Management and Business Implications of IT-supported Performance Measurement System

Sai Sudhakar Nudurupati

Thesis submitted for the Degree of PhD
2003

Department of Design, Manufacture and Engineering Management

University of Strathclyde

Glasgow, UK

Declaration of Author Rights

Acknowledgements

I would like to thank my supervisor Prof. Umit S. Bititci for his indefatigable support rendered in completion of this research. I would also like to thank the industrial collaborators Mr. Rob Hinton, Mr. Robert Cowan, Mr. Bill Dickie, Mr. Wyllie Woodburn and Mr. David Hedley for providing the opportunity to do the research in the companies as well as TCS Associates Mr. George Irvine, Mr. Colin Brown, Mr. Evangelos Charlompous and Mr. Stephen Maddocks for their invaluable input to this research.

I am profoundly grateful to the Committee of Vice Chancellors and Principals (CVCP), Department of Education and Employment as well as University of Strathclyde for offering Overseas Research Scholarship and University Studentship to do this research.

I would like to extend my gratitude to Dr. Jill MacBryde and Mr. Trevor Turner, who gave their valuable time in reviewing and discussing my thesis. I must also extend this gratitude to Mrs. Doreen Sehgal and Mrs. Janice Rodger for correcting English grammar in my research documents and this thesis.

I would also like to take this opportunity to thank my parents and sisters for their support and encouragement during this research. Finally I would like to thank all my friends and colleagues, who have extended their help directly or indirectly in this research.

Abstract

The performance measurement revolution started in the late 1970s with the dissatisfaction of traditional backward looking accounting systems. Since then the literature in this field is emerging. Most of the focus was on designing performance measurement systems, with few studies illustrating the issues in implementing and using performance measurement systems. However there was no solid research reported in literature that demonstrated the impacts of performance measurement when implemented and used with appropriate IT support.

In this research, initial evidence was gathered from four companies where IT-supported performance measurement system (IT-PMS) made positive impact on management and business. The findings obtained from these studies were grounded in theory and formed the basis for creating a set of predictions on management and business implications (dependent variables) and pre-conditions, which are the factors that effect the implications (semi-dependent variables). The objectives of this research were to prove predictions and pre-conditions as well as to build relationships between IT-PMS implementation (independent variables), predictions and pre-conditions.

In order to achieve the research objectives, true experiments with the researcher as facilitator / personal observer (of the experiment) was considered to be essential. It was also essential to have a degree of control by the researcher to vary these independent variables and study their impact on dependent and semi-dependent variables. This strongly urged the researcher to adopt action research as the main research domain, by implementing IT-PMS at four companies and monitoring its impact.

Finally, the research demonstrated that appropriately designed performance measurement systems, if supported through appropriate IT platforms and driven by senior management, appropriately implemented and used will result in positive management and business implications such as: facilitating more pro-active management style, increasing positive behaviour such as focusing on facts, communication, empowerment and teamwork, creating complete transparency and visibility of information, identifying weak areas of the business and promoting continuous improvement.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

1.1 Background

As we moved into the 21st century, manufacturing industries are facing tough challenges to succeed in a globally competitive market. Markets are becoming increasingly sophisticated and dynamic. Customer demand is changing rapidly in terms of sophistication of the products and services they require. As a result, companies need to become more responsive to customers and market needs with a greater number of customer specific products, more flexible processes, suppliers and resources co-ordinated through a number of factories and warehouses, whilst reducing costs.

In order to proactively respond to these challenges, management requires up-to-date and accurate performance information on its:

- Markets and customers
- Competitive position
- Financial performance
- Operational performance
- Suppliers performance and so on

Furthermore, this performance information needs to be integrated, dynamic, accurate, accessible and visible to aid fast decision-making to promote a proactive management style leading to agility and responsiveness.

Some companies are now attempting to make use of information technology to provide the required performance information on-line. However in many of these companies, managers suffer from data overload. These companies have information systems that generate piles of performance reports, often after the incident. Managers in these companies need predictive measures that indicate what will happen next week, next month, or next year (Neely 1999). Managers need up-to-date performance figures on production, quality, markets, customers, etc. through which managers can proactively act on controlling several processes to achieve the financial performance.

1.2 This Research

From previous experience with a number of manufacturing organisations, the research at the Centre for Strategic Manufacturing in the University of Strathclyde identified that: Despite the amount of research and development in performance measurement, systems that are properly integrated, dynamic, accurate, accessible and visible to facilitate responsive manufacturing are still not common (Bititci and Carrie 1998). This is because the technical and people issues concerning the dynamics of performance measurement systems are not completely understood.

Bititci et al (2000) used the IPMS Reference Model to audit the performance measurement systems of over 30 UK and European based manufacturing and service companies. This work identified the main reasons behind the absence of performance measurement systems that would facilitate responsiveness and agility as:

- Today most performance measurement systems are historical and static. That is, they are not dynamic and sensitive to changes in the internal and external environment of the firm. As a result, the information presented is not relevant, up-to-date or accurate. This creates a vicious circle because it has a negative effect on the perceived value and usefulness of the performance measurement system, resulting in lack of commitment and ownership, which, in turn, discourages proper maintenance and updating of the system.

- Few performance measurements systems have an integrated IT infrastructure. Hence lack of IT results in cumbersome and time consuming data collection, sorting, maintenance and reporting. As a result, companies cannot justify further investment of already stretched resources in data collection, sorting, maintenance and reporting type activities, which are seen as having low perceived values.

The five-year action research by Bourne (2000a) based at the University of Cambridge identified the drivers and barriers of performance measurement system design interventions:

- ***Drivers***: Senior Management Commitment, Perceived Benefits
- ***Barriers***: Parent Company Initiatives, Lack of IT Support, Time and Effort Required, Resistance.

Hudson et al (1999) at Plymouth University summarised the reasons for failure of performance measurement systems initiatives in SMEs as:

- Historical measures with out-of-date and irrelevant information
- The time consuming nature of PMS development and maintenance
- Lack of commitment and enthusiasm from senior management

In summary, the research conducted at Strathclyde University, Cambridge University and Plymouth University identified that IT plays a major role in implementing performance measurement. In order to monitor this IT supported performance measurement system and make people use the system, it is necessary that the drive and commitment should come from senior management, as shown in the following stages:

- ***Design*** (such as the type of framework or model used for finding key indicators, type of information required at different levels of management, customers, suppliers, etc.)
- ***Implementation*** (such as software and hardware to support data collection, data analysis, data communication, etc. for implementing performance indicators)
- ***Use*** (such as making people use the above performance information for decision-making, training the people in using it, reducing resistance, etc.)

However, it is difficult to prove the implementation of these IT supported performance measurement systems are worth the investment. Despite the huge number of practical implementations of IT supported performance measurement systems (IT-PMS) in different industrial sectors, little or almost no research has been done in correlating the amount of investment spent in implementing IT based performance measurement systems with the benefits or the impact it had on business and management. "Are the results / impacts worth the system implemented?" According to Bititci et al (2000 and 2002), Holloway (2001) and Neely (2002), there is very little solid research evidence that illustrates the impact of performance measurement systems.

Hence the research set its objective as to study the issues concerning dynamics of performance measurement by embedding performance measurement systems using IT and

web technology, implementing these in collaborating companies and ***studying its impact on management[1] and business[2]***. The initial research questions raised are:

- What is the impact of IT-PMS on management and business?
- What are the critical success factors of IT-PMS projects, which cause the impact identified in the previous research question?

1.3 Structure of this Thesis

The research started with a wide review of literature on performance measurement and this is reported in Chapter 2. It starts with a review on the evolution of performance measurement. It then includes designing performance measurement as well as issues in implementing and using performance measures. The sections covered in this chapter are shown in Figure 1.1. The research strategy adopted to do this general literature review was exploratory (the process used was exploring different issues in literature) and archival (the main data source was archives) approaches.

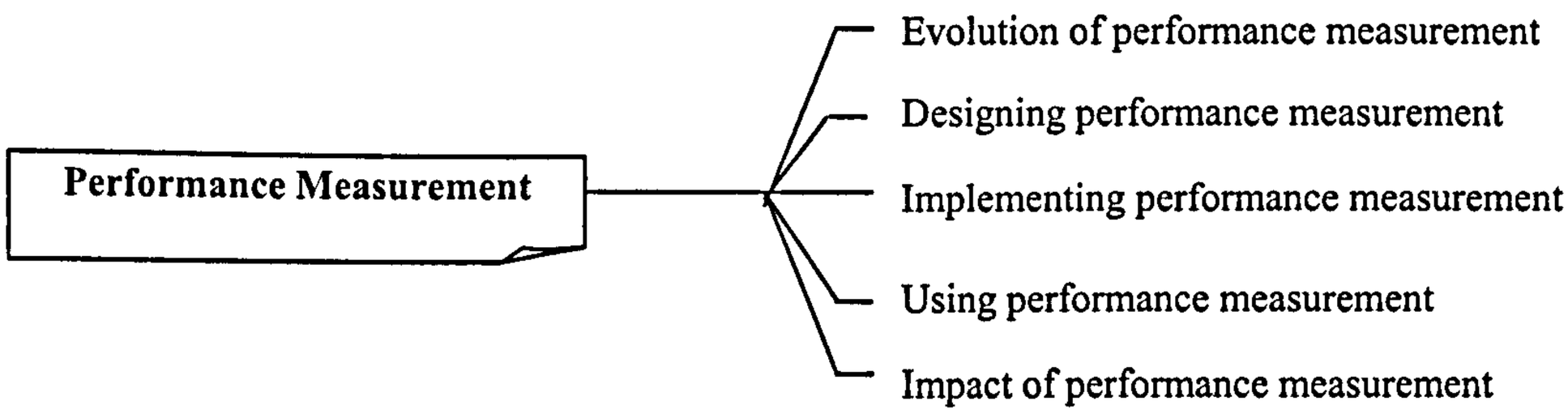


Figure 1.1 Structure of Chapter 2

Chapter 3 starts with evidence from four companies where IT-PMS had positive impact on business and management. Later on it explains the structured pilot case study at AFE, an Aluminium Rolling Mill, which developed a fully integrated IT-supported performance measurement system (IT-PMS) based on the Integrated Performance Measurement Systems (IPMS) Reference Model (Bititci and Carrie 1998). It also describes several factors of IT-PMS, which resulted in management and business implications. The flow of sections in Chapter 3 is shown in Figure 1.2. The research strategy adopted to do the pilot case studies was exploratory (the process used was exploring different issues in companies) and

---

[1] Implementing IT-supported performance measurement would result in management implications such as the change in their behaviour, decision-making, confidence levels on information and decisions, etc.

[2] Implementing IT-supported performance measurement would result in business implications such as performance improvement, relationship across the supply chain, etc.

empirical (the data source was practical observations) approaches. Based on Chapter 2 and the findings obtained from these pilot case studies, the initial research questions are tentatively[1] answered, and two new research objectives are identified. In order to achieve these objectives, a detailed and structured literature review was done, which is reported in Chapter 4.

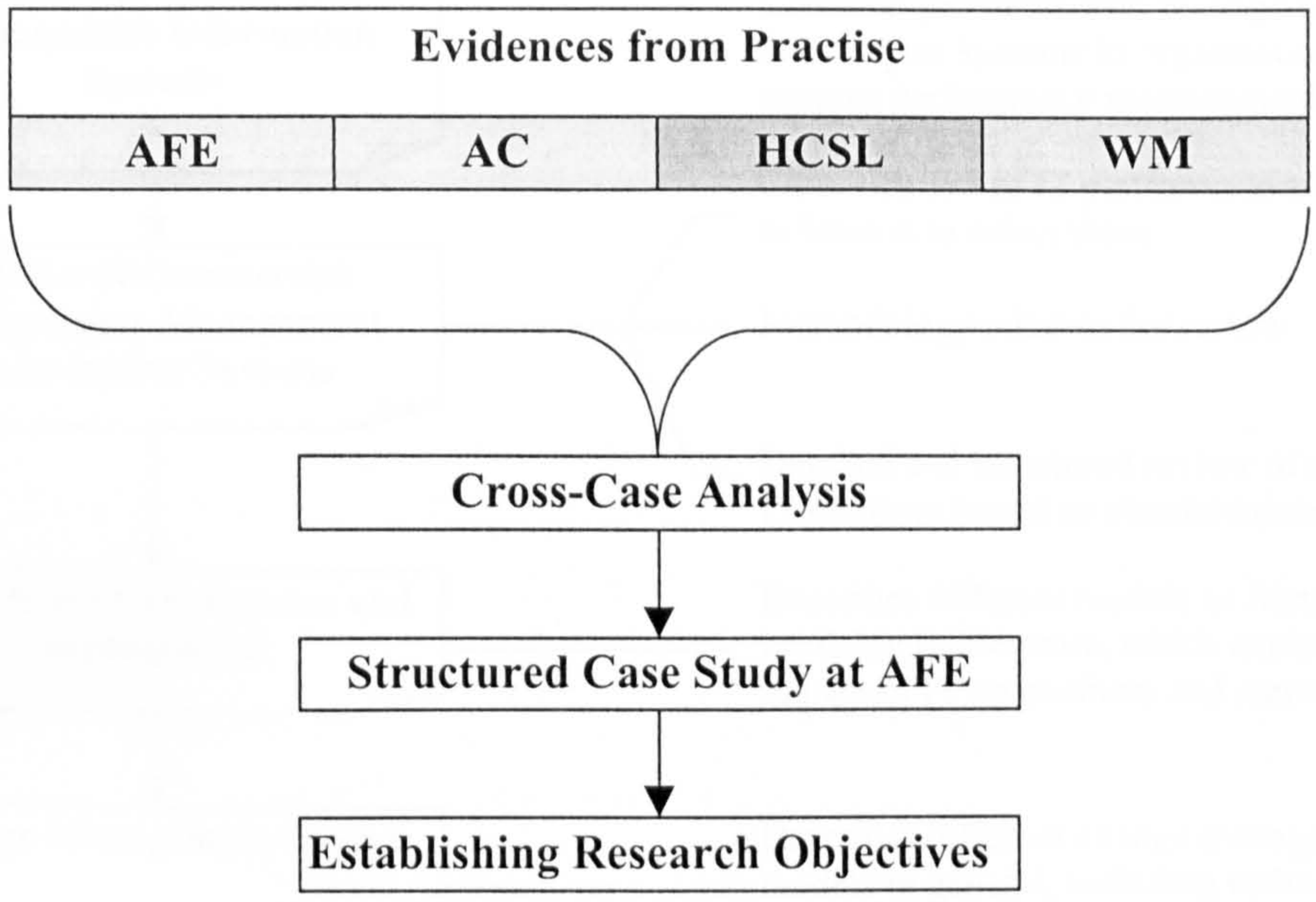


Figure 1.2 Structure of Chapter 3

Chapter 4 covers literature on IT and performance measurement from five different perspectives as shown in Figure 1.3. The research strategy adopted to do the specific literature review was exploratory (the process used was exploring different issues in literature) and archival (the main data source was archives) approaches. The first section reviews literature on general IT for data collection, analysis and communication, which is then subdivided into performance information practices and performance information behaviour. The second section covers the management information systems existing in the companies and their difficulties in supporting performance measurement. The third section reports a review of performance management information systems available in the market to support performance measurement. The fourth section covers the concepts, models and frameworks available in literature to identify the impact of technology on business. Finally, in the fifth section it describes different change management models in general, including technology based change management models, for implementing IT-PMS in companies and studying the change.

---

[1] The research questions are answered from exploratory stage and hence they cannot be directly contributed to theory. Hence they are tentatively answered, which serves as predictions.

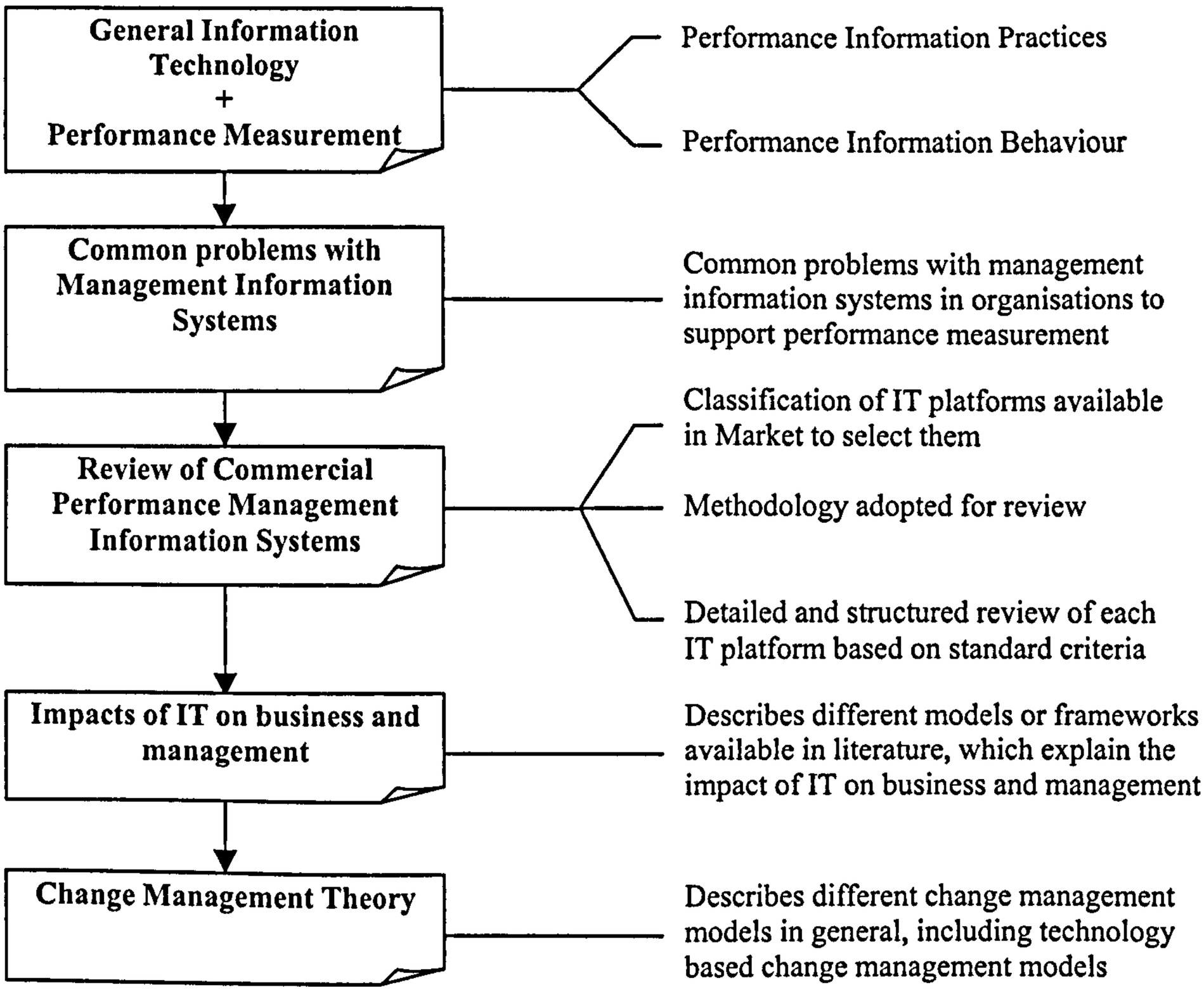


Figure 1.3 Structure of Chapter 4

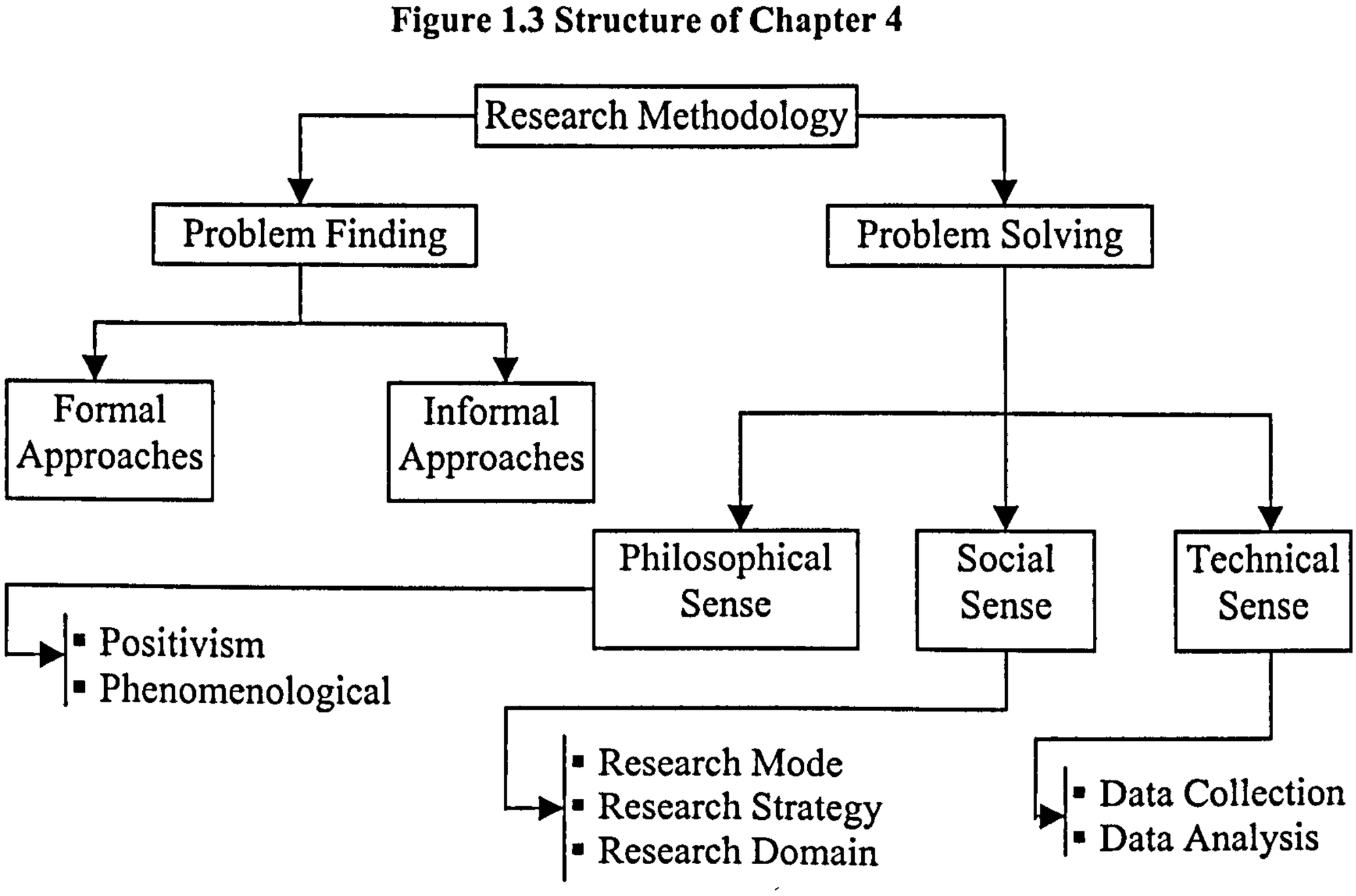


Figure 1.4 Structure of Chapter 5

Chapter 5 covers a description (concept level) of several research methods, strategies, tools and techniques in general as shown in Figure 1.4. It also describes (detailed level) the methodology (group of research strategies, methods, tools and techniques) used for this research by identifying their strengths and weaknesses. It also presents the suitability of the selected methodology for this research. Towards the end of this chapter it defines a set of quality criteria to assess the quality of this research in terms of both the design process of the research as well as its outcome.

Chapter 6 describes the implementations carried out at each company and discusses the results obtained from each of the four companies using personal observation and interviews to assess the impact of IT-PMS. The research strategy adopted to obtain the findings from the four companies was descriptive (the process used was describing what happened in each company) and empirical (the data source was practical observations) approaches. However the research domain used was action research. Finally, it includes cross-case analysis between four cases as shown in Figure 1.5. The research strategy adopted to do the cross-case analysis is explanatory (the process used was explaining different themes identified in this research) and empirical (the data source was practical observations) approaches.

