- Number of problems identified and characterised
- Number of problems already solved
- Percentage of employees involved

#### **Output per employee**

Output must be defined in global units (i.e. finished units) avoiding focusing on local outputs.

#### **Output per labour hour**

A variation of the output per employee is output per labour hour. This measure allows or considering variations of productivity due to overtime, number of working days in the period, etc. In those cases where labour is paid in hourly rates is a quite more complete and representative measure. When considering salaried personnel, this measure does not offer additional information about the profitability of the operation but reflects improvements in working conditions and efficiencies.

#### **Value added per labour hour**

Both measures, output per employee and output per labour hour, can be criticised because they do not consider the percentage of the output that has been bought in [Goldratt and Cox, 1986]. Therefore, an operation can be appear as more productive by means of increasing the amount of components that are purchased. In order to avoid this problem, it is possible to use the measure value added per labour hour. Value added is

the difference between the gross sales and all the payments made for purchased items and services rendered by outsiders. It is expressed in money and includes the company profit, therefore it is affected by pricing and inflation. This can be overcome by using real units but in any case, this measure becomes difficult to understand by shop-floor employees.

### **Ratio of output to capacity**

This measure is necessary in order to assess the effectiveness with which the labour resources are being used. This requires evaluating the capacity by work measurement methods that should establish times to perform certain jobs. Then, output will be measured in standard hours corresponding to the actual output. Capacity will be the number of hours actually worked.

### **Absenteeism**

Absenteeism is a waste and causes disruption to production. It is a management responsibility to create the necessary conditions to reduce absenteeism hours.

### **Labour turnover**

It is a source of waste and lost productivity. It affects the productivity of labour resources by means of lost training, learning curves, low morale, difficulty to create teams, etc.

## **STEP III**

### **Percentage of a product parts which are standard parts (Standard Operations)**

The higher this percentage, the easier it will be to control and plan the production. Standard parts allow for the postponement of production decisions regarding the final mix and therefore, facilitate the reaction to market changes.

### **Average number of operations that a worker can perform**

Supervisors should evaluate if a worker is capable of performing a particular job. This evaluation should be done regularly because non-exercised abilities will erode quickly and individual incentives may be associated with the number of jobs which a worker is qualified to perform. Percentage of workforce doing more than one production job in one month is a measure that could be used to evaluate the actual extent of the workforce flexibility.

### **Number of jobs classifications**

This number is a measure of the difficulty of changing the production jobs of an operator. In many cases, the use of workers across job categories is inhibited by restrictive work rules.

### **Measuring incoming quality**

The traditional approach to supplier quality control has been based on [Perea, 1993]:

- Inspection of incoming goods.
- Castigation of vendors with penalties or loss of contracts whenever certain defects limits were exceeded.

### **Inspection performance and production quality**

The main roles of inspection are to ensure compliance with the specification and provide inspection data. The critical factor when measuring inspection performance is to determine its efficiency in spotting production errors. The basic approach could be to measure the **number of errors non detected in first inspection** [Juran and Gryna, 1988]. This would require tracking the origin of errors to determine if the defect was included in the item when it was previously inspected. A variation of this measure, which may be used to focus in the most critical inspections, could be to monitor the **number of hours worked on defective items** [Juran and Gryna, 1988]. In the ideal situation, where real process control and monitoring has been achieved, inspection of produced items should be completely removed from operations.

### **Output per machine hours**

The machine hours should be the actual hours that the machines have been working to achieve their maximum theoretical output. Obviously this measure will be strongly affected by the current labour productivity.

### **Percentage of programmable equipment and Percentage of multipurpose equipment**

Both measures can be specified in several ways. It must be borne in mind that, the more reduction is processed in a piece of equipment, the more this piece influences the flexibility of the plant. This fact should be considered when evaluating these measures. However, in multi-flow and multi-product plants, it can make the measure obscure and difficult to evaluate. Given the indicative nature of this measure, it will be better to establish an index considering only the degree of programmability or general purpose and the proportion of machines which can be included in each index.

## **STEP IV**

### **Number of downtime hours due to breakdowns to number of uptime hours**

The number of downtime hours should be calculated as the sum of non-operative time due to non-scheduled repairs waiting time for spare parts of equipment and losses of capacity due to reductions in speed. The later can be evaluated as the time necessary to manufacture, at full throughput rates, the losses of throughput due to speed reductions. This sum must be done including all the downstream machines that have been stopped because of starvation and/or have had to use buffered parts [Perea, 1993]. Obviously, if the maintenance function is to account for the later downtime, their opinion must be considered when deciding buffer policies. The number of uptime hours is the sum of operative time for all the machines. Making the measure relative to uptime hours allows for the inherent difficulty of scheduling and developing maintenance tasks when uptime gets closer to the full capacity.