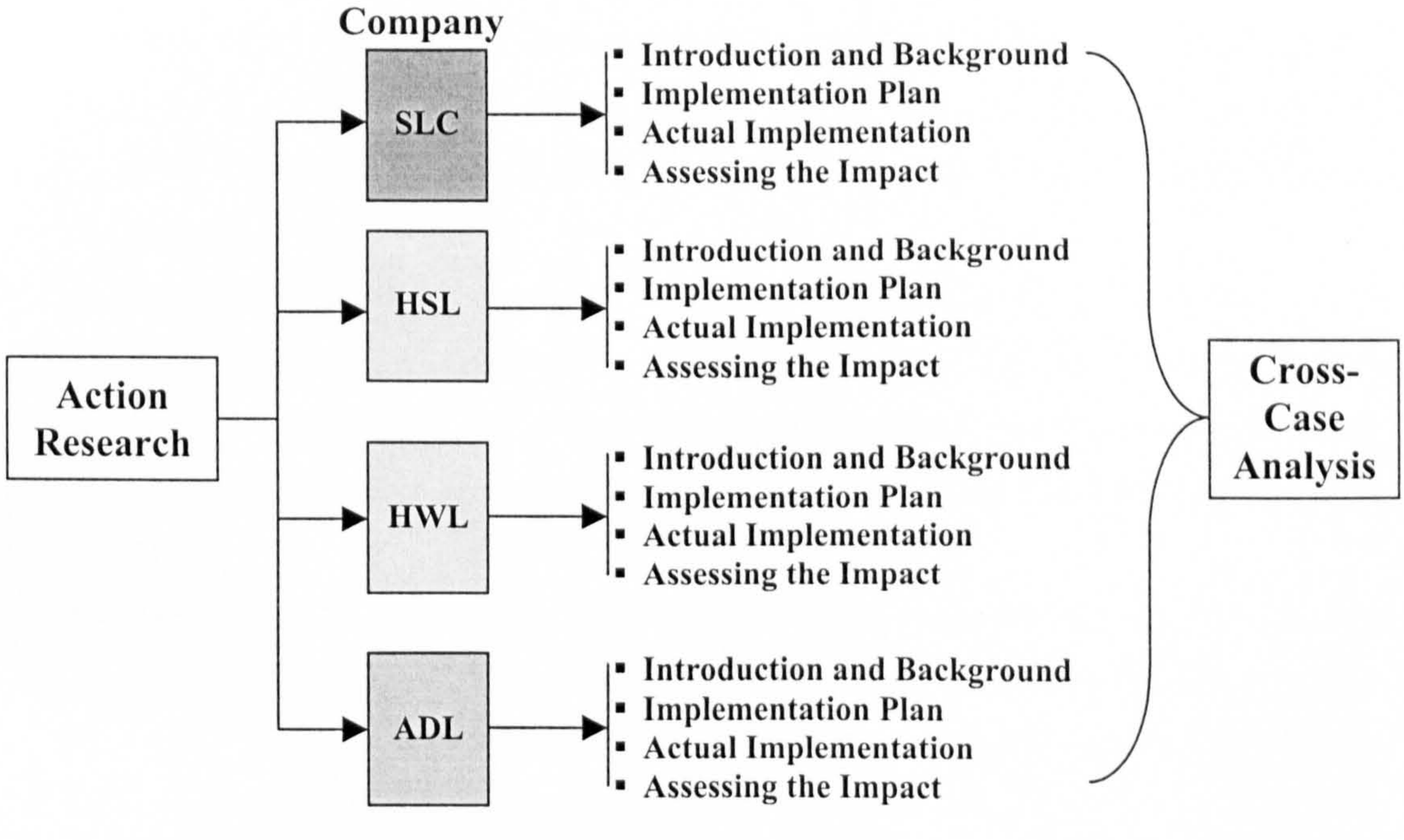


Figure 1.5 The Action Research, Results and Analysis Presented at Chapter 6

The discussion for this research is presented in Chapter 7. Initially it presents the summary of this research. It then presents a critical discussion on how the problem was initiated and

research questions were broken down. It continues to present the discussion on the research findings, including methodology. It then explains the contribution made by this research to theory and practice. Finally, it concludes the chapter by assessing this research design and outcome of this research using quality criteria defined in Chapter 5.

The limitations of this research are presented in Chapter 8. It identifies the potential possibilities of future research in this area. It also includes the personal reflections of the researcher in doing this research.

Chapter 2: Literature Review

2.1 Introduction

This research started with evidence from a number of companies, which had IT supported performance measurement systems (IT-PMS), and had a positive impact on management and business. The details of the evidence are reported in the next chapter (Chapter 3). In order to study the positive impact on business and management, it is necessary to do case studies with the companies where the evidence was found. To facilitate these studies, it is essential to do a structured literature review on performance measurement in general as well as any models or frameworks explaining the impact of performance measurement in particular. Hence the objectives of this literature review are:

- To demonstrate a critical understanding of different stages in the life-cycle of performance measurement: design, implementation and use stages
- To discuss the role of IT at each stage in the life-cycle of performance measurement

Hence the scope of this literature review is limited and structured as shown below:

- Evolution of Performance Measurement: It reports the origins of performance measurement starting from the 1940s and 50s with an industrial assault by a number of Japanese companies facing a number of quality issues, to the latest developments in performance measurement
- Design of Performance Measurement: This is the stage in which the views of customers and other stakeholders' needs are translated into business objectives and appropriate performance measures. There is enormous growing literature and understanding on this stage including several frameworks and models used for designing performance measures.
- Implementation of Performance Measurement: There is much less literature existing about this stage (Bourne et al 2000b). However a few researchers, Meekings (1995), Bourne et al (2000a), Hudson et al (1999), Bititci et al (2000) identified the main blockers and drivers of performance measurement implementation.
- Use and Review of Performance Measurement: This is also an area much less explored by researchers. The real benefit of performance measurement lies in people using these measures to assess their achievement towards achieving strategy. However there should

be a review mechanism, which ensures that these measures are not diverging from strategy.

- Impact of Performance Measurement: Identification of any models or frameworks existing in literature to study the impact of performance measurement.

2.2 Evolution of Performance Measurement

In the 1940s and 50s there was a big industrial assault by a number of Japanese companies facing a number of quality issues such as lot sizes, defects, inventory wastes, processing wastes etc (Suzaki 1987). Japan is a small country with over population and insufficient resources, hence the Japanese always aimed at reducing idle inventories (which comprises of scarce materials), storage of idle inventories (occupying their limited space), defective parts, assemblies, etc. the Japanese have then translated their solutions into a collection of tools, techniques, procedures into Total Quality Control (TQC). This combined with just-in-time (JIT), Kaizen and other productivity improvement techniques has given Japanese industry, a cutting edge decision power in Industrial Management (Schonberger 1982).

In the 1950s, the quality guru Deming recommended that the closed-loop control system, as shown in Figure 2.1 (Ho 1999), to be used to continuously monitor the performance of the business processes to identify and change the parts of the process that need improvements.

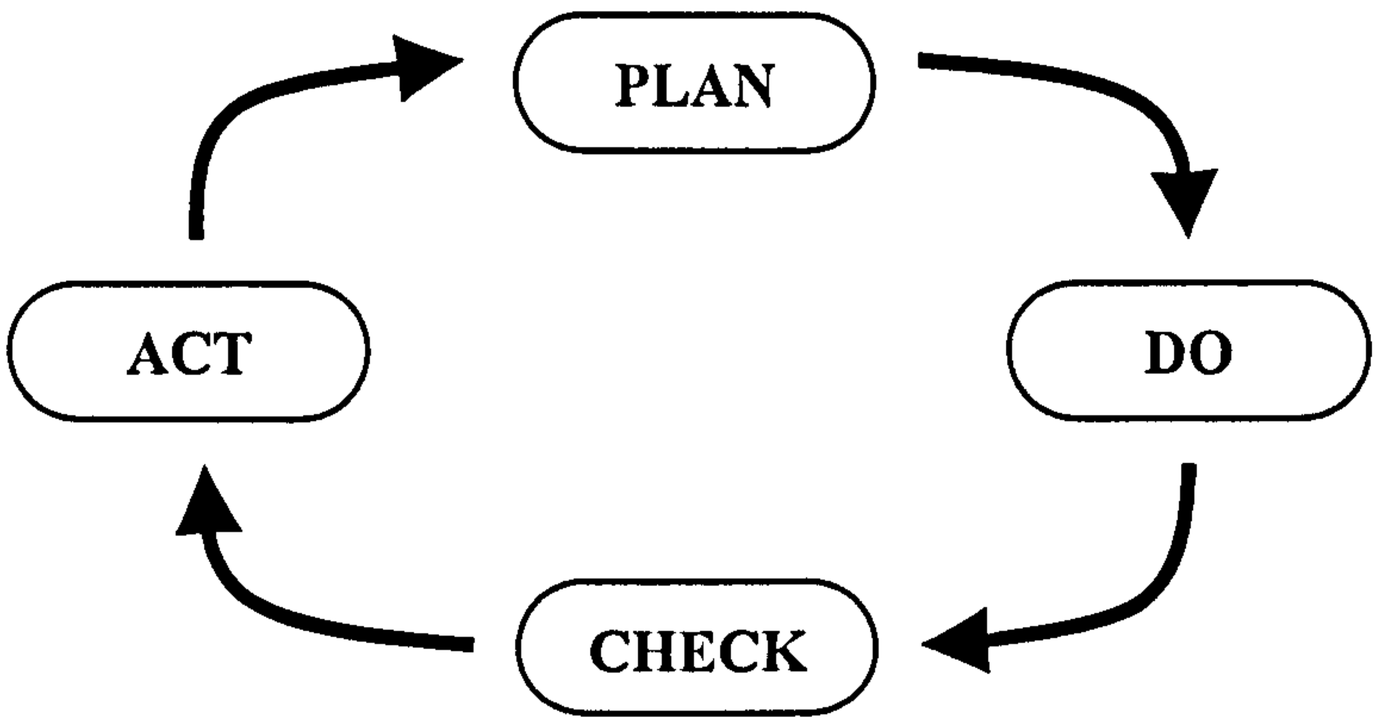


Figure 2.1 Deming's PDCA Cycle

In contrast to Japan, the Western World had a plenty of resources. Most of the manufacturing industries operate based on consumer demand for variety and change. The industries held the goods and parts in inventory in order to be responsive in the changing demand of the consumer. Prior to the 1970s, manufacturing industries in the western world based their management paradigm on its manufacturing capacity and sales (Neely et al 2002). Much of

the emphasis was kept in controlling the business with financial indicators such as sales, productivity, efficiency, ROI, etc. Hence the cost accounting and management control systems were designed based on these measures.

Western countries put much of their emphasis in innovation and caught up with major advances in Computer Aided Design (CAD), Computer Aided Manufacture (CAM), Materials Requirements Planning (MRP), etc (Imai 1986). The traditional cost accounting models developed for mass production and few standardised products were up-dated to accommodate the manufacturing environment in 1970s (Kaplan 1983). Much of the Japanese techniques have not been recognised until World War – II. All the countries in the western world, which supplied the resources to the World War – II felt the scarcity of resources. Added to this, the five-fold rise in the price of crude oil between 1970-74 led to the worldwide economic travail (Schonberger 1982).

In the 1980s recognition came in Europe and US that Japanese economic success (with limited resources) was with their operational efficiency and effectiveness (Hayes et al 1980). Japanese techniques and practices in their manufacturing firms had then widely accepted throughout the world. The cost accounting models described the production processes using extremely simplified models such as Economic Order Quantity (EOQ) (Kaplan 1984). The importance of cost of quality is questioned by many people. New dimensions of manufacturing performance such as quality, time, cost and flexibility came into the picture (Slack 1983). Hence a number of academics and practitioners recognised the need to change traditional accounting measurement systems to accommodate the new manufacturing philosophies and dimensions (Dixon et al 1990). However despite this recognition, the accounting systems in most of the companies included only financial information in their management reports.

Towards the late 80s and 90s many academics have criticised the problems with the traditional financial measures, which are internal and historical based (Hayes et al 1980, Skinner 1974, Kaplan et al 1992, Dixon et al 1990, Johnson et al 1987, Goldratt et al 1986, Keegan et al 1989, Neely et al 1995). Since then there has been a number of frameworks and models for performance measurement evolved such as Strategic Measurement and Reporting Technique (SMART) Model (Cross K F and Lynch R L, 1988-1989), The Performance Measurement Matrix (Keegan et al 1989), Results and Determinants Framework (Fitzgerald et al 1991), Balanced Scorecard (BSC) (Kaplan and Norton, 1992, 1996 & 2000), Cambridge

Performance Measurement Systems (CPMS) Design Process, (Neely et al, 1996), Integrated Performance Measurement System (IPMS), a reference model (Bititci and Carrie, 1998), Performance Prism (PP) (Neely and Adams, 2001), Business Excellence Models etc.

Other research programmes, and to a certain extent consultancy organisations, also developed approaches, procedures and guidelines for developing and designing effective performance measurement systems (Doumeingts et al, 1995, Krause 1999). There have been several other initiatives for developing and defining performance measures for various business areas and processes, including performance measures for production planning and control (Kochhar, 1996), performance measures for the product development process (Oliver, 1996) performance measures for planning and control (Oliver Wight inc, 1993).

Neely (1999) reports that from 1994 to 1996, there were more than 3600 articles published on performance measurement, which he uses to describe a revolution in the business. According to Neely et al (1995), performance measurement is the process of quantifying effectiveness and efficiency of actions. What is the purpose of performance measurement? Its purpose is to monitor and improve the performance of these actions on a continuous basis. Waggoner et al (1999) argued that performance measurement in business serves the purposes of monitoring performance, identifying the areas that need attention, enhancing motivation, improving communications and strengthening accountability. Neely (1995) defines performance measurement system as the set of metrics used to quantify both the efficiency and effectiveness of actions. Lebas (1995) characterises performance management system as the philosophy supported by performance measurement. It is the organisation-wide shared vision, team work, training, incentives etc. that surround the performance measurement activity. It is the application of information and knowledge arising from performance measurement system (Adair et al 2003).

Holloway (2001) reports that much of the literature exists on particular models and frameworks for performance measurement but they do not include the many evidences of failed systems describing and analysing the problems of performance measurement. However a state of art review in "business performance measurement" done by Adair et al (2003) has demonstrated that empirical research is comprised mostly case studies and survey methods, with very few progressive research methods. Methods such as path analysis and action research have been used by handful of investigators (Neely 2000 and Bourne 2000a&b). Bourne et al (2000b), proposed a three-stage model for the development of performance measurement systems as shown in Figure 2.1. There has been constant

development in designing performance measurement. However, implementation and use of performance measurement has received considerable attention in recent years (Kennerly et al 2003, Nudurupati et al 2003, Bourne et al 2000a,).

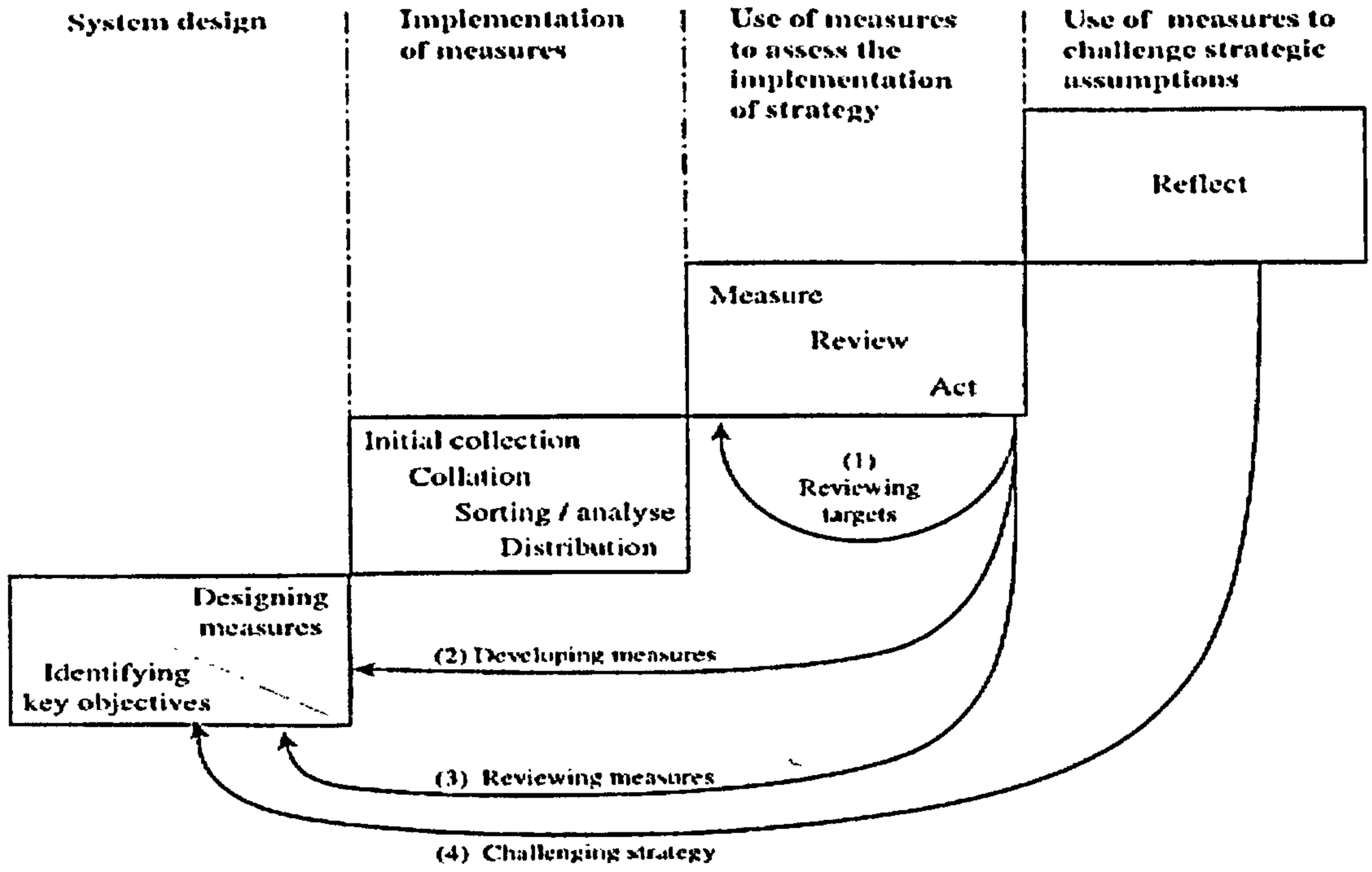


Figure 2.2: Phases in Developing a Performance Measurement System *(Source: Bourne et al, 2000b)*

There is a need for a systematic closed-loop approach that promotes improvement on a continuous basis. Deming proposed that business processes should be analysed and measured to identify the sources of variations that cause processes to deviate from customer requirements. Deming also recommended that the closed-loop control system should be used by managers to continuously monitor the performance of processes (business and manufacturing) to identify and change the parts of the process that need improvements. Bourne's three-stage model for performance measurement together with Deming's PDCA cycle for continuous improvement are illustrated together with its performance measurement implications as shown in Figure 2.3.

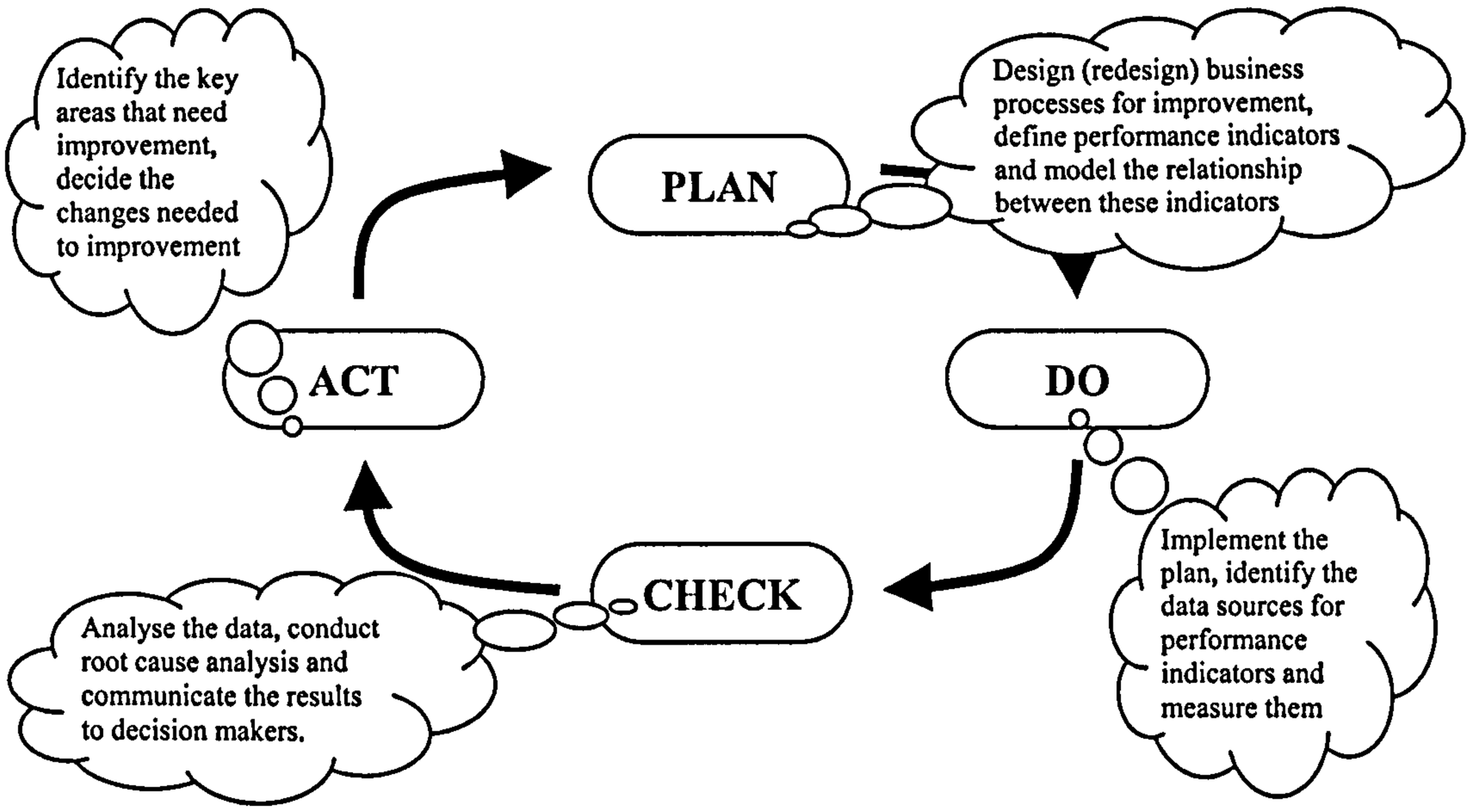


Figure 2.2: Deming's PDCA Cycle *(Source: Bititci et al, 2002b)*

These three stages of performance measurement: design, implement and use are discussed as follows.

2.3 Designing Performance Measurement

The performance measurement revolution started in the late 1970's and early 1980's with the dissatisfaction of traditional backward looking accounting systems (Kaplan et al 1992, Dixon et al 1990, Johnson et al 1987, Skinner 1974). Since then, a number of frameworks as well as tools and techniques have been developed for designing performance measurement, some of which are listed below:

- Active Monitoring (Turner and Bititci 1999)
- Balanced Scorecard (Kaplan and Norton 1992 & 1996)
- Cambridge Performance Measurement Systems Design Process (Neely et al 1996)
- Deming Award (Ho 1999, Oakland 2003)
- European Foundation for Quality Management (EFQM) Excellence Model (EFQM 1999)
- Integrated Dynamic Performance Measurement System (IDPMS) (Ghalayini et al 1997)
- Integrated Performance Measurement System Reference Model (Bititci et al 1998)
- Malcolm Baldrige Award (Ho 1999)
- Performance Measurement Questionnaire (Dixon et al 1990)

- Performance Prism (Neely et al 2001)
- Strategic Measurement and Reporting Technique (SMART) Model (Cross K F and Lynch R L 1989)
- Quantitative Methods for PMS (Suwingnjo et al 1998)

The major performance measurement frameworks, which made a significant impact in this field, are:

2.3.1 Strategic Measurement and Reporting Technique (SMART) Model

(Cross K F and Lynch R L, 1988-1989)

It supports a four level pyramid of objectives and measures that ensures an effective link between strategy and operations by translating strategic objectives from top down and measures from bottom up as shown in Figure 2.4

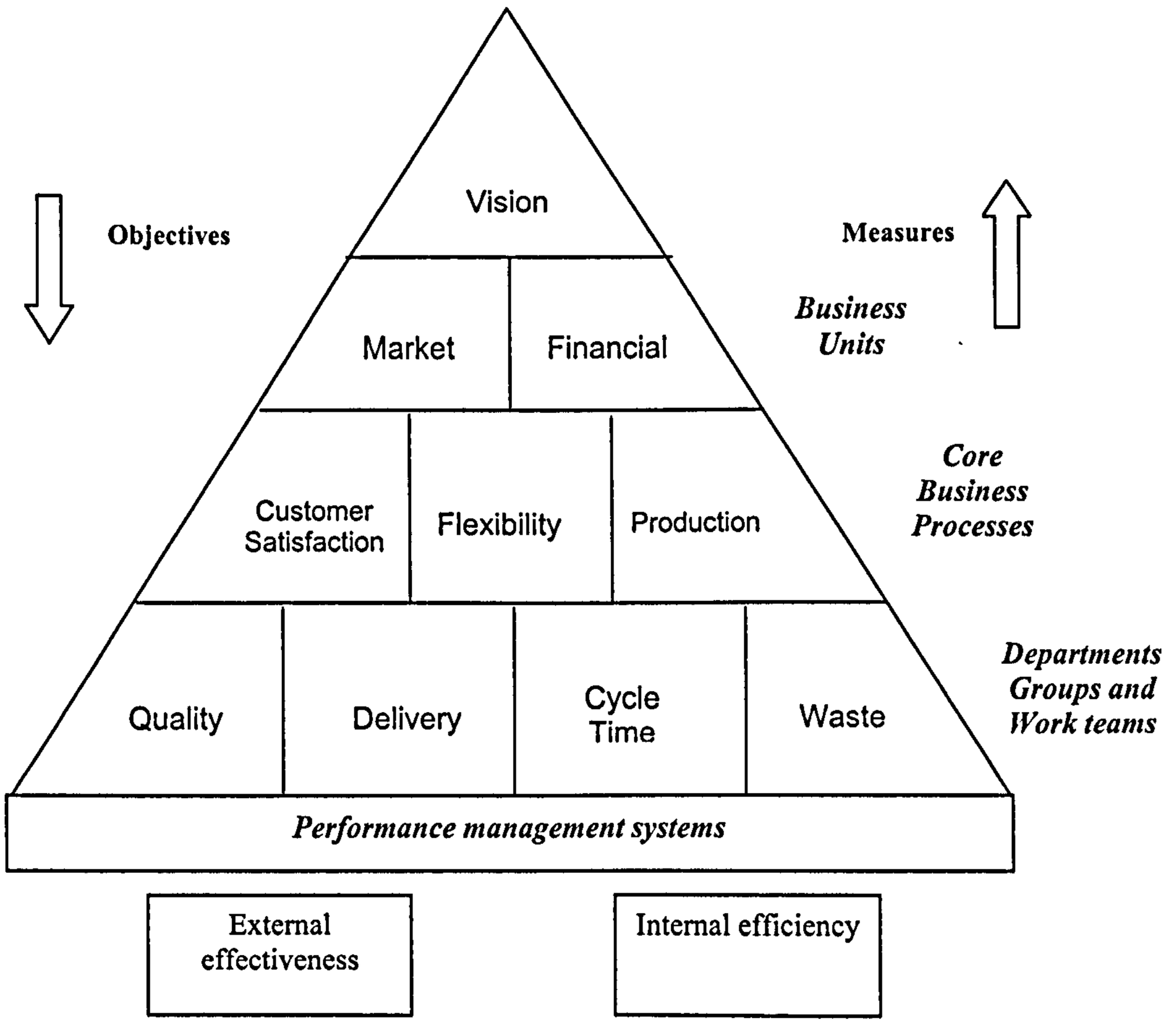


Figure 2.4: SMART Pyramid Model

At the top level, a vision for the business is articulated from both the internal and external environment. At the second level the objectives of each business unit are defined in terms of market and financial issues. Based on these objectives strategies are formulated. At the third level, the operating objectives and priorities are defined for the important success fronts: Customer Satisfaction, Flexibility and Production. At the fourth level, the last one, more specific operation criteria are defined such as Quality, Delivery, Cycle Time and waste for each department. It cascades the measures down the organisation in such a way that the measures at department level reflect the vision created at top level.

This framework illustrates how the performance measures are cascaded from the corporate vision to the shop floor. It also makes the performance indicators relevant at various levels of business, for instance, financial and market share indicators are only relevant at top levels, which are cascaded into customer satisfaction, flexibility and production at the next level, which are further cascaded into quality, delivery etc.

However, the framework does not put any emphasis on creating a strategy for the business. It does not take into consideration the external fluctuations such as competitors' positions, external benchmarks etc. It does not model any inter-relationships between different performance indicators (both leading and lagging). It does not have an audit tool for finding the relevance of various measures from time to time.

2.3.2 The Performance Measurement Matrix

(Keegan et al 1989)

The framework starts with strategy by defining the strategic objectives of the company. These objectives are converted into divisional and functional goals. These goals are translated into overall performance measures, which are hierarchical as well as integrated across business functions. These measures should be more specific as they extend down towards operational levels. Finally, these measures are populated into a matrix as shown in Figure 2.5.

The performance measures are basically classified as internal or external, cost based or non-cost based. The basic idea behind the matrix is to make performance measures support the company's multidimensional environment. The authors kept an emphasis that performance measures must be based on a thorough understanding of cost relationships and cost

behaviour. It also argues that the performance measurement system must be revised regularly to report or eliminate the wrong measures.

However, the framework does not put any emphasis in creating a strategy for the business. It does not model any inter-relationships between different performance measures (both leading and lagging). Even though it puts emphasis on finding the relevance of measures from time to time, it does not include an audit tool for finding the relevance of the measures from time to time.

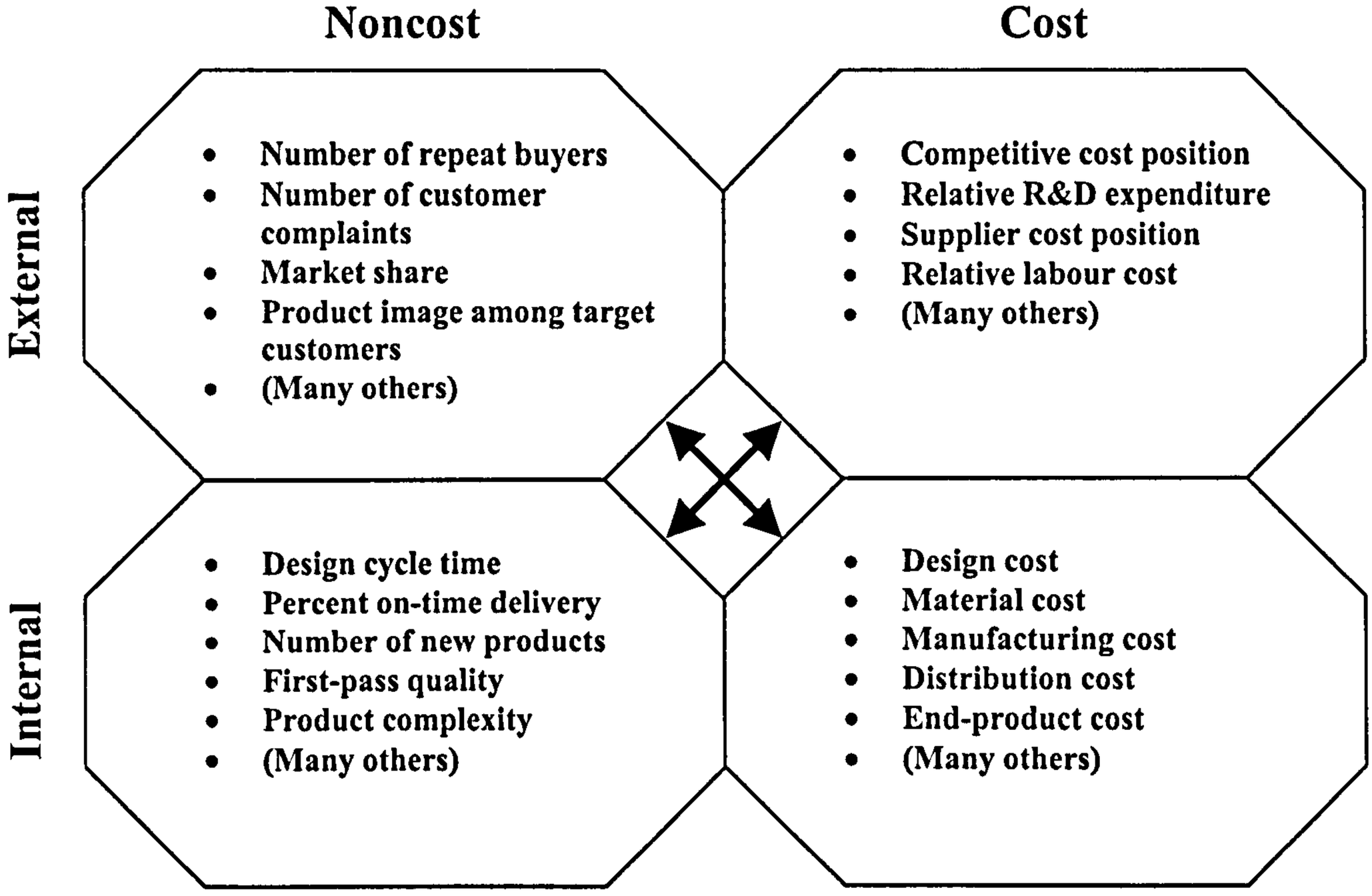


Figure 2.5: Supportive Performance Measures *(Source: Keegan et al 1989)*

2.3.3 Results and Determinants Framework

(Fitzgerald et al 1991)

The framework identifies that both financial and non-financial measures should be used to assess the health of organisations. According to the authors, financial performance and competitiveness are the results of the actions taken in the past, but the other four dimensions, quality, flexibility, resource utilisation and innovation are the factors that determine the competitive success now and in the future. Some of these measures under each dimension are shown in Figure 2.6

It includes both internal and external measures as well as leading indicators (determinants) and lagging indicators (results). It puts more emphasis on quality. The authors believe that if there are any improvements in quality, it is usually reflected in their financial results.

	Dimensions of performance	Types of measure
RESULTS	**Competitiveness**	• Relative market share and position • Sales growth • Measures of the customer base
	Financial	• Profitability • Liquidity • Capital structure • Market ratios
DETERMINANTS	**Service quality**	• Reliability • Responsiveness • Aesthetics/appearance • Cleanliness/tidiness • Comfort • Friendliness • Communication • Courtesy • Competence • Access • Availability • Security
	Flexibility	• Volume flexibility • Delivery speed flexibility • Specification flexibility
	Resource utilisation	• Productivity • Efficiency
	Innovation	• Performance of innovation process • Performance of individual innovations

Figure 2.6: The Results and Determinants Framework *(Fitzgerald et al 1991)*

However, the framework does not put any emphasis in creating a strategy for the business. It does not model any inter-relationships between different performance indicators (both leading and lagging). It does not insist on finding the relevance of measures from time to time, it does not include an audit tool for finding the relevance of various measures from time to time.

2.3.4 Balanced Scorecard (BSC)

(Kaplan and Norton, 1992, 1996 & 2001)

It is a widely accepted framework. It begins with the proposition that financial measures are not sufficient to manage a business organisation. Financial measures only tell the story about the past. They are not helpful, when improving the value created through investments in customers, suppliers, employees, technology, etc. Hence the Balanced Scorecard framework was constructed to complement measures of past performance with measures of the drivers of future performance. The objectives and measures of the scorecard are derived from an organisation's vision and strategy.

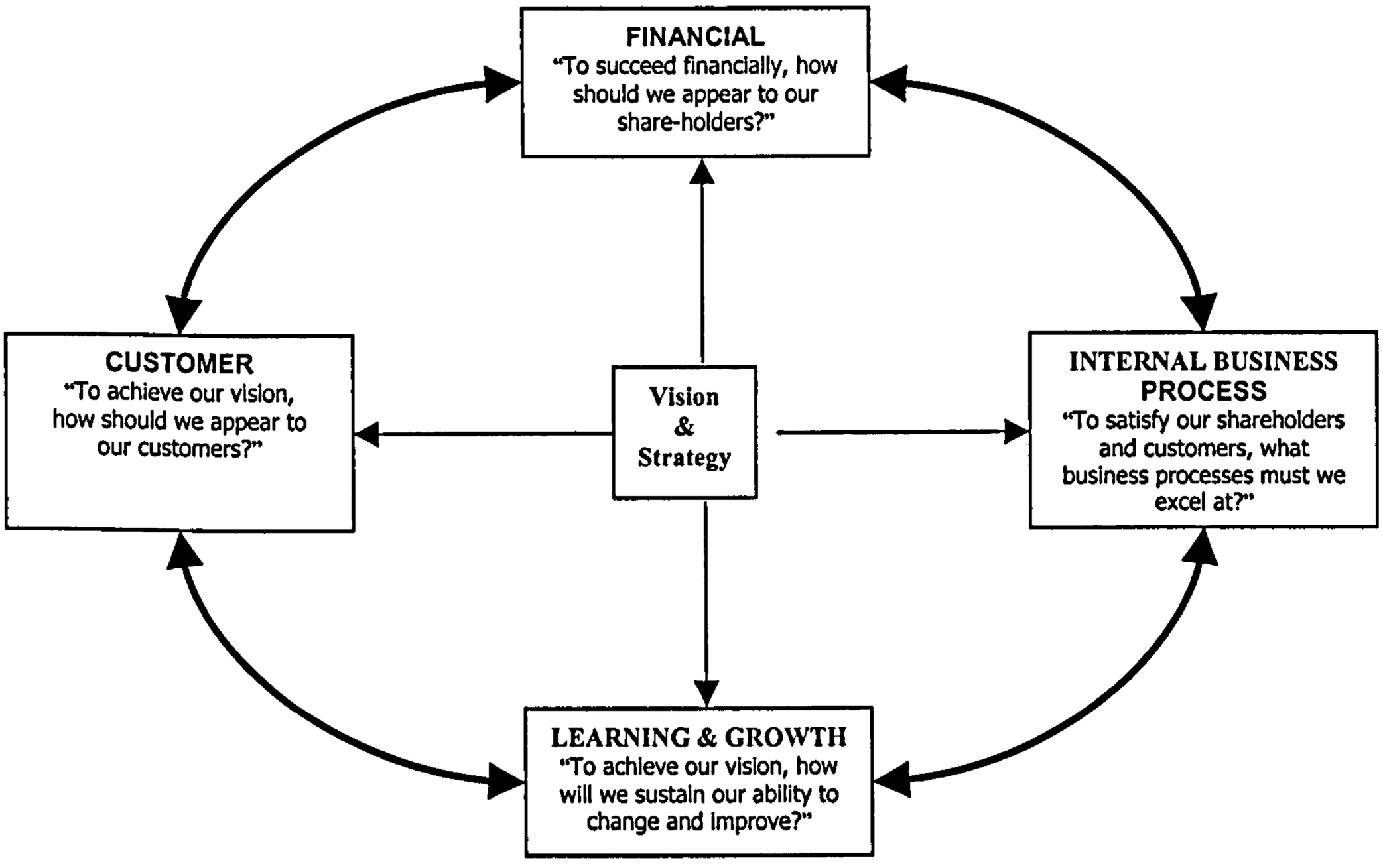


Figure 2.7: Balanced Scorecard *(Kaplan and Norton, 1992)*

It includes a set of measures that gives top managers a comprehensive and balanced view of the business by including financial measures, customer satisfaction measures, internal business process measures and learning and growth measures as shown in Figure 2.7. Although it was developed originally in the early 90s, since then it has evolved considerably.

Later versions of Balanced Scorecard included the cause and effect relationships between various performance indicators (both leading and lagging) defined under different views as illustrated by a simple example of a low cost airline with RONA as one of the main target indicators to improve, as shown in Figure 2.8 (CIMA, 2001). In this way, Balanced

Scorecard includes modelling the effect of relationships between financial lagging indicators and non-financial leading indicators.

However, Balanced Scorecard does not put much emphasis on competitor analysis when making a strategy. This is very important in this volatile business environment, in order to be ahead of all competitors. Since it includes cause and effects relationships, it results in very large numbers of indicators that are very difficult to maintain and require a greater deal of effort, unless it has IT support. It does not have an audit tool for finding the relevance of various measures from time to time.

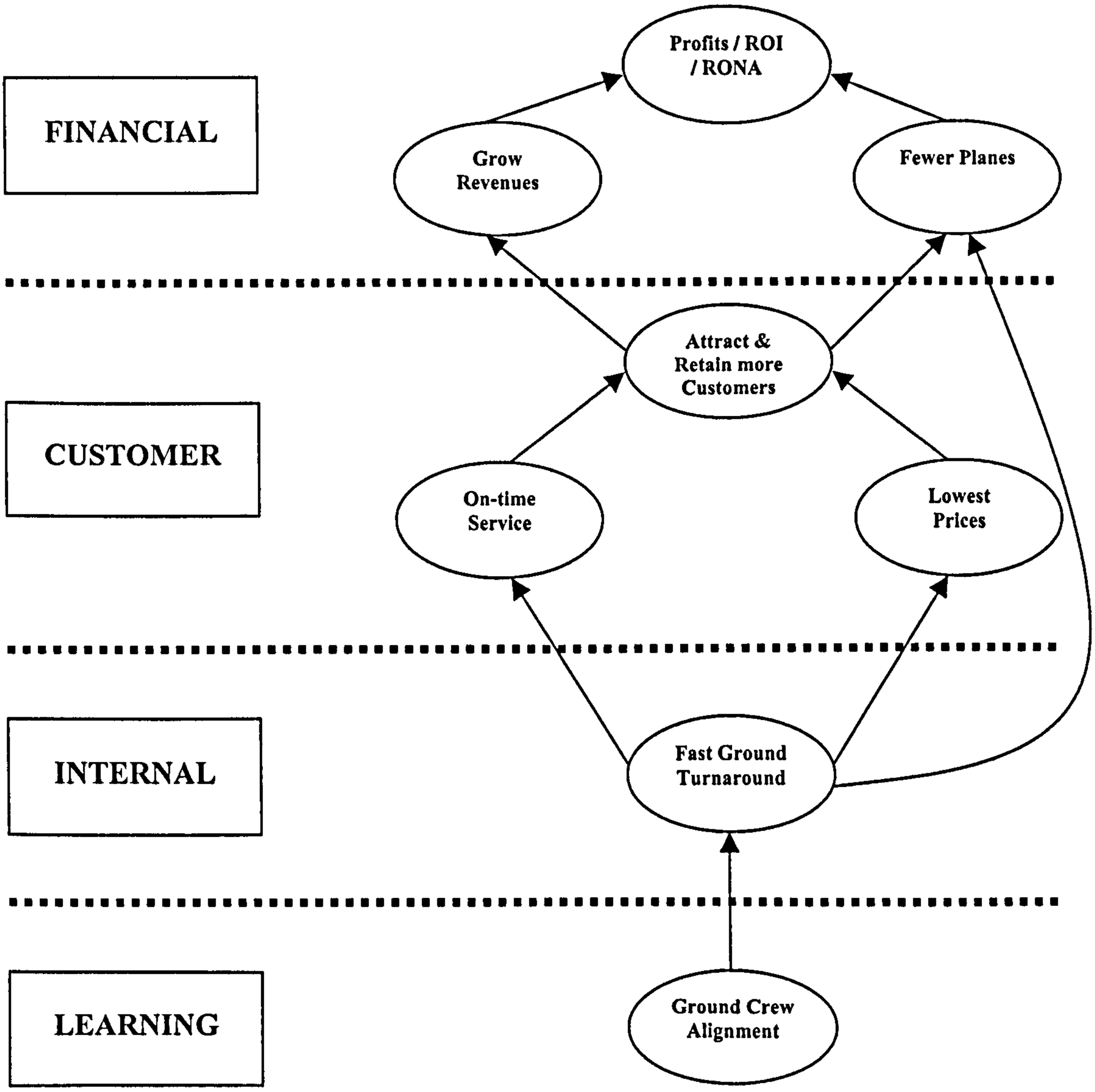


Figure 2.8: Strategic Theme – Operating Efficiency *(CIMA, 2001)*

2.3.5 Cambridge Performance Measurement Systems (CPMS) Design Process,

(Neely et al, 1996)

It is widely known as a workbook "Getting the measure of your business". It is developed to identify, design and implement a balanced set of performance measures. It is explained as a process of performance measurement system design. The framework includes four sections:

- ***Process overview***: It includes several questions such as what is involved, how long will it take, how much resources will it consume, what benefit will be there? The information on these questions are captured in this section.
- ***Selecting a facilitator***: It includes a guide designed to decide the facilitator required for launching this process.
- ***Launching the process***: It collects input from several people in the organisation, on "as-is" situation of the performance measurement system and "to-be" situation of the performance measurement system. It also contains several tools and techniques to launch this process.
- ***The workbook***: It is a guide, which is divided into two phases:
  - ***Phase 1*** Includes how to identify, design and implement a balanced set of top-level measures for the business.
  - ***Phase 2*** Explains how these top-level measures can be cascaded through the organisation so that appropriate local performance measures are developed.

Unlike other frameworks, it includes a detailed process of identifying performance measures from the objectives of business units, design them and implement them. It also identifies the performance measures for the key drivers and ensures that both these performance measures and key drivers are properly aligned with objectives of the business units. It can also be used as an audit tool for finding the relevance of different performance indicators from time to time.

However, it does not put much emphasis on creating strategy and competitor analysis while developing strategy. Competitor analysis is very important in this volatile business environment, in order to be ahead of all competitors. It also does not model relationships between different performance measures.

2.3.6 Integrated Performance Measurement System (IPMS), a reference model

(Bititci and Carrie, 1998)

The structure of the reference model is classified at four levels, the business, business units, business processes and activities as shown in Figure 2.9.

The business level represents the entire business, which consists of logical or physical business units. The business unit is defined as a portion of organisation, which services a particular market segment with particular competitive requirements. Each business unit in turn consists of a number of business processes such as core processes, support processes. These processes, in turn, consist of a number of activities. At each level of the organisation, the model breaks down into four key elements:

- Stakeholder requirements
- External monitor
- Objectives
- Performance measures

Unlike other models, this model puts more emphasis on developing the objectives based on stakeholder requirements and external monitoring, which are very important in the volatile business environment. It also includes an audit workbook to find the relevance of performance indicators from time to time.

Even though the framework ensures that the performance indicators at all levels are aligned with objectives and strategies of the business, however, the reference framework does not model any relationships between different performance indicators (both leading and lagging).

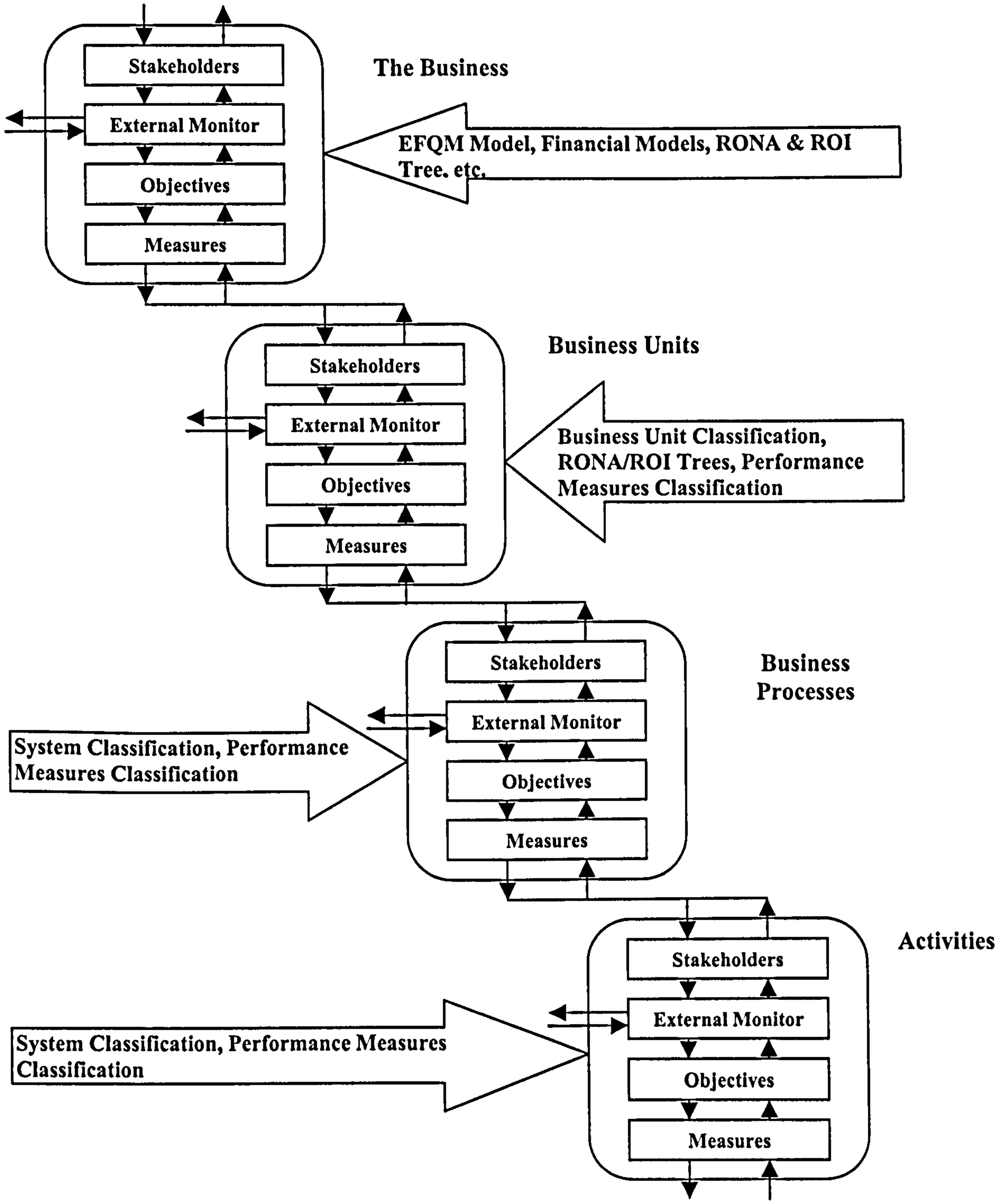


Figure 2.9: Integrated Performance Measurement System Reference Model *(Bititci and Carrie, 1998)*

2.3.7 Performance Prism (PP)

(Neely and Adams, 2001)

It is a multi-faceted performance prism framework, which has five facets. The top and bottom facets are stakeholder satisfaction and stakeholder contribution respectively. The other three sides of facets are strategies, processes and capabilities as shown in Figure 2.10.