A variety of the previous measure is the so called **availability**. It is usually expressed as the ratio of uptime to the sum of uptime and downtime. This expression is equivalent to the ratio of mean time between failures (MTBF) to the sum of MTBF plus meantime to repair.

### **Mean Time Between Failures (MTBF)**

This measure could be used to evaluate the performance of preventive maintenance operations.

### **Response Time to Breakdowns**

Evaluated as the time elapsing between breakdown occurrence and end of repair. This measure allows monitoring the readiness of the maintenance function. It should be used only as an orienting measure to avoid rushing the repair tasks.

### **Actual Preventive Maintenance tasks completed versus planned**

This measure should be used to monitor and evaluate the causes and consequence of non-completion of scheduled maintenance tasks.

### **Variability of MTBF**

Although this variability cannot be blamed on the maintenance function, they are responsible for improvements in this measure because their knowledge of the equipment must continuously improve.

**Reduction in machine repairs times**

This time must be continuously reduced by means of training and improvements in the initial equipment design.

**Ratio of external changeover time to internal changeover time**

This proportion may indicate the reduction on changeover and setup times, as the ratio is becoming higher and higher.

**STEP V****Average percentage of lot-size reduction (or batch-size reduction)**

This measure is a good indicator for the lead time reduction, and the improvement of the process according to JIT principles.

**Measuring Work in Process (WIP)**

The measure could be obtained as the standard money value of the WIP (this value can be obtained from cost accounting records). In those cases where high WIP is responsible of poor throughput time, it will be useful to establish Input/Output control procedures [Fry and Smith, 1987]. In these cases, data can be obtained from the input/output control systems at the gateway and terminal operations.

**Measuring the schedule adherence (Lead Times)**

Time based performance is clearly affected by the synchronisation of tasks between different work-centres. This synchronisation is planned and controlled by the manufacturing planning and control function by establishing when parts and materials are needed and when are to be processed in the work-centres. The aim is to complete the production tasks on time with neither queuing or unplanned waiting times. All the production problems affect the efforts towards this goal. Raw material delays and shortages, schedule changes, equipment breakdowns and quality problems will randomly reduce the capacity of work-centres and obstruct the achievement of the planned schedules. Additionally, longer manufacturing lead times are more likely to suffer from changes in customer's orders. Therefore, systems with shorter lead times are more likely to obtain high schedule adherence. Depending on the type of system and the criteria used to evaluate it, the following measures could be used [Perea, 1993]:

- Percentage of orders delivered on time
- Ratios of actually produced to scheduled quantities
- Items which are past due date
- Ratio of accumulated requirements to capacity
- Number of orders, items, parts or pounds (£) waiting
- Unavailable components by due time

These measures can be tracked daily, weekly or monthly for each work-centre, department or the whole plant. In each case, data can be collected by the shop-floor personnel, production control department or sales department. Wherever MRP systems are used, they can be employed to collect data.

#### **Percentage of inputs that can be obtained in X lead time**

This lead time must be improved whenever one hundred per cent has been reached. This percentage refers to input classes or types rather than to volumes of input. An indirect way of evaluating this flexibility factor, is to monitor the inventory levels of incoming items. If a company wants to evaluate their ability to customise products or introduce new ones, they should monitor the lead times to supply newly-specified items.

### **STEP VI**

#### **Process Performance**

The goal of any quality improvement program is to increase quality by gaining process control rather than by reducing the amount of defective output by means of identifying and removing non-conformance products. Further quality improvements can be obtained if the batch size is reduced and close scheduling is practiced. This will happen since, the smaller the batch size the sooner it is passed to subsequent operations. Therefore, the shorter it will take to detect defective production. The final goal of the quality improvement process is to make products right first time. SQC techniques help to control and detect non-conforming output but there is slack between process and control. Therefore, some non-conforming items could be produced and passed to downstream processes [Montgomery, 1991]. In the ideal JIT environment, the rule should be:

Make one → Check one → Pass one

Devices assisting inspectors and workers should be developed to ensure that the produced items are conforming to requirements.

**Reject Rates**

Reflecting the average number of items rejected in final inspection as the percentage of total output.

**Warranty Claims**

Reflecting the amount of money that is properly claimed as defective by customers. This measure could be made relative to the total revenue or the total gross profit.

**Rework Levels**

This measure should reflect the standard value of the amount of work and material expended in reworking. This measure could be made relative to the total throughput value only in those cases in which it can be guaranteed that overproduction cannot be used to reduce the percentage.

**Scrap Levels**

This measure should record the value of items that are rejected by means of poor quality and cannot be reworked. With the same constraint mentioned for rework, it could be made relative to the period output.