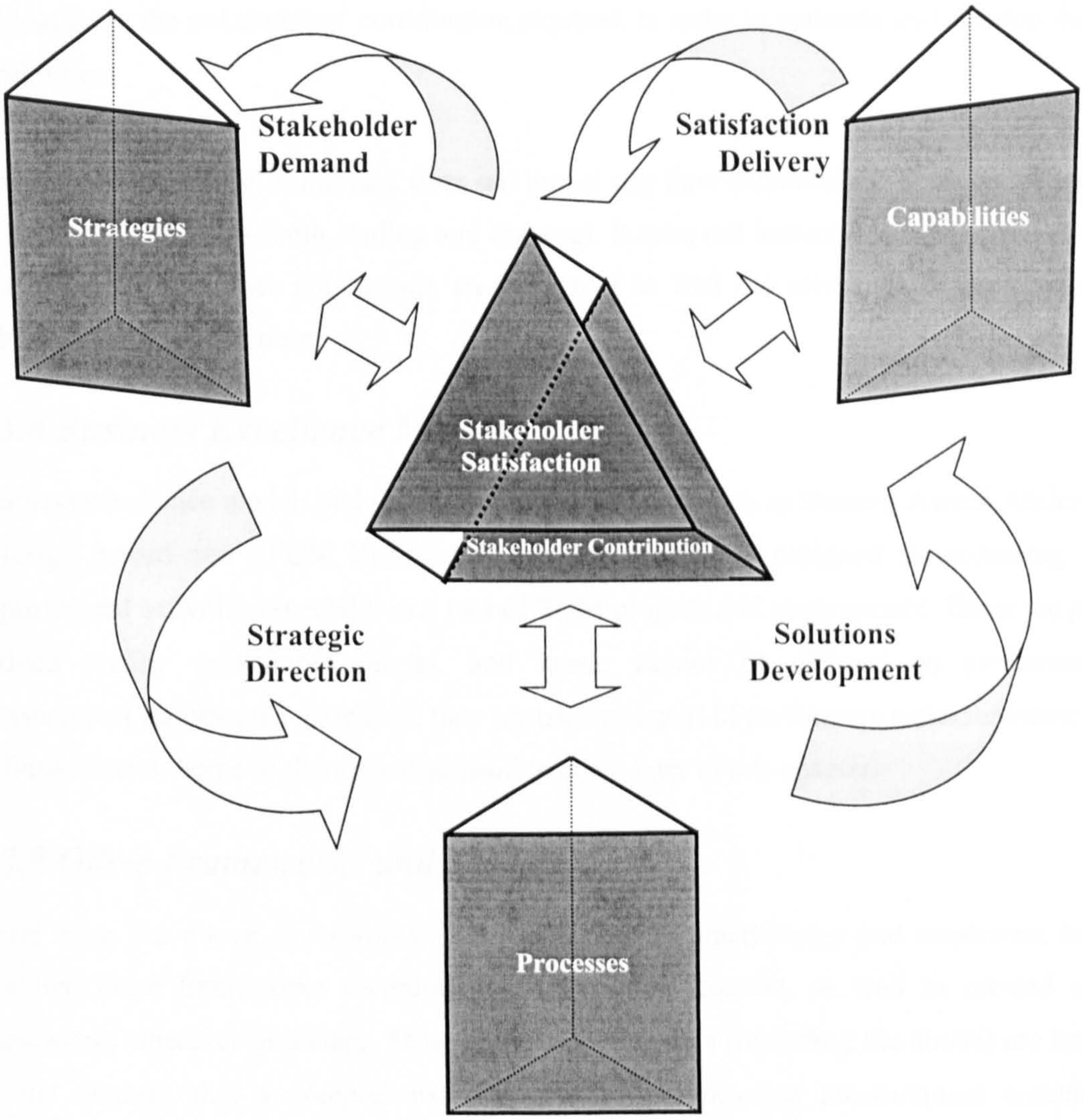


Figure 2.10: Performance Prism – Delivering Shareholders Value *(Neely and Adams, 2001)*

- ***Stakeholder Satisfaction***: Who are the key stakeholders and what do they want and need?
- ***Strategies***: What strategies do we have to put in place to satisfy the wants and needs of these key stakeholders?
- ***Processes***: What critical processes do we require if we are to execute these strategies?
- ***Capabilities***: What capabilities do we need to operate and enhance these processes?

- *Stakeholder Contribution*: What contributions do we require from our stakeholders if we are to maintain and develop these capabilities?

It also puts more emphasis on stakeholder requirements like IPMS. Unlike other frameworks, it put more emphasis not only in aligning processes with their strategies but also in aligning capabilities required to operate these processes. It also includes a new dimension in identifying the stakeholders' contribution required, in order to maintain and develop these capabilities.

However, the reference framework does not model any inter-relationships between different performance indicators (both leading and lagging). It does not include emphasis on external monitoring. It also does not include an audit tool to find the relevance of performance indicators from time to time.

2.3.8 Business Excellence Models

Business excellence models and quality award frameworks such as Deming Award, Malcolm Baldrige Award and EFQM Business Excellence model are designed for assessing the improvement activities especially as a part of TQM projects and programmes. These are pre-defined readily measurable results, and hence cannot be claimed as performance measurement frameworks. However, they are used as a part of performance measurement for self-assessment. Some of them are discussed in detail later in this chapter.

2.3.9 Other Frameworks and Models

Apart from the above frameworks, many consultants, practitioners and academics have modified these frameworks according to the practical context, as well as created new frameworks wherever necessary. Most of these frameworks (including the above) are based on the concept that a comprehensive system of performance measurement combines financial and non-financial measures in the right proportion in the right way (Reilly et al 2001, Davis et al 1997, Neely et al 1996, Kaplan and Norton 1996 and 1992, Eccles et al 1992).

On the other hand system dynamics is an approach that changes the way businesses are managed by focusing on what is happening outside and inside the organisation (Davis et al 1997). It creates a clear statement of objectives and uses influence diagrams to map out the business activities and objectives. Later, the model is built in a computer to identify the key

activities, the so-called key performance drivers and then develop the ways of measuring them.

2.4 Implementing performance measures

Most of the literature existing in performance measurement includes defining performance measures, or aligning performance measures to the strategy or performance measurement systems, etc. From these approaches, managers will know what to measure, but there is little systematic and evidence based literature existing in assisting the implementation of these measures (Neely et al 2000, Bourne et al 2000b).

There are many practical implementations of these measures and systems in the companies. However there is not much literature existing for organisation in discussing the various issues in implementing performance measures, to improve an organisation's market position. The following sections discuss some of these issues.

In many companies, metrics / indicators are too poorly defined (Schneiderman 1999), which creates a lot of misunderstanding by different people. Hence, for each indicator, it is advised that a performance measure record sheet is used to record the definition of the performance measure. It is designed to make managers think about why this aspect of performance is being measured and the link between the performance measure and the business objective, which the organisation is trying to achieve. It should also contain information on the formula, target, measurement and action (Bourne et al 1998, Neely et al 1996) as shown in Figure 2.11.

Once the above information is captured for each measure, according to Bourne et al (2000b), Marr et al (2002), Nudurupati et al (2000 and 2003) each measure is implemented with the following tasks:

- **Data Creation:** It is the raw data captured or recorded at source. However companies capture different data sets at different sources using, hard copies, IT, etc.
- **Data Collection:** It is the collection of raw data required to measure the performance indicators defined.
- **Data Analysis:** It is the conversion of the collected raw data into useful information, in the form of trend charts, comparison charts, reports, statistical analysis, etc.

- **Information Distribution:** It is the communication of this information to the right people in the business for assisting decision-making.

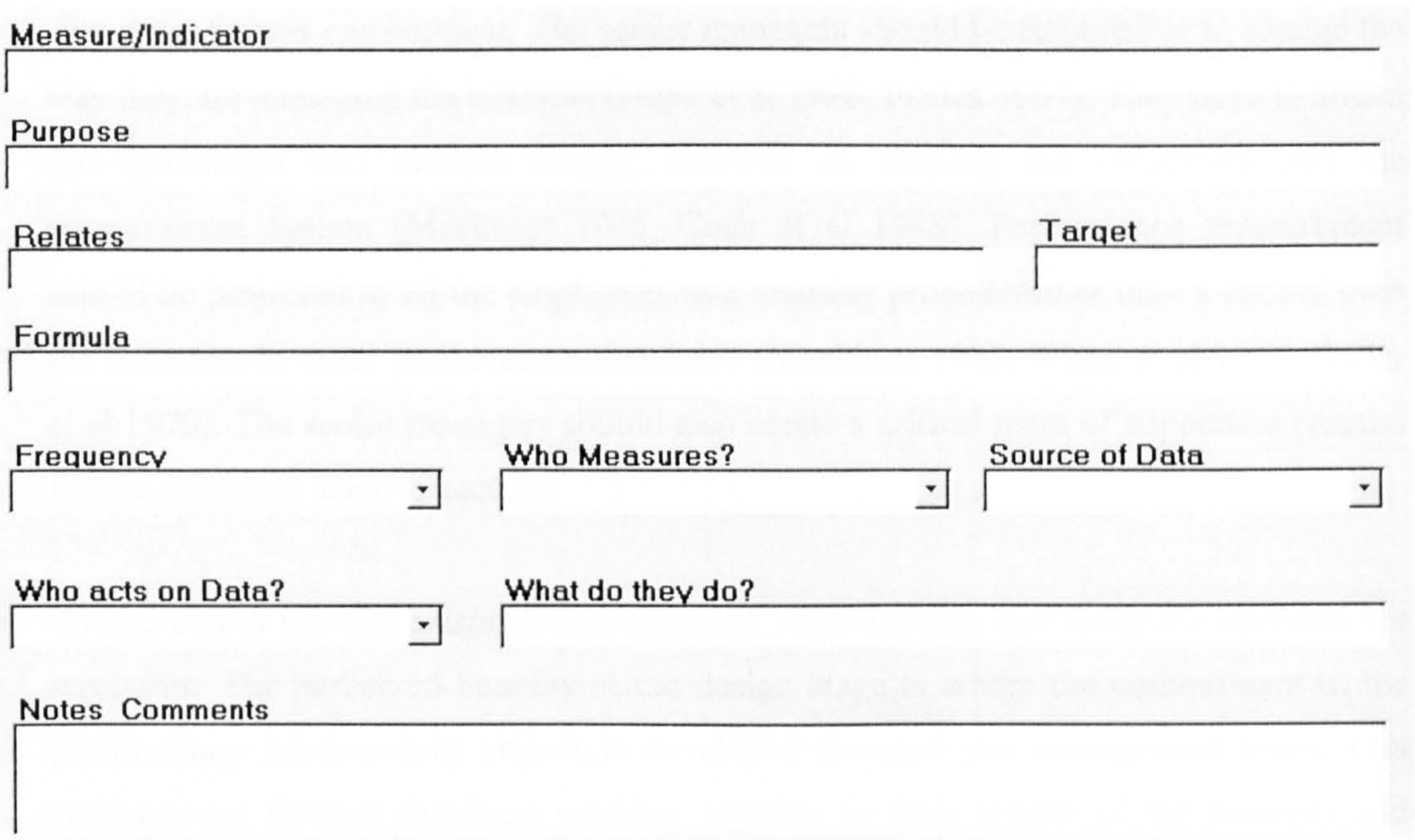


Figure 2.11: Implementing Performance Measures

All these tasks are mechanistic in nature requiring hard aspects such as manual procedures or software programs to be written to provide the information automatically.

However, if we consider soft aspects of performance measure implementation, there will be several factors affecting the implementation. According to Lewin's (1947) force field analysis technique, there will be two forces, namely drivers and blockers for any implementation of techniques or technology in an organisation. Lewin's (1951) three-phase model suggests to decrease or eliminate the barriers before implementing and increase the drivers after implementing for a successful management change (or implementation). To bring about this change, it does not suffice to consider one property, the total circumstance has to be examined in reality (context and process). These emergent changes can only be realised in action (Orlikowski 1996).

A five-year action study of the implementation of performance measurement systems by Bourne (2001) concluded that there were two main drivers and four blockers as key forces that drive successful implementation.

The two main drivers were:

- *Top management commitment:* The senior managers should be responsible to change the way they are managing the business (Hope et al 1998, Eccles 1991). They have to attend the workshops and become deeply involved in shaping the objectives and the measurement system (Meekings 1995, Coch et al 1948). Performance measurement should be projected to all the employees as a learning process rather than a control over the business, in order to overcome resistance (Meekings 1995, White et al 1991, Kotter et al 1979). The senior managers should also create a critical mass of supporters (teams) for the system to achieve success.

- *The perceived benefits arising from designing, implementing and using the performance measures:* The perceived benefits at the design stage is where the commitment to the performance measurement project is developed amongst the management team. This comes about through the team working together in their review of the business and development of the performance measures. The next stage of implementation includes tasks that are mechanistic in nature requiring either new manual procedures to be implemented or computer programs to be written to provide the information automatically (Eccles 1991). The automation reduces the amount of time required in the collection of data, converting it to information and communicating it to the internal and external users (Woods 2001). Finally, using performance measures, results in gaining a clearer view of performance, being able to assess how well the strategy has been implemented, creating a map of real drivers of performance, etc.

The four main blockers were:

- *The time and effort required:* Managers are always busy with many conflicting demands on their time. Managers naturally attend to the most pressing crisis, apparently promising project (Simons 1998). Performance measurement is just another demand and hence the benefits have to be worth the effort required. This is a major factor in performance measurement project failures.

- *The difficulty of implementing the measures caused by inappropriate information being available from the IT systems:* In most of the companies often the data is not available or

is not in the format required. Then there is the problem of presentation. Measures have much greater effect if they appear in the form of a graph and many systems do not automatically present the data in this format.

- *Resistance to performance measurement:* Resistance is prevalent when the employees are uncertain about the outcome of implementing new technology (Waddell et al 1998, Macrosson 1998, Meekings 1995, McNurry 1973, Sayles et al 1966). According to Meekings (1995) there will always be some resistance to performance measurement in most companies due to the fear of personal risk. In organisations that are highly politicised or have a strong 'blame culture' or show 'favouritism' the resistance can be severe (Waddell et al 1998, Orlikowski 1996, Ansoff 1988) preventing the implementation of the performance measures.

- *New parent company initiatives:* In many subsidiary companies, the performance measurement fails because of the parent company removing the resources necessary for performance measurement, assigning new higher priority projects, and other unintentional fluctuations such as restructuring the company, changing the strategy quite often, will make the existing measures obsolete.

2.5 Using performance measures

Providing performance information is not sufficient to improve business performance results. The real success lies in peoples' behaviour in using this performance information (Prahalad et al 2002, Davenport 1997, Eccles 1991). Many executives and academics believe that the main reason, why performance measurement is short lived is because of the employees' behaviour with the information (Bititci et al 2002a, Marchand et al 2000b). Meekings (1995) argues that making people use measures properly not only delivers performance improvement but also becomes a vehicle for a cultural change, which helps in liberating the power of the organisation.

In this ever-changing business environment companies are becoming more dependent on sharing and using performance information dynamically and hence becoming more knowledgeable and proactive. However, the performance information behaviour of the business lies in one or more of the following factors as shown below:

- Drive from the senior management (Bititci et al 2002a, Marchand et al 2000b, Feeny et al 2000, Bourne et al 2000a, Hudson et al 1999)
- Communicating strategy throughout the company in the form of relevant performance measures (Bourne 2001)
- Employees using the performance information for identifying business trends (Feeny et al 2000, Donovan 1999, IFAC 1999, Orlikowski 1996)
- Employees using the performance information for decision making (Lebas et al 2002, Marchand et al 2000b, Donovan 1999, Orlikowski 1996)
- Employees not being resistant in using performance information (Markus 2000, Battista et al 2000, Waddell et al 1998, Macrosson 1998, Orlikowski 1996)
- Proper training provided for the people in using performance information (Marchand et al 2000b, Markus 2000, Macrosson 1998)
- Empowering people in making decisions based on performance information (Badham et al 2001, Macrosson 1998, Schein 1996, Schaffer et al 1992)
- Stimulating the actions required for improving key areas (Bourne 2001, Bititci et al 2002b)

Just as the strategy for the company changes dynamically based on external fluctuations, the relevant performance measures/indicators should also be reviewed to sustain their relevance with the strategy (Bourne et al 2000b, Dixon et al 1990). Hence a performance measurement system should include an effective mechanism for reviewing targets (Ghalayini et al 1996) and a process for developing measures or indicators as circumstances change (Meekings 1995, Dixon et al 1990, Maskell 1989). Many people also developed audit tools to find out the relevance of performance indicators defined for the business (Bititci et al 1998, Neely et al 1996)

2.6 Impact of Performance Measurement

Cost of measurement is a predominant issue in performance measurement literature. This concern is not only exclusive to data collection, analysis and communication, but also exclusive to high level of both technical and managerial expertise required, new information technology requirements, ongoing maintenance costs, training costs, etc. (Adair et al 2003). Some of the businesses recognise performance measurement to be a luxury and unnecessary because success and failure were obvious. The labour cost for the conceptual part can reach a level where it becomes difficult to claim that the benefits of performance measurement clearly exceed the yield (Kueng et al 1999). In many cases, this will make organisations

deciding in poor investment decisions, or an over cautious approach that may result in missed opportunities. Having seen the difficulty of correlating between the performance measurement investment and its yield (Holloway 2001), it is necessary to demonstrate the impact of performance measurement (not necessarily in tangible terms) to ensure organisations to resort their investment decisions.

As of now there was only very limited solid research reported in identifying the impact of performance measurement (Bititci et al, 2000 and 2002a, Holloway, 2001 and Neely, 2002). Busby (2000) and Holloway (2001) argue that performance measurement is simply and un-questioned belief that it leads to positive improvement. Very few researchers focused on quantifying the impact or change in the organisations as a result of performance measurement implementation (Mooraj et al 1999). McAdam et al (2001) argues that there are two difficulties in studying the effectiveness of performance measurement. The first one is in determining the direction of causality of impact and the second one is a tendency to attribute any and all organisational improvement to the performance measurement system. Holloway (2001) argues that new management approaches come and go more quickly than they can be evaluated or assessed.

Waggoner et al (1999) argued that performance measurement impacts the business in monitoring performance, identifying the areas that need attention, enhancing motivation, improving communications and strengthening accountability. However there are frameworks and models available in literature, which can also be used to give some insights in terms of where the potential impact of IT-PMS can be on business and management.

2.6.1 EFQM Model

The EFQM Excellence Model (EFQM 1999) as shown in Figure 2.12 is a tool that helps organisations by measuring their current level of performance and helps them identify and understand the gaps. Organisations use these outputs from the assessment as part of their business planning process. However, the key areas in which the business impact/improvement assessed is as follows:

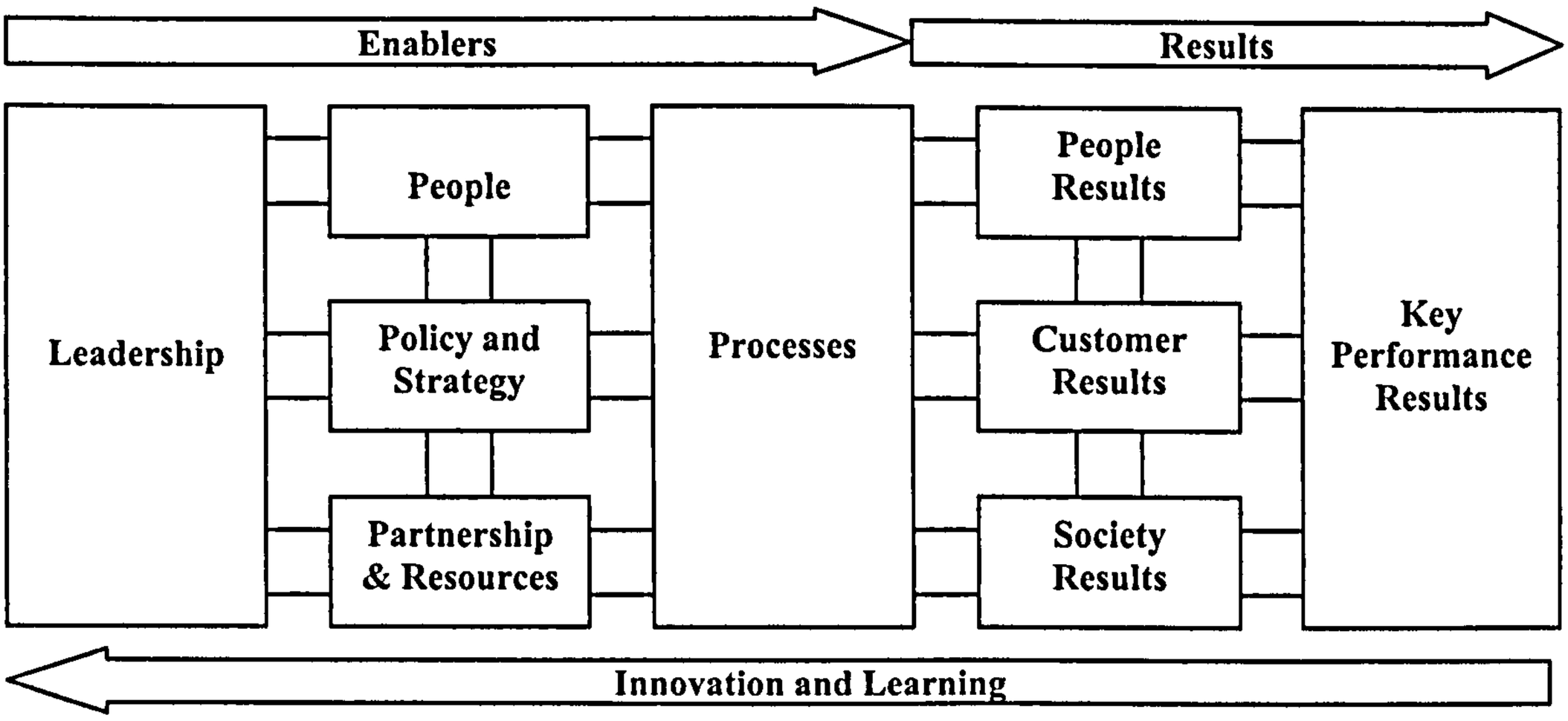


Figure 2.12: EFQM Excellence Model *(Source: EFQM 1999)*

Enablers:

- Leadership: It is assessed how leaders develop and facilitate the achievement of the mission, vision and develop values required for long term success and implement them through appropriate actions and behaviours.
- People: It is assessed how the organisation manages, develops and releases the knowledge of its people at an individual, team and organisation level to support its policy and strategy and the effective operation of its processes.
- Policy and Strategy: It is assessed how the organisation implements its mission and vision through a focused strategy, supported by relevant policies, plans, objectives, targets and processes.
- Partnerships and Resources: It is assessed how the organisation plans and manages its external partnerships and internal resources in order to support its policy and strategy and the effective operation of its processes.
- Processes: It is assessed how the organisation designs, manages and improves its processes in order to support its policy and strategy and fully satisfy, and generate increasing value for its customers and other stakeholders.

Results:

- Key Performance Results: It is assessed what the organisation is achieving in relation to its planned performance?
- Customer Results: It is assessed what the organisation is achieving in relation to its external customers?
- People Results: It is assessed what the organisation is achieving in relation to its people?
- Society Results: It is assessed what the organisation is achieving in relation to society?

2.6.2 ABCD Check List

ABCD Checklist for Operational Excellence (Wight 2000 and 1984) is a tool for assessing company's effectiveness in executing business processes especially in manufacturing companies. Similar to the EFQM Model, it guides them to evaluate current levels of performance, identify problems and evaluate different ways for improvement. The ABCD Checklist is also a drive for continuous improvement and helps organisations to meet the challenges of today's competitive business environment, such as flexibility to change, responding quickly to customer expectations and continuously improving quality, price, etc. for their customers. *The ABCD Checklist* helps the organisations to determine their level of performance in the following business processes:

- Strategic Planning: To assess whether the organisation's strategic planning is an ongoing process, focusing on the customer as well as to assess whether this plan drives all the decisions and actions.
- Planning and Control: To assess the use of planning and control processes that generates significant improvements in customer service, productivity, inventory, master production scheduling, bill of material structure and accuracy, costs, etc.
- Total Quality and Continuous Improvement: To assess the improvement in quality, reduction in costs, increase in velocity (of flow), increase in customer partnerships, improve supplier partnerships, etc.
- People/Team Systems: To assess trust, teamwork, mutual respect, open communication and high degree of employment security of the employee/company relationship, etc.
- New Product Development: To assess all the functions in the organisations that are involved in actively supporting the product development process such as reduction of product development times, level of participation of internal and external suppliers, who are actively involved in the product development process, early team involvement, etc.

Under each process there will be an over view item with an executive summary to evaluate whether necessary processes exist. Under each overview item there are several detail items. These detail items provide additional information, guidance and means for assessment, which make the checklist. The response to both overview and detail items are scored on a range as "Excellent", "Very Good", "Fair", "Poor" and "Not Doing" and finally an overall grade is given for the whole process.

2.7 Discussion

Despite the considerable amount of research done in the field of designing performance measures, most of the performance measurement frameworks were not able to fulfil all the requirements (necessary for a framework) identified by two independent researchers, Bititci et al., (2002a and 2000) and Hudson et al., (1999). However the requirement set is modified to include some of the continuous improvement criteria as shown in Table 2.1.

Table 2.1 Requirements set for performance measurement framework

Requirement	*SMART*	*PMM*	*R&D*	*CPMS*	*IPMS*	*BSC*	*PP*
Identify Stakeholder Requirements	×	×	×	*Ltd*	✓	*Ltd*	✓
Perform External Monitoring	×	×	×	×	✓	×	×
Develop Objectives	*Ltd*	✓	×	✓	✓	✓	✓
Aligned Deployment System (performance indicators)	✓	✓	✓	✓	✓	✓	✓
Causal Relationships (between leading and lagging indicators)	*Ltd*	*Ltd*	*Ltd*	*Ltd*	*Ltd*	✓	*Ltd*
Proactive Controlling Mechanism							
▪ Quantify the Causal Relationships	×	×	×	×	×	×	×
▪ Identify Capabilities	×	×	×	×	×	×	✓
▪ Assess Risk of Potential Failures	×	×	×	×	×	×	×
▪ Early Warning Mechanism	×	×	×	×	×	×	×
Review and Maintenance (relevance of performance indicators)	×	×	×	*Ltd*	*Ltd*	×	×
Include IT Platform	×	×	×	×	×	×	×

One of the two gaps identified is the lack of a proactive controlling mechanism, which can be fulfilled by using tools and techniques already developed, and in practice for several years such as Active Monitoring (Turner and Bititci, 1999), Quantitative Methods for PMS (Suwingnjo et al, 1997), Failure Mode Effect Analysis, Cause and Effect relationships etc. From the above requirement criteria, it is evident that ***the role of IT is limited at the design stage***, however IT is essential in providing pro-active control mechanism. Hence the other gap identified is a ***lack of IT support*** to design the performance measures.

Most of the indicators we measure today have the power to give insight into the future, but however future outcomes can only be predicted from the trends, and cannot be measured (Reilly et al 2001). In most of the cases non-financial measures such as quality, customer satisfaction, cycle time, innovation, etc. will act as the leading indicators for the financial performance (Bititci et al 2002b, Suwingnjo et al, 1997, Ittner et al 1998). In fact, emphasis of the performance measurement frameworks and similar continuous improvement approaches such as Lean Manufacturing, Six Sigma, etc. results in (Bititci et al 2002b):

- Few measures at higher levels for senior management, easy to manage as they are measured on a monthly and annual basis and there are only a few of these.
- A lot of measures at lower levels for operational teams, difficult to manage as they are measured on an hourly and daily basis and potentially there are a lot of these.

While implementing these measures, considerable effort is required at all levels to capture, collect, analyse and report performance measurement information. According to Simon (1965), Bullers et al (1991), Atkinson et al (2000), humans have basic limitation in their information processing capabilities. ***Hence the role of IT is very significant at implementation stage.*** According to Bititci et al (2000), Bourne et al (2000a), Hudson et al (1999), Neely (1999), Bierbusse et al (1998), performance measurement implementation fails in many companies for the following reasons:

- A lot of time and investment is required for data collection, analysis and reporting.
- Historical measures with out-of-date and irrelevant information.
- The large number of measures, which are difficult to be managed on a paper-based performance measurement system.
- The difficulty of implementing measures cause inappropriate information being available from the performance measurement system
- Resistance to performance measurement

From these reasons it is evident that ***lack of IT support*** plays a major role directly or indirectly in influencing performance measurement implementation.

The factors, which influence the 'use' stage of performance measurement, would be based on its design and implementation stages. Hence ***IT plays a major role*** in indirectly influencing the 'use' stage.

From the review of the literature the researcher got a strong understanding that IT plays a major role in supporting performance measurement implementation and its use. It also demonstrated ***that without the IT support***, coping with performance measures and indicators becomes very difficult, complex, frustrating, abused, misused and short-lived. However this literature review did not provide any evidence that, performance measurement or IT-PMS would have positive or negative impact on business and management. Hence this evidence is gathered from practice as presented in Chapter 3.

Chapter 3: Pilot Case Studies

3.1 Introduction

From Chapter 2 literature review, it was demonstrated that there was little solid research reported on impact of performance measurement on business. Hence the next best source of information for studying the impact was from practice. This chapter initially includes four case studies providing evidence on impact of IT-PMS. The research strategy adopted to do these case studies was exploratory[1] (the process used was exploring different issues in companies) and empirical[2] (the data source was practical observations) approaches. The main objective of doing these four case studies was to understand how these companies implemented IT-PMS and to know what happened as a result of it. Common themes will be identified from the cross-case analysis[3] across the four companies.

Based on these findings, the latter part of this chapter includes a structured pilot case study in detail on one of the four case studies (mentioned above) and reports the findings of the study. The main objective of doing this structured pilot case study was to understand the factors leading to management and business implications as a result of IT-PMS implementation. Based on these findings, the initial research questions will be tentatively answered. It finally establishes the main research objectives for this research.

3.2 Case Studies from Practice

The Centre for Strategic Manufacturing (CSM), University of Strathclyde, was involved with four companies in Scotland in implementing performance measurement. The methodology adopted in doing these case studies was exploratory and empirical, which involved visiting the company (one or two days visit) and speaking to people informally by asking questions such as:

- What framework did they use for performance measurement?
- How was the IT support provided for performance measurement?
- What happened as a result of implementation?
- What impact did it bring on management within the business?

---

[1] Exploratory approach is explained in detail in Section 5.2.2.2.8
[2] Empirical approach is explained in detail in Section 5.2.2.2.2
[3] Cross-case analysis is explained in detail in Section 5.2.3.2.6

The objective of these studies was to get answers for these questions from each company and conduct cross-case analysis across the four studies to identify common themes. The findings obtained at one company are triangulated[1] with findings obtained against the other companies. The implementation and its impact on the management in these four cases are described briefly as follows:

3.2.1 Company AFE

AFE, is a profit centre of a bigger organisation. The site specialises in the manufacture of thin aluminium foil (such as those used for cooking, food and confectionery packaging) and laminated aluminium foil (such as those used in the cigarette packaging). The main processes within the factory are rolling and laminating.

The scope of the project was implementing the performance measurement for business and operational activities. The IPMS Reference Model (Bititci and Carrie 1998) was used to guide the management team to identify and structure the key performance measures. The following were some of the performance measures used in the company:

Internal Measures

- Porosity
- Thickness of Laminate Gauge

Human Resource Measures

- Absence Analysis

Customer-oriented Measures

- Quality Credits
- Delivery Performance
- Customer Complaints

Health and Safety Measures

- Case Rate

The heart of the performance measurement implemented at AFE was the NWA Quality Analyst Software product (Quality Analyst), which is essentially a software platform designed specifically for supporting statistical process control applications. It also has the capability of getting data from different sources and communicating the processed information through the web server.

As a result, the performance information at AFE was disseminated throughout the company. All the necessary information for decision-making was available on the intranet of the company. Slowly managers gained confidence and realised the benefits of the system and started using the system for decision-making. The management style was changed from

[1] Triangulation is explained in detail in Chapter 5, Section 5.2.3.2.5

reactive to proactive style. Managers started thinking about the future from the information available in real time on their intranet. Even though resistance was observed in some people initially, it was overcome with non-threatening management style. Managers conducted root-cause analysis by relating external stimuli (such as customer complaints, needs etc.) with internal stimuli (such as process control, improvement etc) and hence improved customer satisfaction by better monitoring the internal processes. Some of the relevant performance information was also shared with their key customers, which led to strong relationship with the customers. It improved the identification of business weaknesses[1] and hence facilitated AFE to focus in continuous improvement.

3.2.2 Company AC

AC based in Burntisland, Fife, which is part of a bigger organisation, which provides the global solution to the alumina chemical needs. The site specialises in precipitation of Alumina and Aluminium Tri-Hydrate from Bauxite using the Bayer process. Its products are typically used in toothpaste, ceramics, spark plugs, fire retardant cabling and a variety of other fire retardant applications.

The scope of the project was implementing the performance measurement for the operational activities of the business. The Balanced Scorecard was used in identifying the Key Performance Measures. Some of the measures used in the company were:

Internal Operational Measures

- On-Time Delivery
- Productivity
- Quality Rates
- Down Time Analysis

Initially the company maintained data completely in the paper-based sources using manual input. However when implementing the Balanced Scorecard, they used MS Excel for storing the data, analysing the information required for decision-making and presenting that information on the intranet of AC. MS Excel is a non-relational database and hence could not present the information in real-time.

The performance information disseminated at AC was not structured. Even though all the necessary information for decision-making was available on the intranet, managers have to search for the information from different sources. It has provided open communication

[1] Identifying key areas in business for improvement

internally to some extent. Since MS Excel has limited statistical analysis capabilities, it has not facilitated root cause analysis. Even though some managers were confident about the information, they were not as proactive as the managers at AFE, because MS Excel does not have the capability of presenting statistical analysis as well as presenting the information in real-time. Due to technical difficulties, AC cannot share the key performance information with the customers and suppliers. In short, AC gained overall benefits in supporting MS Excel to performance measurement, however the benefits were not significant due to the limitations of MS Excel.

3.2.3 Company HCSL

HCSL based at Newhouse in Lanarkshire is a wholly owned subsidiary of the global organisation. It is serving the customers in domestic homes, commercial buildings, the industrial arena, as well as space and aviation. The products include heating, ventilating, zoning, humidification and air-conditioning controls for homes and commmercial buildings; thermostats; heaters and fans; air-quality products including humidfiers, air cleaners and vaporisers; lighting controls and security products; burner/boiler and combustion controls; thermostatic radiator valves; water flow valves and system; home automation and security; utility services

The scope of the project was implementing the performance measurement for the business operational activities. The EFQM Business Excellence model was used as a self-assessment process to identify the main business improvement areas. The IPMS Reference Model was used to identify Key Performance Measures through the performance measurement system audit. Some of the measures used in the company were:

Business/Financial Measures

- Operating Costs
- Net Sales
- Cost of Quality
- Business Excellence Assessment

Customer-oriented Measures

- Delivery performance

Human Resource Measures

- Employee Satisfaction Survey

The heart of performance measurement implemented at HCLC was Cause and Effect diagrams (Suwingnjo et al 1997), Active Monitoring Techniques (Turner et al 1999) and Traffic Light Reports (TLR) generated in MS Excel as well as disseminating this information in their management briefings. TLR is a detail activity plan and was so called because it

shows simple "go/caution/alarm" rating against major KPIs such as cost, schedule, quality, etc.

The performance information at HCSL was made more visible and exploited in their management briefings. Since the information was presented in MS Excel, it has limited capability to perform the data collection, analysis and communication in real-time. However, these MS Excel reports were always available on the company's intranet. This facilitated HCSL in using an agile and proactive management style to monitor and control the critical factors. Using the simple TLR in MS Excel became a visual system to identify gaps within each project, before a major problem threatened the failure of each project (Mendibil et al 2002). It improved the identification of business weaknesses and hence facilitated HCSL to focus in continuous improvement. In short, HCSL gained overall benefits in supporting MS Excel to performance measurement, however the benefits were not significant due to the limitations of MS Excel.

3.2.4 Company WM

WM based in East Kilbride, Glasgow, it is a company dedicated to the manufacture of high performance, variable data labels for major electronic OEMs, such as Compaq, IBM, Motorola, Hewlett-Packard and Nokia etc. The products include thermal transfer printable labels, high temperature thermal transfer printable labels, thermal transfer ribbons, industry leading thermal transfer printers, label design and print software, scanners and applicators.

The scope of the project was implementing the performance measurement for the operational activities of the business. The SMART Model was used in identifying the Key Performance Measures. Some of the measures used in the company were:

Internal Operational Measures

- On-Time Delivery
- Turn Around Time
- 1st Pass Yield
- Down Time Analysis

The heart of the Performance Measurement System were Active Monitoring Techniques (Turner et al 1999) and Failure Mode Effect Analysis (FMEA) (Bititci et al 2002b) together in MS Excel were used as to improve the performance by reducing the problems faced while processing the customers' orders. MS Excel was used for data collection, analysis to produce

statistical charts, analysis, etc as well as communicating the information throughout the organisation.

WM significantly improved the reliability of their processes in delivering the performance required by major customers. Since the information was presented in MS Excel, it has limited capability to perform the data collection, analysis and communication in real-time. However, these MS Excel reports were always available on the company's intranet. Hence implementing this system allowed greater visibility in identifying the deterioration of press performance. Hence the ability of the WM to sustain the improvements in performance and to build on them for the future has been greatly enhanced (Turner et al 2002). It improved the identification of business weaknesses and hence facilitated WM to focus in continuous improvement. In short, WM gained overall benefits in supporting MS Excel to performance measurement, however the benefits were not significant due to the limitations of MS Excel.

3.2.5 Cross-Case Analysis and Discussion

The choice of dimensions for cross-case analysis is based on the questions used in the methodology, which was applied for these four cases:

- Scope of implementation
- Framework/Model used for performance measurement
- IT Support for implementing performance indicators
- Issues in implementing and using performance indicators
- Impact/Benefits identified in the organisation

From Table 3.1, it is evident that AFE enjoyed significant benefits when compared to other three cases because of the following reasons:

- Data collection, analysis and communication were made simple by proper IT support and the performance information was made available in real-time
- The IT was also supported to do SPC analysis to present both process and business based information
- Non-threatening management style in making people use the system in business decision-making

Table 3.1 Cross-Case Analysis

Dimension	AFE	AC	HCSL	WM
Scope of the implementation	Business and Operations	Operations	Business Operations	Operations
Framework / Model	IPMS Reference Model	Balanced Scorecard	Active Monitoring Techniques, EFQM Business Excellence Model, IPMS Reference Model	SMART Model, Active Monitoring Techniques and Failure Mode Effect Analysis
IT support	NWA Quality Analyst Web Server, Intranet	MS Excel, Intranet	TLS, MS Excel, Intranet	MS Excel, Intranet
Issues in implementation and use of performance measures	• Data collection was made simple • Data analysis and communication was made real time • Statistical Process Control (SPC) analysis • Complete transparency and visibility • Non-threatening management style in making people use the system, thus overcoming resistance	• Even though the information was available on Intranet, it was not available in real-time • Limited in producing SPC analysis • Limited transparency and visibility of information	• Even though the Information was available on Intranet, it was not available in real-time • Limited in producing SPC analysis • Limited transparency and visibility of information	• Even though the Information was available on Intranet, it was not available in real-time • Limited in producing SPC analysis • Limited transparency and visibility of information
Impact / Benefits of implementation and use	• Increased confidence in management • Proactive management style • Identification of business weaknesses and hence leading to continuous improvement • Improved relationship with customers and suppliers • The are significant overall benefits	• Identification of business weaknesses and hence leading to continuous improvement • There are some overall benefits	• Proactive management style • Identification of business weaknesses and hence leading to continuous improvement • There are some overall benefits	• Identification of business weaknesses and hence leading to continuous improvement • There are some overall benefits

From the four case study findings and experiences of the team at CSM, it was identified that performance measurement with proper IT support is making the implementation a success. However this evidence is not enough to answer the following research questions defined in Chapter 1.

- What are the critical success factors and barriers to performance measurement design and implementation?
- What is the impact of these critical success factors and barriers?

In order to answer these questions, the researcher decided to do a structured pilot case study in one of the above-mentioned companies. As the impact of IT-PMS at AFE is significant in contrast to the other three companies, AFE was chosen for a detailed study, which is thoroughly discussed in the next section.

3.3 Structured Pilot Case Study: AFE

3.3.1 Background to AFE

AFE is a profit centre of a bigger organisation. The site specialises in the manufacture of thin aluminium foil (such as those used for cooking, food and confectionery packaging) and laminated aluminium foil (such as those used in the cigarette packaging). The main processes within the factory are rolling and laminating.

The objective of the pilot case study was to examine the management and business implications of IT-PMS. This was achieved by:

- Having a complete understanding of the life cycle of IT supported Performance Measurement System (IT-PMS), i.e. design, implementation and use of performance measures in the company.
- Creating a semi-structured data collection tool to assess the impact on management and business, before, during and after implementation of the IT-PMS. (What is the impact?)
- Identifying success factors that caused the impact on management and business (What are the factors causing this impact?)

3.3.2 Methodology adapted at AFE

Throughout the study, the researchers played a dual role. Stephen Creighton was one of the managers within AFE responsible for designing, implementing and using the fully integrated IT-PMS. Trevor Turner was the researcher acting in an advisory capacity assisting with the design of performance measures using IPMS Reference Model. The IT department within the company supported the implementation and the senior management had taken on the

commitment to make people use the system. Umit Bititci and Sai Nudurupati were acting as external observers, who conducted the empirical research independent of the development and implementation process.

At the outset of the research, a number of interviews were held with the senior management and middle management teams, which led the research team to understand the Before scenario at AFE. During the design, development and implementation of the new performance measurement system, Creighton and Turner were observing and recording the implementation process, which was reviewed by the senior management team and the research team on a quarterly basis, through project steering committee meetings. The After scenario was captured as a result of a set of structured interviews with the key users of the system. This involved all levels of management from the general manager to team leaders. The results presented in this case study are based on a population of 29 managers, which remained stable throughout the research with no changes (i.e. nobody leaving or joining the Company).

In order to evaluate the management and business implications of the IT-PMS, a set of semi structured interview questions were formulated at the outset (from the evidence of four case studies presented in previous sections). These questions included:

- What is the cost of implementing and operating IT-PMS?
- What are the business benefits of implementing and operating IT-PMS?
- What is the impact of the IT-PMS on business performance and strategy?
- Are managers more confident in their decisions as a result of IT-PMS?
- Are the managers and decisions becoming more proactive as a result of using IT-PMS?
- How does the IT-PMS affect management behaviour?
- How does the IT-PMS affect the dissemination of knowledge throughout the organisation?
- Does the IT-PMS impact upon the visibility of information throughout the organisation?
- Does the IT-PMS highlight or pinpoint the weaknesses of the business?

The semi structured interviews were prepared for the Before and After scenarios to capture the management opinion with respect to the above questions. During the After interview each respondent was asked to rate the impact of the system, in the context of each question, on a five-point scale (Significant Improvement, Some Improvement, No Improvement, Some Deterioration, Significant Deterioration). The respondents were also asked to justify their

choice by explaining the key features of the change. The data was collected through face-to-face interviews with a cross-section of personnel in AFE.

3.3.3 Designing and Implementing Performance Measures

The IPMS Reference Model (Bititci and Carrie 1998) was used to guide the management team to identify and structure the key performance measures. The details of the structure of the performance measurement system was presented in Chapter 2, thus it is not included here. The following were some of the performance measures used in the company:

Internal Measures

- Porosity
- Thickness of Laminate Gauge

Human Resource Measures

- Absence Analysis

Customer-oriented Measures

- Quality Credits
- Delivery Performance
- Customer Complaints

Health and Safety Measures

- Case Rate

At the heart of the IT enabled Performance Measurement System (IT-PMS) implemented at AFE is the NWA Quality Analyst software product (Quality Analyst), which is essentially a software platform designed specifically for supporting statistical process control applications. It provides a good combination of flexibility, and ease of use. It easily integrates into manufacturing data systems. It produces all standard SQC charts, plus many special-purpose charts. It allows the user to dig into the information by "drilling down" into the charts.

With the Open Data Base Connectivity (ODBC), the Quality Analyst can pull down data from different sources into its own database. In this case, it is being used as a tool to collect and convert numerical data into graphical Shewhart charts (more commonly known as SPC charts). In AFE the numerical data is available from a number of sources including:

- MRPII system
- Spreadsheet applications, i.e. MS Excel
- Database applications, i.e. MS Access
- Machine controllers, i.e. the process controllers of various equipment, such as mills
- Data loggers

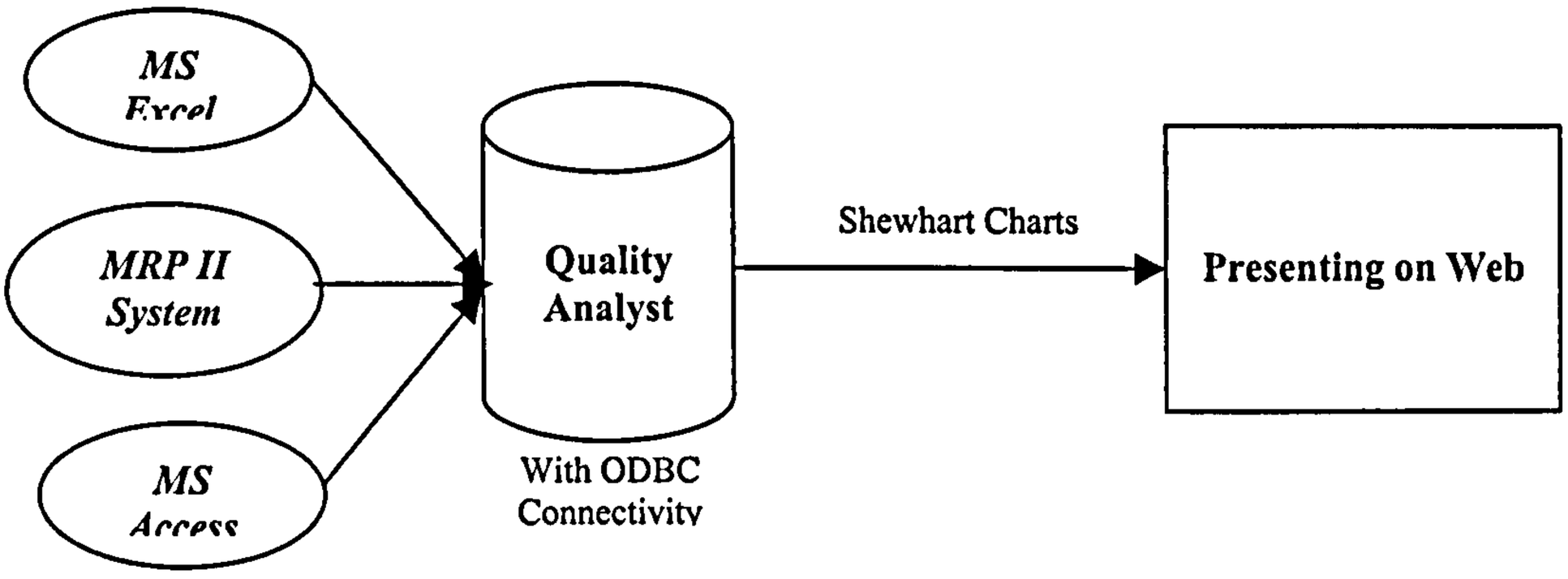


Figure 3.1: Architecture of the IT-PMS at AFE.

Figure 3.1 illustrates the structure where the Quality Analyst provides the main interface between the web pages and the numerical data. This architecture enables the following:

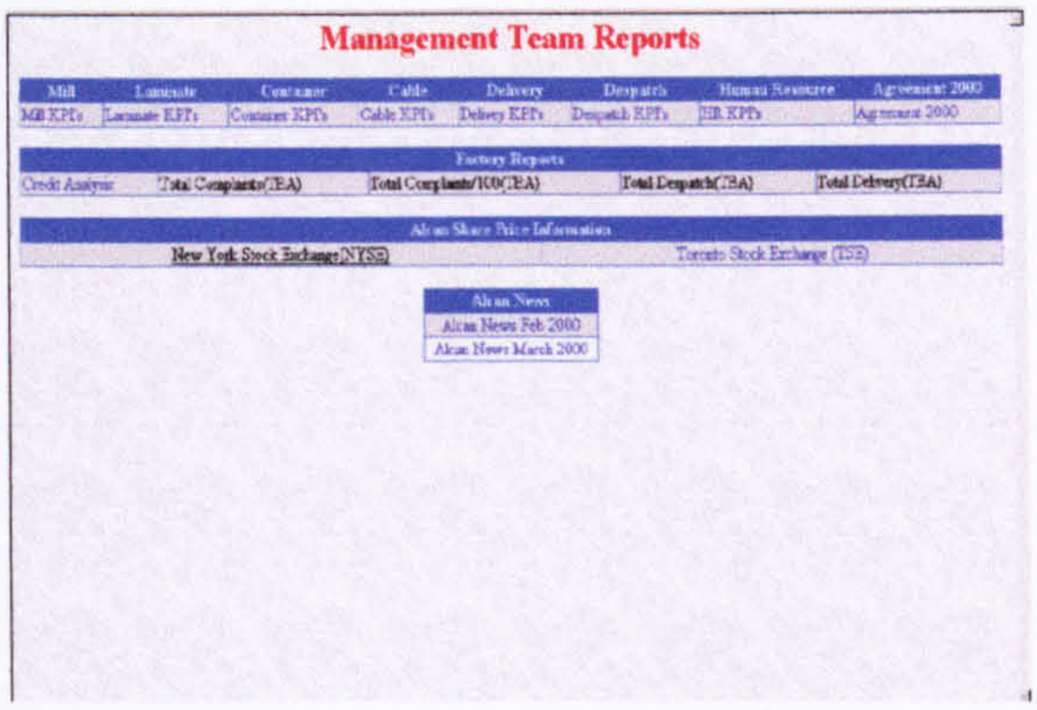
- Collection of data either automatically (through the MRPII system, machine controllers and the data loggers) or manually (through spreadsheets and databases)
- Representing that data in a more useful format such as SQC Charts, Statistical Analysis, Pareto Analysis etc.
- Annotation of data either manually (e.g. by providing a comment field within the database or spreadsheet) or automatically (through reason codes that may be available within the existing systems)
- Communicating this information through AFE's intranet pages

In AFE the IT-PMS is known as the Management Team Reporting (MTR) System. Initially there was resistance from some people to its implementation and use. However, it was overcome as they became aware that the senior management were very much committed and interested in the system. Figure 3.2 illustrates a sample of the performance reports used by the managers available through the MTR System.