**Percentage of inputs that allow X variation in the volume within the standard lead time**

This measure should identify the percentage of input types that can be delivered within required lead times in quantities that vary a certain percentage from the average order size. This percentage variation will affect the volume flexibility of the customer company. The percentage variation must be increased whenever 100% of input types is reached.

**STEP VII****Inventory turnover**

This measure should be used to evaluate the system's abilities to use effectively and efficiently the working capital. This working capital will be evaluated in money value.

**Output per employee (i.e. finished units)**

Described in Step I.

**Output per labour hour**

Described in Step I.

**Value added per labour hour**

Described in Step I.

**Ratio of output to capacity**

Described in Step I.

**Ratio of labour hours used to labour hours available**

This measure should be used for second order feedback to adjust capacities in long and medium term planning.

**Customer Satisfaction and Marketing Surveys**

Marketing surveys are necessary in order to obtain feedback in terms of what the customers expect, what are their needs, what are the trends and how do customers perceive the company is performing. These surveys must be continuous and should be used to adjust products and manufacturing processes to the customer needs. They can be done both by having regular based interviews with customers or by inducing customers to send back a questionnaire.

Surveys are the most powerful tool when measuring customer satisfaction. They are the most expensive too. They require personnel, travelling, calls, documentation, etc. Maintaining high frequency surveys seem prohibitive for medium and small sized companies. For these companies, reducing the frequency of surveys and using some cheap measures in the meantime seems the optimum solution.

Those cheaper measures must be supported by the current information systems of the company. Some possible measures are [Talley, 1991]:

- Analysis and monitoring of repeated sales divided by total sales of the product.
- Warranty claims plus bill adjustment values divided by total revenues for the product.
- Number of warranty claims related to number of sales

## **APPENDIX D**

### ***QUESTIONS FOR THE MODEL EVALUATION***

## QUESTIONS FOR THE MODEL EVALUATION

### **STEP I**

What is quality according to the definition of your company's policy?

Is it Top Management committed to quality? Does the Management have clear targets about quality?

### **STEP II**

What quality standards have you been certified for so far? Do you have an ISO 9000 series certification?

How did you educate/train your employees on TQM and JIT principles?

How long did you educate/train for?

Do you employ cross-function training? If yes, how do you do that?

Do you operate quality control circles? If yes, how many employees does a circle have (average)?

Do you employ multifunction teams or multiskilled teams?

Do you consider that your employees participate in the audit of quality? Have they been trained to do so? *Poka-yoke*?

Did you employ the 5S (organisation, neatness, cleaning, standardisation, discipline)?

Do you measure the performance of your employees? If yes, how do you do that?

How did you know that they had assimilated the TQM and JIT principles? Did you measure their performance?

**STEP III**

Do you employ standard operations (product parts which are standard parts)?

Did you rearrange (optimise) the equipment layout since you started operating TQM and JIT?

Can you give me an approximate percentage of programmable equipment and multipurpose equipment?

**STEP IV**

Do you employ Total Productive Maintenance?

Can you give me an approximate proportion of number of downtime hours due to breakdowns to number of uptime hours?

What was the impact of TQM and JIT on the changeover times?

**STEP V**

Did you proceed to lot-size (batch-size) reduction? If yes, can you give the average percentage?

Do you have flow line production?

What was the impact of TQM and JIT on the lead time?

**STEP VI**

Do you employ production levelling and Kanban Systems?

How do you measure the quality of your products?

Do you employ Statistical Quality Control?

What's the reject rate that you have (the average number of items rejected in final inspection as the percentage of total output)?

What's the scrap levels that you have (the value of items that are rejected by means of poor quality and cannot be reworked)?

### **STEP VII**

Do you think the implementation of TQM and JIT improves the quality of your products?

Do you think the implementation of TQM and JIT reduces the inventory?

Do you think the implementation of TQM and JIT reduces the excess labour hours?

Have the production and manufacturing costs been reduced because of the TQM and JIT implementation? If yes, by what percentage?

Do you think the implementation of TQM and JIT improves the customer satisfaction?

Do you measure the customer satisfaction? If yes, how do you do that?

### **GENERAL**

What is your reward system for the operators?

Do you measure the incoming (supplier) quality? If yes, how do you do that?

Do you take into account the warranty claims as a measure of product quality and customer satisfaction?

What were the major problems that you had in the production process during the implementation of TQM and JIT? How did you solve them?

Do you think that your process is running smoother now? Have you seen any changes in the effectiveness of your system?

Have the warehouse space and warehouse costs been reduced? If yes, in what percentage?

How often do you get measures about the performance of your process? What are these measures?

Do you employ any Kaizen (Continuous Improvement) programs?

How long did it take to you to profit from the TQM and JIT implementation? What were the first fruits that you reaped?

## **APPENDIX E**

### ***THE FINAL (REVISED) JOINT TQM&JIT IMPLEMENTATION MODEL***