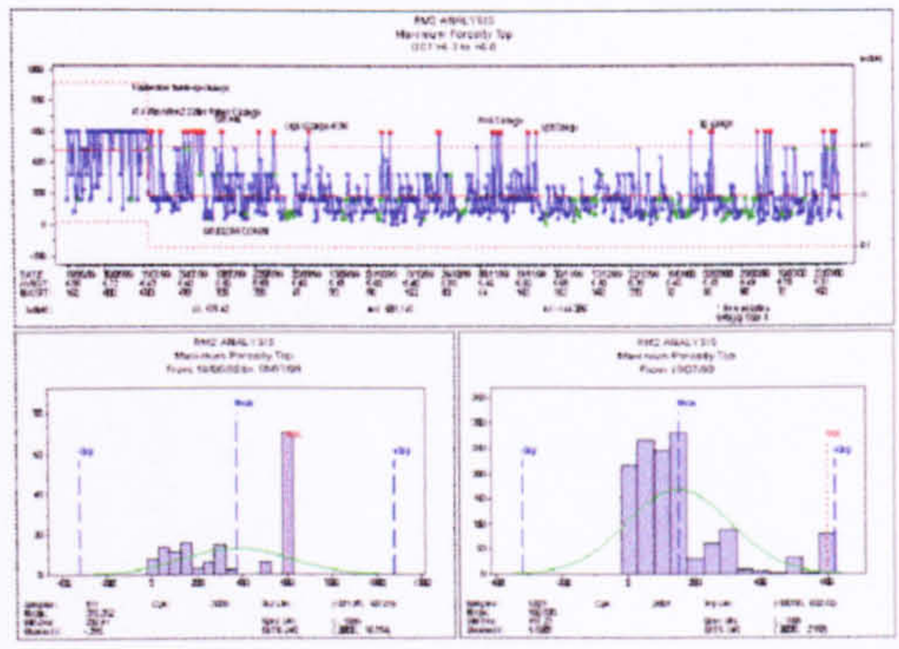
The web-page in Figure 3.2a illustrates the main menu page providing access to performance reports for various parts of the business.

In Figure 3.2b, the top chart illustrates a Shewhart chart for monitoring variations in the porosity during the rolling process. This is a critical technical measure captured by the data loggers on a continuous basis and the daily averages are reported automatically by the MTR system at the end of each day. The figure also illustrates that the tolerances were tightened in

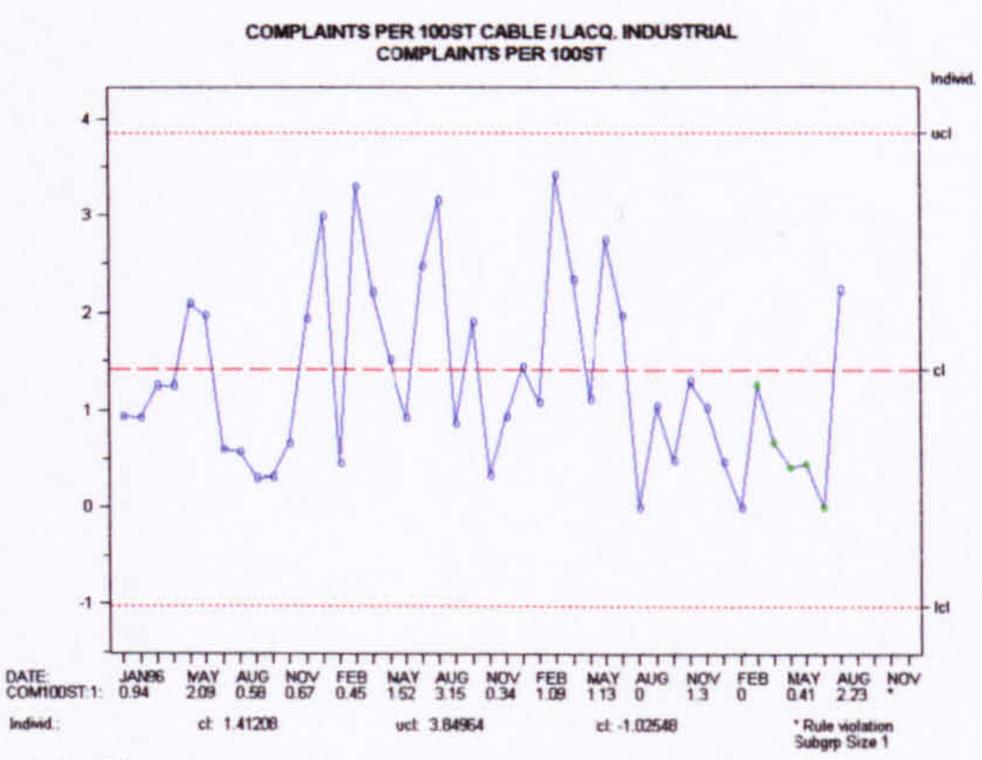
July 1999. Where targets were not achieved, annotations indicate the reasons for it, such as paper change, roll change, etc. The bottom charts illustrate the process capability histograms, one before tightening the tolerances and the other after tightening the tolerances.



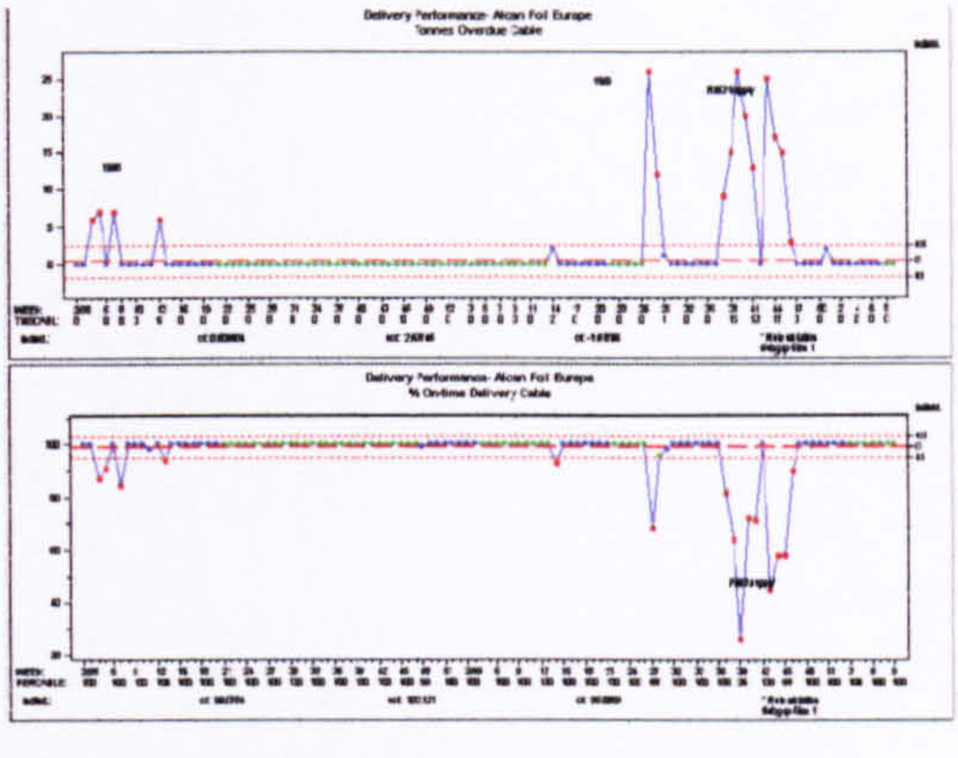
(a) Menu Page



(b) Porosity (daily)



(c) Customer complaints (monthly)



(d) Delivery performance (weekly)

Figure 3.2: Sample pages from the AFE's MTR System (IT-PMS).

The web-page in Figure 3.2c illustrates AFE's performance with respect to customer complaints received each month. This information is captured manually. As customer complaints are received by the customer services department they are entered into a customer complaints log (MS Access Database), in accordance with the Company's ISO9000 procedures. Quality Analyst picks this information from the database and presents it on the web-page. The chart in Figure 3.2c shows customer complaints received by AFE.

Figure 3.2d illustrates two charts, one illustrating backlog against customer orders and the other illustrating delivery performance against customer orders. The chart shows that

delivery performance has been within target of 95% except between weeks 36 and 41, where delivery performance has suffered considerably due to a problem with raw material supply (as annotated).

3.3.4 Interview Results: Evaluating the Management and Business Implications of MTR System

Cost and scope of implementation

The Company had invested approximately £20,000 on buying and implementing the software, which includes the cost of the software products and training. It has invested £50,000 in hardware to support the software, which includes new PCs, Data loggers, etc. The Company had provided one full time employee and allocated, on average, approximately equivalent of ten percent of one manager's time to this project. Most of the interviewees responded that it was very difficult to quantify the operating costs, as the use and maintenance of the MTR System had become a routine part of their business.

Business benefits of implementing and operating MTR system

Even though few respondents indicate that there are some benefits, many respondents indicate that there are significant benefits. According to the responses, the MTR System had created visibility for promoting continuous improvement. It identified, strengths, weaknesses, opportunities and threats for the business.

Before:

- Many people are involved in collecting data.
- Duplication of data (often inaccurate).
- Limited transparency of information at all levels.
- Measures with no clear targets and focus on what needs to be done.

After:

- Information is now from a single source and accurate.
- There is complete transparency and visibility of information.
- Problems are clearer, which helps to focus and manage improvement.
- The cause and effect relationships between capital targets and operational activities are more visible making monitoring against capital objectives easier and more visible.
- Everyone knows what needs to be done and problems are not hidden.

Effect on dissemination of knowledge throughout the organisation

Almost everybody responded that there is a significant positive effect. Previously, only a few people knew what was happening in the Company, but now everybody knows what's happening. They said that:

Before:

- Knowledge was only disseminated through management briefings.
- Consequently some of the information and knowledge was retained at top levels without reaching operational levels.
- Each function collected its own data independent from each other.

After:

- All critical information and knowledge was completely accessible by all members of the organisation.
- Support and operational staff (e.g. line operators, manufacturing engineers, quality engineers etc.) use the information because they need to resolve problems. Management use the information because they need to make decisions, drive improvement and create focus.

Impact on business performance and strategy

Even though some people responded that there was some improvement, many people responded that there is significant improvement. The consensus view was that the business performance would have stagnated if the system was not in place. They said that:

Before:

- Managers found it difficult to focus on key areas of business improvement.
- "Flavour of the Month" approach to improvement
- Unstructured approach to performance planning

After:

- Now completely focused on areas needing improvement.
- The capabilities of business and manufacturing processes are better understood.
- There is a systematic approach to improvement.
- Achieved state of excellence on certain quality characteristics, which allowed adoption of higher technical specifications resulting in improved margins.
- Improved partnership with major customers who can view MTR system during audits and see that the issues concerning business problems are being addressed.

In one particular case a customer was ready to take its business elsewhere. Having seen how AFE was planning to tackle the problem, they got involved in the process. The customer was given access to the MTR system to look at AFE performance, on the issues related to them (customers). As a team they (both AFE and its customer) improved the performance of the product using the MTR system to such an extent that the customer was delighted with the results. Later, they (customers) formalised a partnership agreement for AFE to supply other products.

Business weaknesses highlighted by MTR system

Half of the people responded that it highlighted some weaknesses. The other half responded that it highlighted many weaknesses.

Before:

- People did not understand the effect of operational problems on business performance.
- Improvements were mainly driven by reactions to customer complaints.

After:

- The cause and effect relationship is better-understood and more visible.
- Improvements are internally driven rather than being reactions to feedback from customers.

Confidence in management decisions

Most of the respondents have reported that now they are more confident in their management decisions. They said that:

Before:

- It took several hours to collect and analyse data, this usually meant that in most cases it was not done at all or not done properly.
- Arguments about the validity of data caused friction between individuals.
- More often the organisation reacted to external stimuli, such as customer complaints, rather than internal stimuli due to the lack of confidence in the information available.
- Decision-making was based on inaccurate and historical data.

After:

- Information is accurate and reliable - because it is from a single source - this also eliminated animosity and friction between individuals caused as a result of arguments over the validity of data - *"we are managing by fact, using a single set of data"*

- It is easier to conduct root cause analysis to resolve problems and improve operations. As the people are confident about the information available, they had built the cause and effect relationships between external stimuli and internal stimuli.
- Decisions can now be made quickly with confidence, as the information is available in real-time or near real-time and the trends are visual on 'active' SPC charts throughout the business (the training of people was the key to this).

Impact on management style

Most of the respondents have indicated that management decisions have become more proactive by selecting the "some improvement" option. They said that:

Before:

- Managers were reactive and unfocused because of duplicated information and low levels of confidence in the information.

After:

- When things go wrong everybody knows the reason - it is annotated on the charts. Visibility like this makes us get on with our jobs rather than arguing about the data.
- Common view of transparent information, which allows managers to discuss and plan work to improve performance and then act on it.

Effect on management attitude and behaviour

Many people responded that the MTR system has a significant positive effect in many cases. In isolated cases some negative effects were mentioned mainly related to manual data collection and sorting. They said that:

Before:

- Easy not to be a 'team player' and hide behind the poor data and so use a political approach to each situation.
- Most decisions were based on instinct and not on facts.
- There was a lot of pressure and wasted time before weekly management meetings, analysing data, understanding what went wrong and justifying why - "we used to try to justify the past"

After:

- Managing Director used the MTR system to change the management style from reactive to proactive by insisting that all analysis would be based on statistical approach.

- Now there are no places to hide. This was difficult to get to grips within the beginning. People felt very exposed. Thus, the open management style helped a lot to overcome their fears.
- If you are not a 'team player' it becomes very obvious, very quickly.
- Now managers just turn up to the weekly management meetings and discuss what they are going to do rather than trying to explain what went wrong and why - "we are now managing the future".

3.3.5 Discussion

One of the objective of this study was to identify the management and business implications of IT supported performance measurement systems, because the current literature in performance measurement suggests that with IT support, performance measurement can be made less cumbersome, more dynamic and responsive, thus leading to a more proactive management style.

One of the first questions asked related to the cost-benefit of such systems. At the conclusion of this study this was a question the researcher felt unsatisfied with because: Although it was fairly easy to establish the implementation costs, it proved difficult to establish the operational costs or saving of such systems (i.e. the marginal cost or saving of operating, maintaining, updating and using such a system). As the MTR system became an inextricable part of the Company's processes and structures, it became increasingly difficult to separate the impact of MTR system from other assets and activities (Willcocks 1999). Another related question is that, how the benefits achieved in this Company, are correlated with the total investment of implementing the MTR system? Even though the study demonstrated that there were overall benefits of the MTR System, it failed to address whether the benefits were worth the investment. However, the management team's opinion was that the business benefits enjoyed were largely attributable to the MTR system and that it far outweighed its costs.

Figure 3.3 summarises the results of the feedback received from the selected cross-section of employees within AFE, providing qualitative answers to the rest of the questions posed earlier in this Chapter.

No	Question	Significant Deterioration	Some Deterioration	No Improvement	Some Improvement	Significant Improvement
1.	The business benefits of the MTR System				●	
2.	The impact of MTR System on business performance				●	
3.	Confidence in manager's decisions					●
4.	Management style - proactive				●	
5.	Effect on the behaviour of management					●
6.	Effect the behaviour of operational staff				●	
7.	Effect on the team behaviour - management				●	
8.	Effect on the team behaviour - operational staff				●	
9.	Effect on dissemination of knowledge					●
10.	Effect on visibility of information					●

Figure 3.3 Summary of structured interviews

The results of this research may be summarised as follows. The IT-PMS, locally known as the MTR system, implemented in AFE, plant resulted in significant benefits by:

- Simplifying data collection, analysis and communication
- Making performance information more transparent and visible
- Improving accuracy, reliability and credibility of performance information
- Creating awareness of issues and focus on critical problems
- Creating an understanding of the cause and effect relationship between the business measures and operational measures

Consequently, managers are:

more confident with their decisions;
more proactive in their management style;
more efficient as a team;
working more as a team than individuals;

As a result AFE demonstrated improvements in its bottom line performance, which is measured through EVA (Economic Value Added).

The researcher's opinion is that the majority of the benefits gained are not only attributable to the MTR System (IT-PMS) but also to other factors, which played a significant role in its success. These are:

- Adoption of a framework (in this case IPMS Reference Model) to structure the performance measurement system. It is evident that creating a set of performance measures and publishing these on the web would not have created the depth and breath of understanding evident in this case.
- Adoption of Shewhart charts as a standard method of documenting performance information. In a process plant where SPC techniques are widely understood this approach gained considerable support mainly due to familiarity and also due to the visual and graphical nature of the charts. However the familiarity of Shewhart charts was gained through providing training to senior and middle managers.
- Senior management commitment, by far was one of the key influences that led to the success of the MTR system. The Managing Director insisted that all personnel, when they were talking to him on performance related issues, should use the MTR system. He said *"I look at several charts several times every day, I ask questions to my managers and team leaders about them, I expect them to communicate to me using these charts".* In our opinion it is his commitment that resulted in the adoption of the MTR system as an everyday management tool.
- Open and non-threatening management style from the very top of the organisation. One of the difficulties with the implementation of this system was that with the previous systems it was easy for managers to hide behind inaccurate and historical data. The difficulty was that as soon as the managers found out about the project they felt threatened and vulnerable. This feeling continued until the system was operational and they could see that the General Manager was using the system to improve the business, and not to point fingers and apportion blame. The General Manager's continuous assurance and his sensitive approach throughout the development and implementation was a key factor for the success of this system.
- Data collection and analysis was integrated into the business as part of one's everyday job. Where possible, data collection was automated. In certain areas data collection and recording methods were changed, e.g. customer complaints were logged into a database instead of a book, allowing the MTR system to collect data directly from the database.

These conclusions are consistent with Sauer (1993) who stated that, every successful IT project has new work practices supporting it. The discussion above makes is clear that providing just the hardware and software would not have resulted in these benefits. Other major influencing factors include changes in working practices, the general managers commitment and his open and non-threatening management style.

3.4 Answering initial Research Questions

Based on the above results, the initial questions defined in Chapter 1 were tentatively answered as follows:

What is the impact of IT-PMS on management and business?

- *Business implications such as improving business performance, identifying the weaknesses, improving transparency and visibility and improving relationship with customers and suppliers*
- *Management implications such as building confidence in information, proactive decision-making and team behaviour*

What are the critical success factors of IT-PMS design and implementation, which causes the impact identified earlier?

- *Senior management commitment*
- *Reduction of the amount of time spent on data collection, analysis and reporting*
- *Up-to-date performance information*
- *Accurate and consistent information*
- *Adoption of statistical analysis, such as Shewhart charts, control charts etc.*
- *Open communication of information*
- *Open and non-threatening management style (drive from management)*
- *Secured access to customers and suppliers*
- *System is used for identifying business trends*
- *System is used for decision-making in routine business*
- *People are not resistant to using the system*
- *Customer and suppliers are using the performance information from the system*
- *People are confident in information*
- *People acting as teams in structured process improvement*

3.5 Predictions, Pre-conditions and Research Objectives

In the previous section the initial research questions were answered based on four anecdotal case evidence and one structured pilot case study. Hence the answers at this stage were from exploratory and cannot be directly contributed to theory, as the results are not yet subjected to external validity and reliability. However these answers will still remain as predictions and pre-conditions, which can be tested through this research (at other companies) in the later chapters and then contribute to theory.

These case studies provided strong empirical evidence that appropriately designed performance measurement systems, if supported through appropriate IT platforms, appropriately implemented and used, will impact the following management and business implications:

Prediction 1.1: *Disseminates the performance information throughout the organisation (improved transparency and visibility of information)*

Prediction 1.2: *Identifies weak areas of the business for improvement (business weaknesses)*

Prediction 1.3: *Facilitates as a critical component of an ongoing process improvement*

Prediction 1.4: *Facilitates management to be more pro-active in decision-making*

*(*Note: Pro-active does not imply that managers make decisions by knowing the future. In this research it means making decisions faster than before, with up-to-date information available in a near-real-time basis*)*

Prediction 1.5: *Changes the behaviour of the people in the organisation (either negatively or positively) such as focusing on facts, communication, empowerment, teamwork etc.*

Prediction 1.6: *Improves relationship with customers and suppliers*

The appropriateness of the IT platform is defined as how well it is designed and implemented in the organisation. It is achieved, if the following technical factors result/exist in an organisation. The appropriate usage of the system is defined as to how well the people use this system in their organisation, which is achieved with the following people factors.

Note: These technical and people factors were identified from the structured pilot case as well as literature. Hence these factors have both practical and theoretical relevance.

Pre-conditions: Technical Factors

Pre-condition 1.1: *Up-to-date information and access to managers* (Bititci et al 2002c, Prahalad et al 2002, Woods 2001, Battista et al, 2000, Bititci et al 2000, Marchand et al 2000b, Bourne et al 2000a, Roland et al 1999, Donovan 1999, IFAC 1999, Booth 1998, Orlikowski 1996, Mockler 1989, Porter 1980)

Pre-condition 1.2: *Means to compare against targets and best-class performances*

Pre-condition 1.3: *Open communication of information throughout the organisation* (Andersen et al 2002, McNurlin et al 2002, Bititci et al 2002c, Kueng 2001, Battista et al 2000, Marchand et al 2000b, Bourne et al 2000a, Neely 1999, Roland et al 1999, Booth 1998).

Pre-condition 1.4: *Secured access to customers and suppliers* (Andersen et al 2002, Prahalad et al 2002, Battista et al 2000, Roland et al 1999, Donovan 1999, IFAC 1999, Booth 1998, Mockler 1989, Porter 1980)

Pre-condition 1.5: *Provides consistent and accurate information* (Bititci et al 2002c, Prahalad et al 2002, Woods 2001, Battista et al, 2000, Bititci et al 2000, Marchand et al 2000b, Bourne et al 2000a, Roland et al 1999, Donovan 1999, IFAC 1999, Booth 1998, Orlikowski 1996, Mockler 1989, Porter 1980)

Pre-condition 1.6: *Reduces the time and effort required in data collection and analysis* (Woods 2001, Bourne et al 2000a, IFAC et al 1999, Donovan 1999)

Pre-condition 1.7: *Statistical analysis for controlling and monitoring processes* (Andersen et al 2002, Bititci et al 2002b, Turner 1999)

Pre-condition 1.8: *Simple and easy for the users* (Macrosson 1998, Bititci et al 2000)

Pre-conditions: People Factors

Pre-condition 2.1: Senior management commitment and drive (Bititci et al 2002a, Marchand et al 2000b, Feeny et al 2000, Bourne et al 2000a, Hudson et al 1999)

Pre-condition 2.2: Using the system in identifying business trends (Feeny et al 2000, Donovan 1999, IFAC 1999, Orlikowski 1996)

Pre-condition 2.3: Using the system for decision-making (Lebas et al 2002, Marchand et al 2000b, Donovan 1999, Orlikowski 1996)

Pre-condition 2.4: Acting as teams to solve the issues (Marchand et al 2000b, Feeny et al 2000, Donovan 1999, Orlikowski 1996, Schein 1996)

Pre-condition 2.5: Using the system as a routine part of their business (Donovan 1999, Orlikowski 1996)

Pre-condition 2.6: Not resistant to using the system (Markus 2000, Battista et al 2000, Waddell et al 1998, Macrosson 1998, Orlikowski 1996)

Pre-condition 2.7: Knowledgeable enough to use the system (both producing information and understanding how to interpret the information) (Marchand et al 2000b, Markus 2000, Macrosson 1998)

Pre-condition 2.8: Empowered to make decisions based on information (Badham et al 2001, Macrosson 1998, Schein 1996, Schaffer et al 1992)

Pre-condition 2.9: Confident about the information (Battista et al 2000, Woods 2001, IFAC et al 1999, Macrosson 1998, Orlikowski 1996)

Pre-condition 2.10: Customers and suppliers are using the system (Battista et al 2000)

However, there is an ambiguity between the IT-PMS implementation, technical factors, people factors and the management and business implications (impact). Even though the starting point is IT-PMS implementation and final point is the impact on management and business, the relationship between them as shown in Figure 3.4 is not understood. Hence the new objectives of this research are:

To test the predictions and pre-conditions (implications as well as technical and people factors), and hence prove

$$\textit{Impact of IT-PMS on Management and Business} \propto \textit{Impact of IT-PMS on Technical and People Factors}$$

(Impact on management and business is proportional to impact on technical and people factors. i.e. if the impact of IT-PMS on technical and people factors increases/decreases, the impact on management and business also increases/decreases respectively)

- Understand and build the relationship between technical factors, people factors as well as impact as shown in Figure 3.4

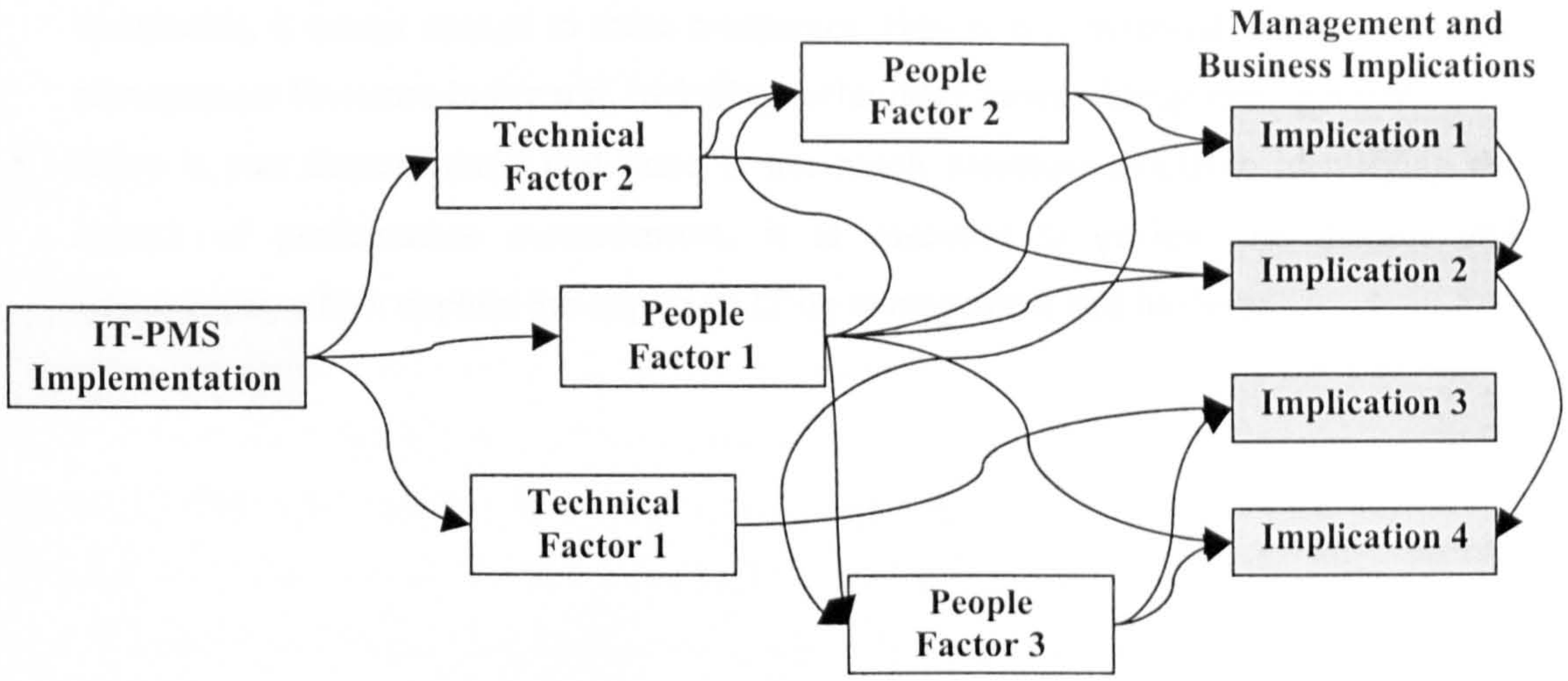


Figure 3.4 Understanding the relationships between technical and people factors as well as management and business implications

In order to achieve the above objectives, it is obvious that similar studies should be made at other organisations (socially constructed and subjective world). Hence it is necessary to implement IT-PMS at other organisations and study the impact. The design, implementation and use stages of IT-PMS require a number of iterative cycles to meet the requirements of the people and business. Since it is necessary to understand the relationship between IT-PMS implementation and its impact on management and business, the observer should be part of what is being observed. Hence, this is possible only with the phenomenological view and action research as the research domain. However, before setting up the research design (methodology in Chapter 5), a structured literature review should be conducted (Chapter 4) in the following areas:

- General IT to support performance measurement i.e. a review on the ideal ways of performance "information practices" and performance "information behaviour"
- The IT support for performance measurement in the collaborating companies can be obtained from the existing management information systems available within the company. Hence a review is necessary on the existing management information systems in organisations to support performance measurement
- Even though the IT platform used in a pilot case study can again be used in collaborating companies, it is necessary to find other software in the market, which can be superior to the one used in the pilot case study. Hence, a review is essential on commercial IT platforms available in the market to support performance measurement

- Since performance measurement was implemented together with IT in collaborating companies, it brings change to these companies. Hence, it is essential to review change management literature in general, including technology based change management
- Since it was demonstrated that there is not much literature available identifying the impact of performance measurement, it is essential to review the models and frameworks, which explain the impact of IT on management and business

Chapter 4: Performance Measurement and Information Technology

4.1 Introduction

Chapter 2 demonstrated that most of the models and frameworks developed for designing performance measures and demonstrated that necessity of IT support is limited at the design stage. It also identified the key barriers and drivers of performance measurement design, implementation and use, demonstrating that IT systems are seen as a major barrier to performance measurement implementations in most of the cases. However the literature review reported in Chapter 2 includes only performance measurement and does not include any review in IT.

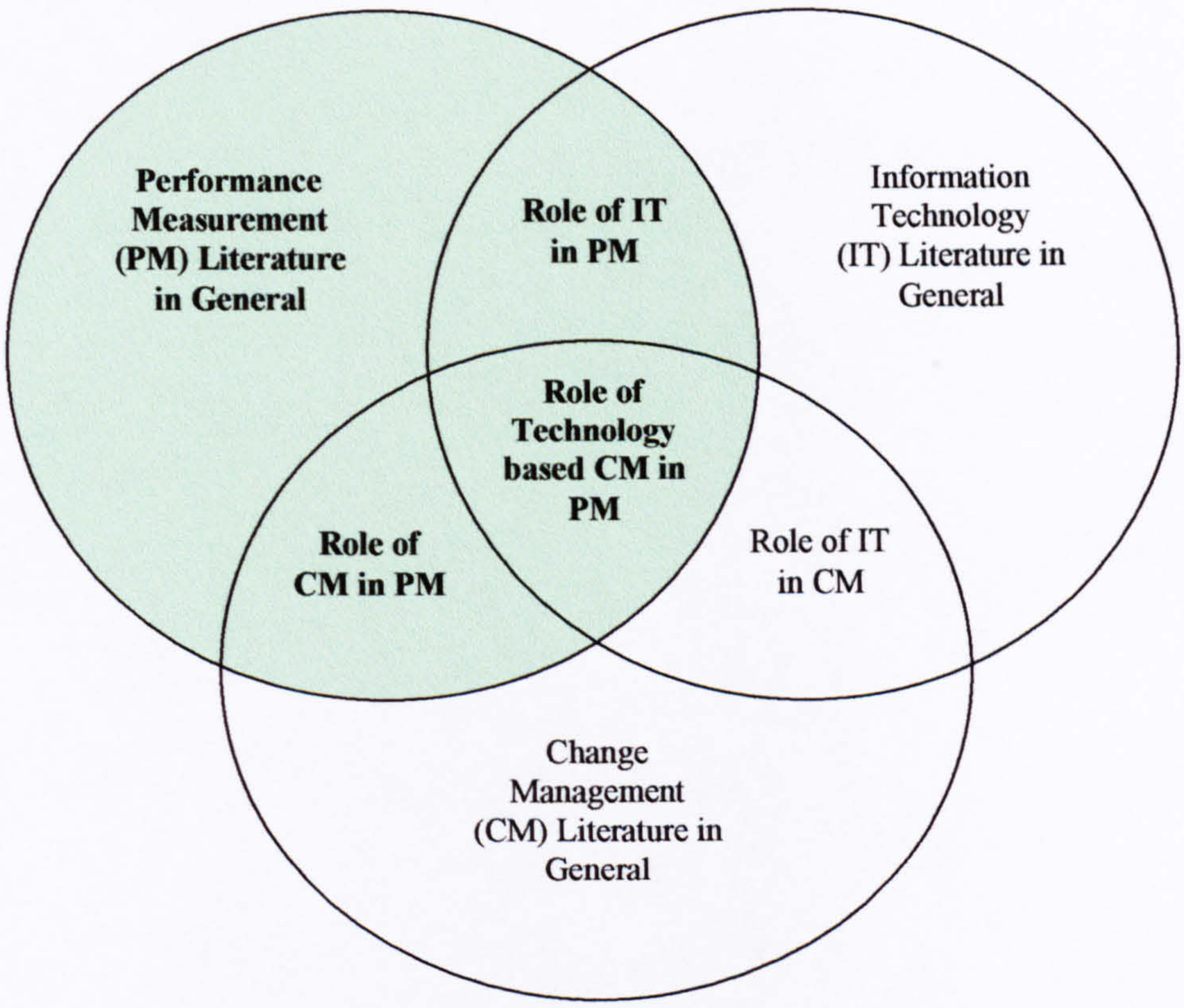


Figure 4.1 Venn diagram representing the literature required for this research

Chapter 3 demonstrated that performance measurement when supported with an appropriate IT platform would bring a positive impact on business and management. However, in order to achieve the research objectives identified in Chapter 3, it is essential to implement IT-PMS in collaborating companies. For implementing IT-PMS in companies the

researcher/facilitator should be thorough in the literature as shown in Figure 4.1 highlighted in colour. Performance measurement literature has already been reported in Chapter 2. Hence this chapter is to review the role of IT in performance measurement, role of change management in performance measurement and role of technology based change management.

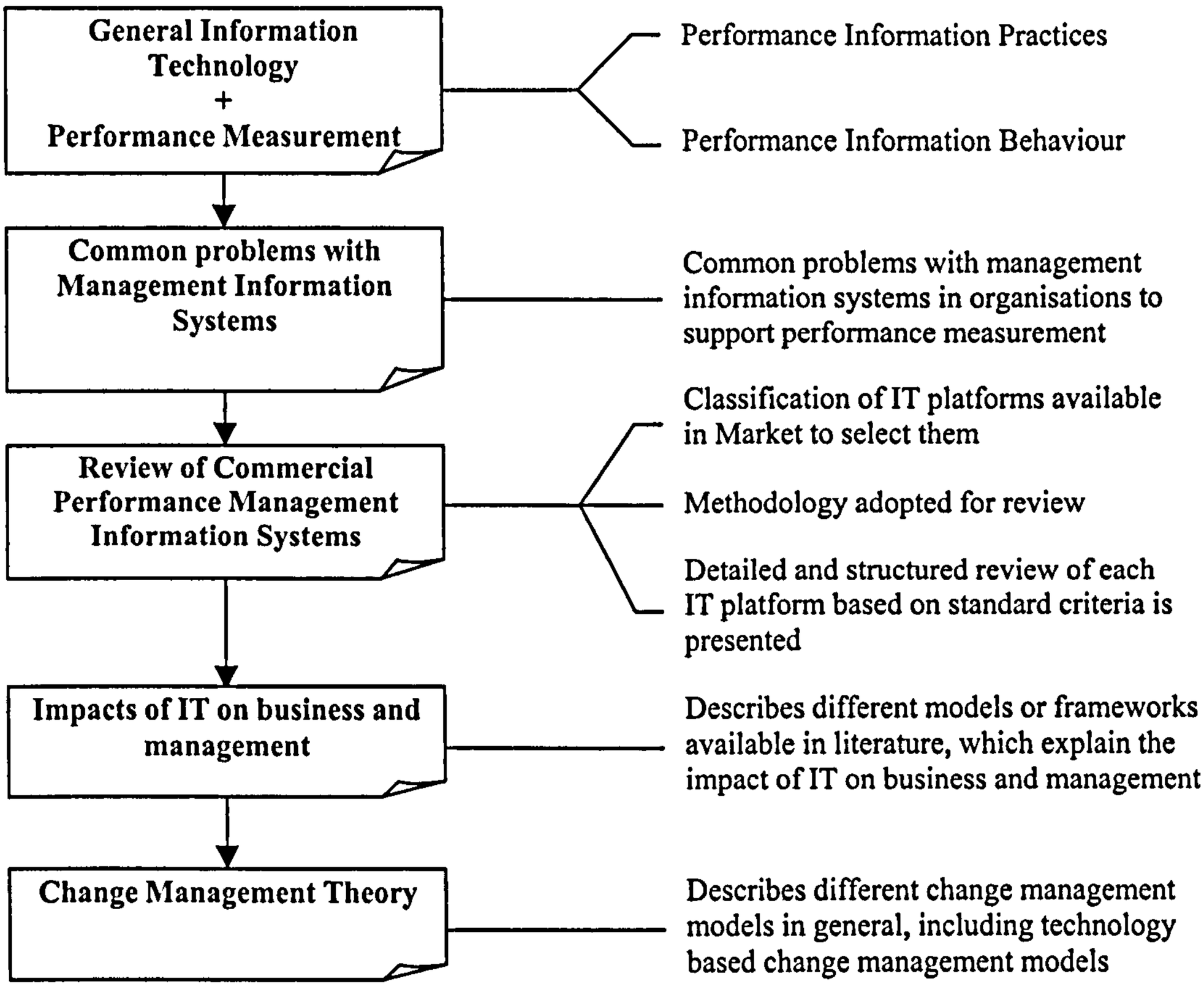


Figure 4.2 Classification of this chapter

Hence this chapter is structured to do the literature review in IT and change management theory to enable the implementation of IT-PMS at collaborating companies as shown in Figure 4.2. Initially a review in general IT is presented in Section 4.2. IT support for performance measurement can be obtained from Management Information Systems (MIS) available within the organisations. However, there are common problems with MIS available in the companies, which are discussed in Section 4.3. The next alternative for IT support is to purchase commercial software, which is available in the market. A review of commercial software available in the market is discussed in Section 4.4. In addition to these perspectives of implementing IT-PMS, the research objective was to identify the impact of IT-PMS. Hence it also has to review any models demonstrating the impact of IT on management and

business, which is reported in Section 4.5. Finally, the last section covers the change management literature in general as well as technology based change management in Section 4.6.

4.2 General Information Technology

In this ever-changing complex, volatile and turbulent business environment, IT has become a critical success factor for many organisations (Blili 1993). Many different products have been developed in the last century to exploit the features of IT to automate, capture, store, process, use and communicate data and information (Eccles 1991). Some of these products include data loggers (such as SCADA systems), mainframe computers, databases (including RDBMS), data marts, application software (such as spreadsheets, notepads), groupware software (such as Lotus Notes), servers (such as web server) and network systems (such as intranet, internet). According to many veterans, IT is designed to deliver many results and benefits. However, in the context of performance measurement, IT is required (Bourne et al 2000a) to deliver one or more of the following:

- For data collection and storage (Haag et al 2002, Blackler 1987)
- For improving operational control, speed and flexibility with customers and hence improve efficiency of business operations (Marchand 2000a & b, Blackler 1987)
- For improving communications supporting the efficient running of business processes (Haag et al 2002, Marchand 2000b)

Finally, IT has played a critical role in making performance measurement revolution possible (Eccles 1991). According to Meekings (1995), successful implementation of performance measurement depends less on selecting the right measures and more on the way the measures are implemented and used by the people in the business. However, many senior managers and researchers contend that good IT systems and appropriate business measures are not just sufficient for implementing performance measurement and management. Infact, many companies have failed to manage the most critical determinant of IT, i.e. how people use it for performance measurement. According to Haag et al (2002), Orlikowski (2000), Marchand (2000b), Remenyi (2000), Neely (1999), Davenport (1997), Eccles (1991) in addition to providing hard aspects of IT, such as creating databases, installing servers, automating data collection systems etc., the companies are also required to provide soft aspects of IT such as Performance Information Practices and Performance Information Behaviour as explained below:

- ***Performance Information Practices (PIP):*** Once the performance indicators are decided and IT is made available in the company, the next step is to find the ways of implementing these measures. *PIPs are defined as the methods used to generate information and rules to regulating its flow.*

- ***Performance Information Behaviour (PIB):*** Once the performance measures are implemented using PIPs, the next step is the exploitation of the information by the people. *PIB is defined as the people's behaviour with performance information in hand. It can be positive behaviour such as pro-active and confident decision making, continuously improving, etc. or negative behaviour such as resistance, wrong interpretation of information, etc.*

4.2.1 Performance Information Practices

Even though critical, providing *IT* alone is not sufficient to implement performance indicators. As mentioned in the above section, *Performance Information Practices (PIPs)* are required (Bourne et al 2000a, Marchand et al, 2000b, Remenyi 2000, Lucey 1997, Davenport 1997) "*to convert data from internal and external sources into performance information and to communicate it, in an appropriate form, to managers at all levels in all functions to enable them to make timely and effective decisions.*"

If IT automates the collection of data and maintenance, PIPs delivers this data in the required formats (such as statistical charts, statistical analysis, summary reports) ready for decision-making (such as, risk analysis, forecasting etc) (Bullers et al 1991, Cash et al 1988, Brancheau et al 1987, Cash et al 1985). In doing this, it links several databases (from different sites, if applicable) with applications and tools necessary to do the analysis. Once the analysis is done, these results are communicated with the help of IT. These information practices have to consider ways in which data and information are:

- Collected up-to-date both consistently and accurately (Bititci et al 2002c, Prahalad et al 2002, Woods 2001, Battista et al, 2000, Bititci et al 2000, Marchand et al 2000b, Bourne et al 2000a, Roland et al 1999, Donovan 1999, IFAC 1999, Booth 1998, Orlikowski 1996, Mockler 1989, Porter 1980)
- Organised and processed to facilitate:

- Collection of information related to the key performance indicators (Bititci et al 2002c, Kueng 2001, Bititci et al 2000, Marchand et al 2000b, Bourne et al 2000a, Roland et al 1999)
- Identification of trends (Bititci et al 2002c, Marchand et al 2000b, Kueng et al 2000, Roland et al 1999)
- Active monitoring (Bititci et al 2000, Turner et al 1999)
- Identification of root causes (Bititci et al 2002c, Bititci et al 2000, Turner et al 1999)

▪ Presented and communicated to the right people including customers and suppliers where applicable (Andersen et al 2002, Bititci et al 2002c, Prahalad et al 2002, Kueng 2001, Battista et al 2000, Marchand et al 2000b, Bourne et al 2000a, Roland et al 1999, Donovan 1999, Neely 1999, IFAC 1999, Booth 1998, Mockler 1989, Porter 1980)

4.2.2 Performance Information Behaviour

Providing IT and performance information practices are not sufficient to improve business performance results. The real success lies in peoples' behaviour in using this IT and performance information practices (Prahalad et al 2002, Orlikowski 2000, Marchand et al, 2000b, Davenport 1997, Eccles 1991). Many executives and academics believe that the main reason why IT based Performance measurement is short lived is because of the employees' behaviour with the information (Bititci et al 2002a, Marchand et al 2000b). Meekings (1995) argue that making people use measures properly not only delivers performance improvement but also becomes a vehicle for a cultural change, which helps liberating the power of the organisation.

In this ever-changing business environment companies are becoming more dependent on sharing and using information dynamically and hence becoming more knowledgeable and proactive. However, the performance information behaviour of the business lies in one or more of the following drivers or factors as shown below:

- Drive from the senior management (Bititci et al 2002a, Marchand et al 2000b, Feeny et al 2000, Bourne et al 2000a, Hudson et al 1999)
- Employees using the information provided by IT and PIPs for identifying business trends (Feeny et al 2000, Donovan 1999, IFAC 1999, Orlikowski 1996)
- Employees using the information provided by IT and PIPs in decision making (Lebas et al 2002, Marchand et al 2000b, Donovan 1999, Orlikowski 1996)

- Employees being not resistant in using IT and PIPs (Markus 2000, Battista et al 2000, Waddell et al 1998, Macrosson 1998, Orlikowski 1996)
- IT and PIPs enabling people to act as teams to solve key issues (Marchand et al 2000b, Feeny et al 2000, Donovan 1999, Orlikowski 1996, Schein 1996)
- Training required for the people on IT and PIPs (Marchand et al 2000b, Markus 2000, Macrosson 1998)
- IT and PIPs improving the empowerment in people (Badham et al 2001, Macrosson 1998, Schein 1996, Schaffer et al 1992)

4.3 Common problems with Management Information Systems

As discussed above, most of the modern Management Information Systems (MIS) have been developed to provide management with the right information required. i.e. different levels of management require different types of information (Haag et al 2002, Brancheau et al 1987, Meltzer 1981) as shown in Figure 4.2

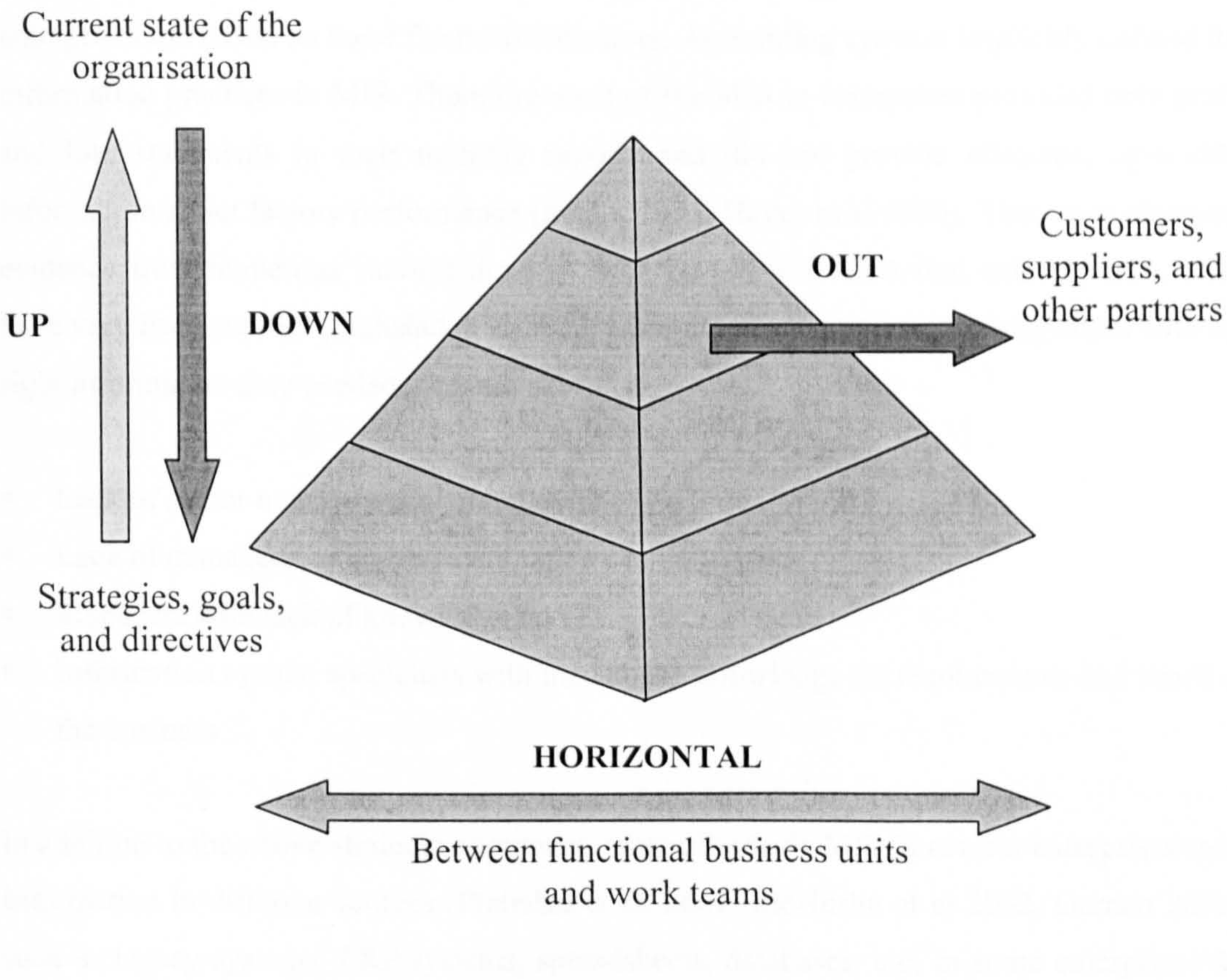


Figure 4.2: An Organisation and its Information Flows *(Source: Haag et al 2002)*

- Strategic information for top-level management
- Tactical information for middle level management
- Operational information for lower level management

MIS plays a vital role in the upward flow of information, i.e. information gathered as part of everyday operations is consolidated and passed *upwards* to decision makers. Strategies, goals and directives are passed *downwards* to the lower levels. It also ensures that information flows *horizontally* across the various departments within the organisation as well as suppliers and customers *outside* the organisation.

According to Haag et al (2002) MIS is defined as a system that "deals with the planning, development, management, and use of information technology tools to help people perform all tasks related to information processing and management".

Traditionally enterprises measured only financial indicators and hence the MIS built in these enterprises are based on these financial indicators. Accounting systems implicitly defined the information practices in MIS. Therefore most of the MIS in enterprises provided only profit and loss statements in their monthly reports and did not provide adequate, up-to-date information about factory performance (Eccles 1991, Hayes et al 1986). There was abundant evidence from numerous surveys done in both the UK and USA that existing MIS, often have very little success (Prahalad et al 2002, Lucey 1997) in providing management with the right information they needed, because of:

- Lack of senior management commitment
- Lack of management involvement in the design of MIS
- Managers with lack of knowledge on IT
- Information system specialists with inadequate knowledge on requirements and needs of the business

In addition to the above strategic alignment, most of today's MIS in several enterprises store information in different sources (Prahalad et al, 2002, McNurlin et al 2002, Garnett 2001), such as legacy systems, ERP systems, spreadsheets, databases, etc. In some enterprises the information is even maintained on paper based sources (personal observation in many Scottish Enterprises). To get application systems up and running quickly, IT system designers have sought the necessary data either from the cheapest source or a politically

expedient source (McNurlin et al 2002). As a result there is no common strategy for IT deployment throughout the organisation. The problems encountered with these systems are:

- Lack of visibility because information is hidden and duplicated (McNurlin et al 2002)
- Difficulties associated with gathering information from different sources (i.e. time and effort required to extract, sort and report information) (Prahalad et al 2002, Garnett 2001)
- Lack of proper links between different sources of information (Prahalad et al 2002, Garnett 2001)
- Lack of effective communication of the information (McNurlin et al 2002)
- Changes and trends occurring are not transparent to everyone concerned

As a result of these problems, enterprises need to invest much of their time in data gathering. As the data is stored in different formats in different departments, some of the data is duplicated (Garnett 2001) and updated by different people. Hence, questions always arise on the validity of data. As information sources are not linked properly, information is not available dynamically (i.e. near real-time), which does not allow managers to make fast and confident decisions. As information is not shared or communicated throughout the organisation, managers cannot work as a team and changes occurring in one source are not transparent to everyone. This often leads to a reactive and closed management style, pointing fingers at one another rather than focusing on the issue in hand. Performance measurement supported by this type of MIS, when implemented often results in a failure, as the management and people will not have enough confidence in information.

The limitations of existing MIS supported performance measurement systems are also relevant in the context of collaboration with customers and suppliers. On one hand, customers will be interested in looking at the process data to either vary the composition of raw material, adjust the process or re-deploy-resources, which would otherwise effect the final quality of their product. On the other hand, suppliers will be interested in seeing the same data to improve the quality of raw material. Apart from quality, there are several issues in which the suppliers and customers would be interested in, such as delivery times, total cycle times, amount of scrap, number of orders etc. Unless the performance information is properly structured, made easily accessible and disseminated in a relevant manner, it cannot be shared across the supply chain to enhance collaboration.

4.4 Review of Performance Management Information Systems (PerforMIS)

4.4.1 Background

As demonstrated earlier, current MIS available in enterprises was unable to support Performance Measurement in most cases. Hence, there is a revolution in the market with several software vendors developing their application/product to support the performance measurement, although most of them are based on Balanced Scorecard. These performance measurement software applications are developed for data communication, integration, analysis and representation to different sets of audience.

In the last decade, there is an enormous growth in the number of software applications offered for performance measurement, which makes it difficult for the users to distinguish between these applications. The software platforms reviewed include products from the following vendors:

- Cognos Ltd.
- CorVu Plc.
- QuantiSoft
- SAP Ltd.
- Comshare
- Lucidus Ltd.
- PeopleSoft
- IPS-Sendero
- Hyperion
- SAS Institute
- PB Views Ltd.
- Inphase Software
- Pilot Software Ltd.
- Active Strategy
- Oracle Corp Ltd.
- QPR Software Plc.
- Gentia Software Ltd.
- PT. Global Performa Maxima
- Show Business

The products offered by the above vendors are classified into three categories:

- Business Intelligence (BI) is a continuous and systematic process, which produces information on a company's operating environment in a timely manner and usable form so that it can have a positive impact on business processes. Effective Business Intelligence will facilitate the improvement of business processes and reduces the time used for decision-making. Typically, it includes software functions, such as data sourcing, data analysis, risk assessment and decision support, etc. It includes software tools, such as Data Marts, Data Warehousing, On-line Transactional Analysis tools, Multidimensional Databases or On-Line Analytical Processing (OLAP) tools, Ad-hoc and Prepackaged Query tools etc. Typical BI platforms are provided by: Oracle Corp., Hyperion, SAS Institute, Cognos Ltd., Pilot Software Ltd, SAP Ltd., PeopleSoft, CorVu Plc., Gentia Software Ltd., Comshare etc.

- Enterprise Resource Planning (ERP) Platforms: An ERP system is a multi-module software system that includes a central relational database and several software

modules for managing purchasing, inventory, production, personnel, shipping, customer service, financial planning, and other important aspects of the business. A number of ERP vendors have started to integrate performance measurement as a module or feature within their ERP platform, e.g. SAP Ltd., PeopleSoft, Oracle Corp. Ltd. etc.

- Dedicated Performance Measurement Platforms: These are software platforms that allow organisations to implement performance measurement frameworks such as Balanced Scorecard, EFQM, etc. Typically it collects the performance relevant information from different sources, analyses the information and communicates the information to different stakeholders, who make decisions. Vendors of dedicated performance measurement platforms include PB Views Ltd., QPR Software Plc., Inphase Software Ltd., Hyperion, Cognos Ltd., Lucidus Ltd., PT. Global Performa Maxima, QuantiSoft, Gentia Software Ltd., IPS-Sendero, Comshare, Active Strategy etc.

Even though ERP platforms were classified separately, vendors who offer performance measurement within ERP modules are not yet common. Therefore, most of the IT based PMS applications are built upon Business Intelligence or Dedicated platforms, which have the capability of integrating with the company's existing ERP and other systems.

4.4.2 Methodology adapted for PerforMIS Review

In order to understand the software platforms (not necessarily Balanced Scorecard) in depth, a structured review was done based on the user requirements (criteria) gathered from five Scottish based enterprises. The criteria (as shown in Table 4.1) used to evaluate these platforms was developed through educating management of five enterprises on performance measurement and best practice applications of PMS and then facilitating them to develop a requirements specification based on how they would see themselves using the system.

Initially, general information about each software and its vendor is collected from their brochures and web sites. Later, based on the criteria we collected from enterprises, we prepared a standard questionnaire and sent this questionnaire to all vendors inviting them to participate in answering it, in order to understand their software and its functionality to fulfil the above criteria. Telephonic conversations were made wherever necessary (where we did not receive enough feedback through the questionnaire).

Table 4.1 Criteria to evaluate software available in market

➢ **Designing Performance Measurement Frameworks or Models** ▪ *Does it contain different pre-built frameworks?* ▪ *Is it customisable to build other frameworks?*
➢ **Defining Performance Measures** ▪ *Does it include deployment of objectives into performance measures?* ▪ *Does it provide library of performance measures?* ▪ *Does it apply prioritisation, cause and effect relationship between the measures?*
➢ **Data Collection and Maintenance** ▪ *Does it extract data from different database file structures?* ▪ *Does it include a relational database to act as a single data source?*
➢ **Analysis of Data** ▪ *Does it include colour coding to identify the danger at a glance?* ▪ *Does it include competitor analysis?* ▪ *Does it include simple charts and statistical quality control charts?* ▪ *Does it include simple calculations to complex statistical analysis?* ▪ *Does it differentiate between control and improvement measures?*
➢ **Reporting and Communicating Results** ▪ *Does it include a structured reporting tool?* ▪ *Is it compatible with any other applications?* ▪ *Is the data in the reports updated as the source data changes?* ▪ *Does it include any web server to communicate these results throughout the organisation?*

The limitation of the review is that we did not play with the actual software to review it. However, we had an opportunity to see some of the software demo versions, online demonstrations and power point presentations. Finally, we gathered all information and critically discussed each software based on the criteria.

4.4.3 Detailed Review

A detailed review of each software is presented in Nudurupati et al (2000). A summary of all the software compared against the standard criteria is given in Table 4.2.

4.4.4 Conclusion

Most of the software and solutions reviewed are expensive for the sake of performance measurement in enterprises. However, the more you pay for the software, the more you get the functionality. Moreover not any single software fits all companies. Some software is good in providing certain functionality where other software is good at other functionality. Some software is good for data collection and analysis, some are good for reporting, etc. However, in any case, it is recommended that the organisation should define a set of criteria essential and then use the above review to find the best software suitable for them. *Most of these software applications and solutions are not capable of incorporating statistical analysis, as required by Six Sigma (and other TQM techniques).* Most of them are built based on Balanced Scorecard concept.

Even though few companies (e.g. large and medium size) are able to buy the software available in the market to support their performance measurement, there are many companies (small and medium size) that are not able to buy the software from the market due to the heavy investment involved in it. However, Chapter 2 has demonstrated with anecdotal evidence that the companies, which cannot buy the software available in the market, can build their own solution using the IT infrastructure available within the company.

Table 4.2 Comparing Different Software against the Standard Functionality (based on User Requirements)

Software Requirements × No Support ✓ Full Support ☑ Partial Support	Pilot Decision Support System	Cognos PowerPlay & Impromptu etc.	Comshare MPC™	CorManage, RapidScorecard & CorServer	Gentia Enterprise Performance Management	Hyperion Performance Scorecard	PerformancePlus™	pbviews	Promeasys	QPR ScoreCard	Performance Profiler™	Strategic Vision	ActiveStrategy Enterprise
Designing Performance Measurement Frameworks:													
➢ Does it contain different pre-built frameworks?	×	×	✓	✓	×	✓	✓	✓	×	×	×	×	✓
➢ Is it customisable to build other frameworks?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Defining Performance Measures:													
➢ Does it include deployment of objectives into performance measures?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
➢ Does it provide library of performance measures?	×	×	✓	✓	✓	✓	×	×	×	✓	×	☑	×
➢ Does it apply prioritisation, cause and effect relationship between the measures?	×	☑	✓	✓	✓	✓	✓	✓	☑	✓	×	✓	✓
Data collection and maintenance:													
➢ Does it extract data from different database file structures?	✓	✓	✓	✓	✓	✓	✓	✓	☑	✓	☑	✓	✓
➢ Does it include a relational database to act as a single data source?	☑	✓	✓	✓	☑	☑	☑	✓	☑	☑	☑	✓	☑
Analyses of data:													
➢ Does it include colour coding to identify the danger at a glance?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓
➢ Does it include competitor analysis?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
➢ Does it include simple charts and statistical quality control charts?	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
➢ Does it include simple calculations to complex statistical analyses?	☑	☑	☑	☑	☑	✓	☑	☑	×	☑	☑	☑	✓
➢ Does it differentiate between control and improvement measures?	×	×	×	×	×	×	×	×	×	×	×	×	×
Reporting and communicating results:													
➢ Does it include a structured reporting tool?	✓	✓	✓	✓	☑	✓	☑	✓	×	☑	×	✓	✓
➢ Is it compatible with any other applications?	✓	×	×	×	☑	✓	☑	×	×	☑	×	×	✓
➢ Is data in the reports updated as the source data changes?	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	×	×	✓
➢ Does it include any web server to communicate these results throughout the organisation?	✓	✓	✓	✓	✓	✓	☑	✓	☑	✓	×	✓	✓
Overall Rating out of 5	3.75	3.75	4.00	4.50	3.75	4.50	3.50	4.00	2.00	3.75	1.50	4.00	4.25
Based on 10 User Licence (SMEs) **Price of Software** Very Low (VL) – Less than £ 5,000 Low (L) - £ 5,000 to £ 10,000 Normal (N) - £ 10,000 to £ 20,000 High (H) - £ 20,000 to £ 35,000 Very High (VH) – Greater than £ 35,000 Annual Rental basis – (AR)	**VH**	**H**	**H**	**H**	**H**	**VH**	**H**	**VH**	**L**	**H**	**L**	**AR**	**VH**

4.5 Impact of IT based Performance Measurement

Despite the huge amount of practical implementations of IT supported performance measurement systems in different industrial sectors, less or almost no research has been done in correlating between the amount of investment spent on implementing IT based performance measurement systems and the benefits or the impact it has on business and management. *"Are the results / impacts worth the system implemented?"*

Many organisations find it difficult to produce a persuasive business justification for any investment opportunities (Booth 1998). There is often high uncertainty about the scale of impact and the scale of costs likely to be incurred. Although it is fairly easy to establish the design and implementation costs of new systems, it proves difficult to establish the operational costs or saving of such systems (i.e. the marginal cost or saving of operating maintaining, updating and using such a system). Hence it becomes increasingly difficult to separate the impact of the new systems from other assets and activities, when they become an inextricable part of the organisation's processes and structures (Bititci et al 2002a, Willcocks et al 1999). This will in many cases make organisations deciding in poor investment decisions, or an over cautious approach that may result in missed opportunities.

Having seen the difficulty of correlating between the performance measurement investment and its impact (Holloway 2001), it is necessary to find the impact of IT enabled performance measurement (irrespective of investment) to ensure organisations to resort their investment decisions. In fact investing money in new technology or systems does not guarantee anything. The benefits rely only on how well they are introduced and managed in a business, which brings in support and reinforces continuous improvement (Hayes et al 1986). However, as it has been already demonstrated in Chapter 2 that there is very little solid research evidence that illustrates the impact of performance measurement systems on business and management. Hence it is necessary to review the IT literature to find any models or frameworks available, which explains the impacts of IT on business and management. After a careful review in IT literature the following model was found.

4.5.1 Enabler-Effect Mapping

According to Lillrank et al (2001), the route from the use of IT to the captured benefits is very difficult. However, their research demonstrated that the Enabler-Effect Map (EEM) is a very useful model for finding the impact of IT on business processes. The three key reasons identified for using EEM models are:

- The technology by itself will do nothing, hence it is required to *find the factors* that are causing the impact (whether techniques, practices, people, etc.)
- It is not possible to establish a *sufficient set of conditions* explaining a benefit in advance. It is difficult to find the factors that are responsible for causing that benefit
- Although there is no direct link between IT implementations and bottom line impact, these *links can be derived* through the relationships between financial and operational indicators (Kaplan et al 1992 & 1996)

The author's idea of using this framework provides some basic descriptors of the terrain and a compass that can be used to travel from beacon of bearings, which acts as the starting point of the effort and beacon of benefits, which acts as the effects and benefits of IT on operative performance level as shown in Figure 4.3.

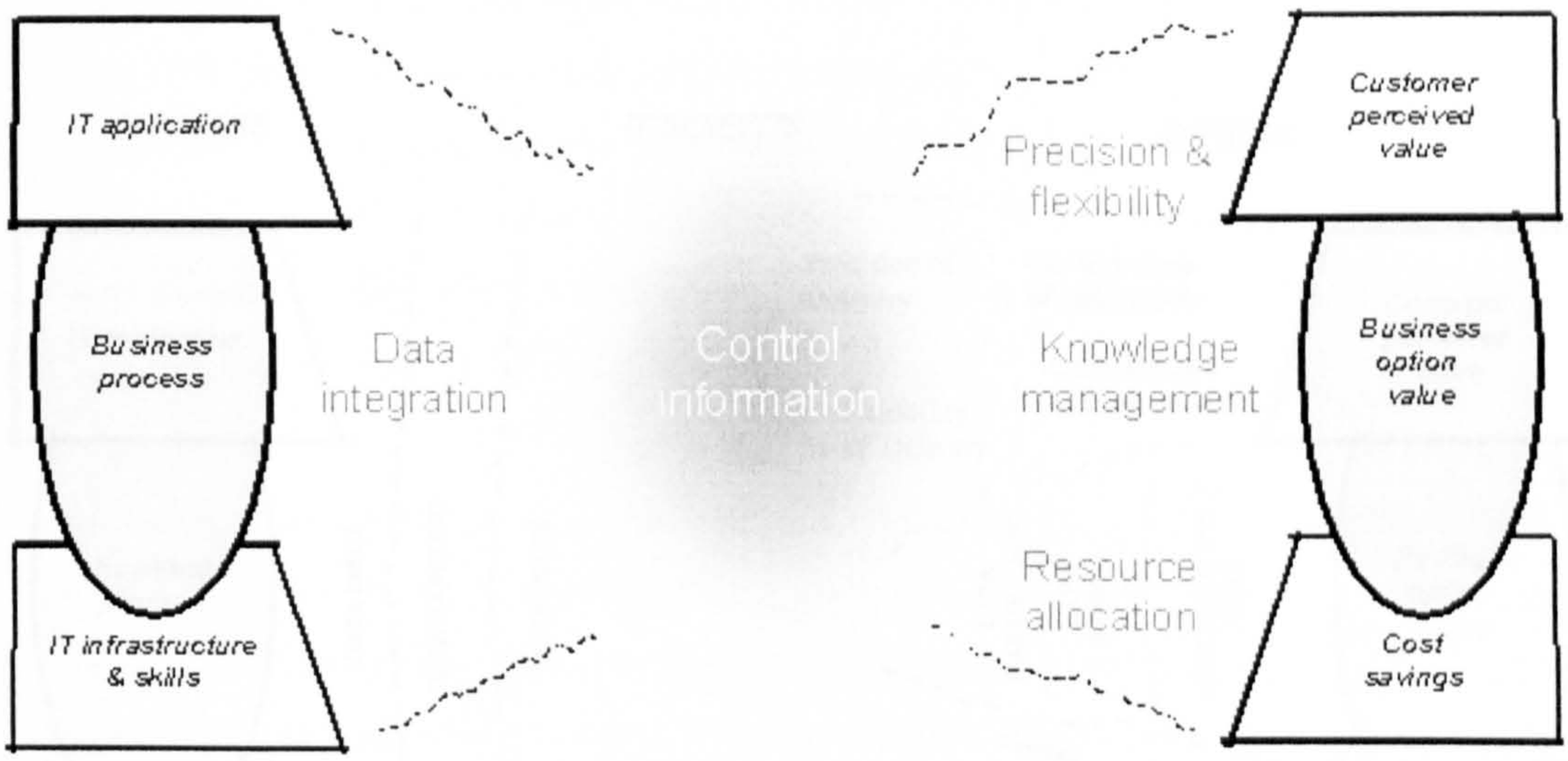


Figure 4.3: Rough features of the terrain (*Source: Lillrank et al 2001*)

Amongst the beacon of bearings, there are three things, which act as the starting position on the way from IT to benefits, they are:

- The business processes in which the new technology is implemented
- The IT infrastructure and skills existing in the company
- The new technology brought into the organisation of implementation (IT application, software, etc.)

Amongst the beacon of benefits, there are three value propositions, in which IT will have the impact, they are:

- Customer perceived value that is obtained by the internal or external customers of the IT supported processes
- Cost savings obtained by the new supported processes
- Business option value, which is an opportunity generated by usage of IT. It must be realised by a strategic move, such as introducing additional services, introducing new pricing schemes, etc.

In determining the bridge (terrain) between the two beacons, the EEM model uses three maps of different scales, i.e. rough features of the bridge as shown in Figure 4.3, more detailed level features of the bridge as shown in Figure 4.4, finally the third map represents the real case (Lillrank et al 2001, Figure 3).

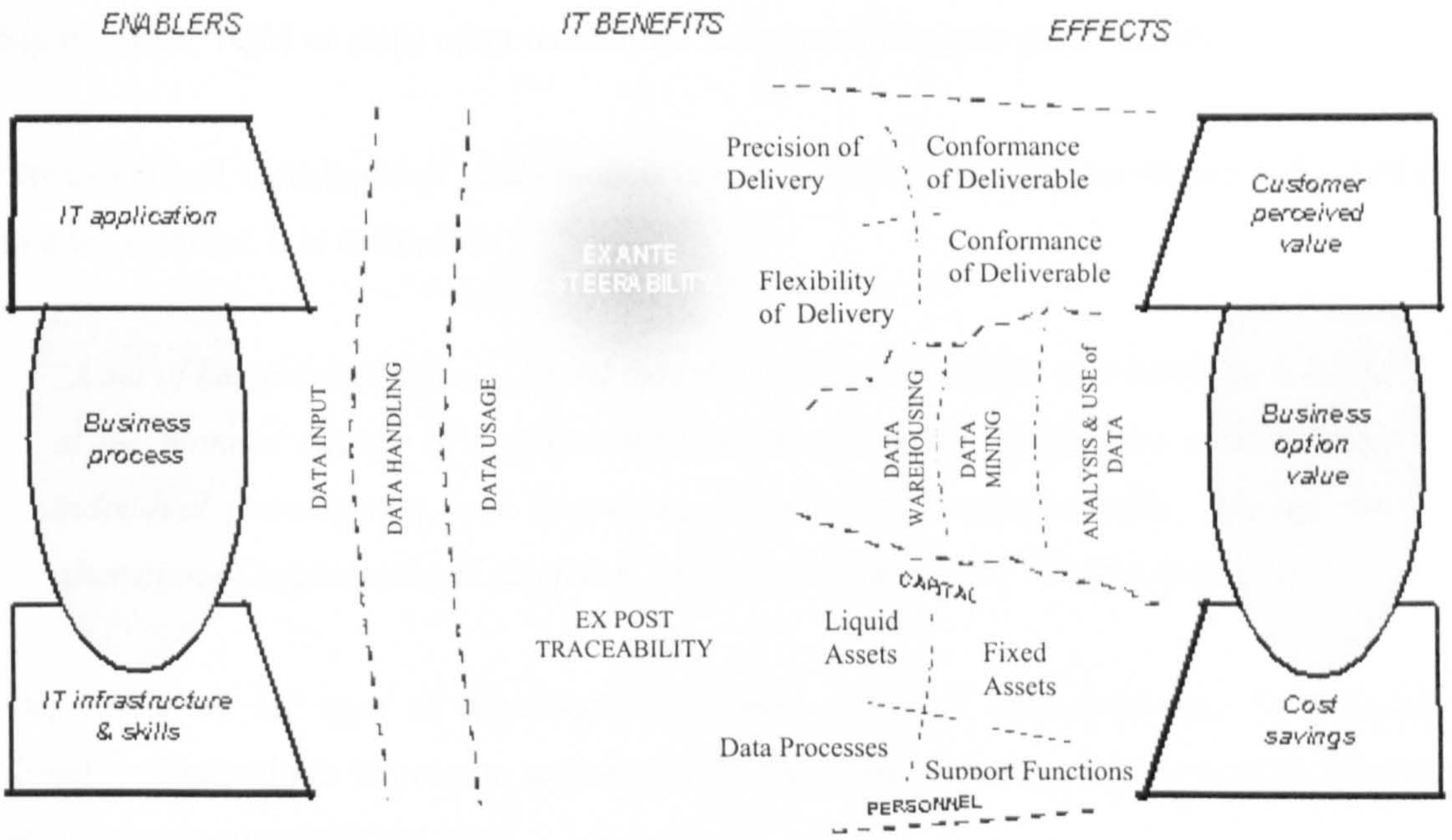


Figure 4.4: Detailed level features of the terrain *(Source: Lillrank et al 2001)*

Towards the beacon of bearings lie the enablers, which are preconditioned for better control of information. Pure benefits such as better control of information lie in the middle of the map. Towards the beacon of benefits lie effects, they are: Ex ante steerability that is to use

real-time or on-line information for managing processes as well as Ex post traceability that is to use stored data for planning and analysis.

While implementing IT based performance measurement, the beacon of bearings, the bridge and the beacon of benefits will differ from above, and will be based on Business Excellence Models such as EFQM and ABCD Checklist, which are generally used to assess the business performance.

4.6 Theoretical perspectives on organisational change

> "*Change management is the process, tools and techniques to manage the people-side of business change to achieve the required business outcome, and to realise that business change effectively within the social infrastructure of the workplace.*" (Hiatt et al, 2002)

This definition allows researchers and practitioners to separate change management as a practice area from business improvement techniques such as performance measurement, Six Sigma, BPR, TQM or some other techniques to improve business performance.

Organisational Development (OD) models are included in management theory and practice to a large extent. It is defined as:

> "*A set of behavioural science-based theories, values, strategies, and techniques aimed at the planned change of organisational work setting for the purpose of enhancing individual development and improving organisational performance, through the alteration of organisational members' on-the-job behaviours.*" (Porras et al 1992)

Depending on the type of organisational change intended, initiatives may be designed directly at individuals in order to secure specific behavioural change, or they may be directed at a group or organisational level.

As a starting point, it is necessary to indicate useful theories in organisational change management literature that are favourable for implementing and using performance measurement. A change may refer to any alteration in activities, tasks or event in an organisation. According to Dawson (1994), there are three different approaches for an organisational change:

- **Orthodoxy Approach:** These approaches are used in organisations operating under stable environment. They are traditional or conventional approaches to a planned change such as introduction of new technology, globalisation of business, increase in product variety and volume, change in government policies, etc.
- **Contingency Approach:** These are planned change models for the organisations operating under a turbulent environment. It is an understanding of a decision criterion or rules and relationships between different contingents such as technology, environment, etc. and its contextual variation under different circumstances. They will also make an implicit assumption that situations are predictable and change agents could diagnose the problem and solve it.
- **Contextualist Approach:** It seeks to encompass knowledge of the whole organisation in order to explain the process by which managers mobilize and reconstruct contexts in order to legitimate the decision of change (Whipp et al, 1987). It is the relationship between the content of change, the context in which change occurs and the process, which takes it through the change.

According to Checkland et al (1991), there is methodology to tackle messy and complex situations in the real world, in action:

- **Soft Systems Methodology:** It helps all kinds of managers to cope with their tasks in real world (Action) in an organised way. It is based on systems thinking, which enables it to be strongly defined and described, but is flexible in use and broad in scope (Ckeckland 1981)

The following sections explain the above four change management models orthodoxy, contingency, contextualist approaches as well as soft system methodology in detail.

4.6.1 Orthodoxy Approach

It includes a range of external factors such as government laws and regulations, technology, social and economic change as well as internal factors that are generally characterised as comprising technology, people task and administrative structures (Dawson 1994). A change in an organisation's techniques, for instance, in our case, involves installation of a performance measurement system. This entirely changes the way people interacted with information before and after implementing the system. This new technique will/might

change the administrative procedures, which in turn modify other aspects such as communication and human aspects involving attitudes, beliefs, values, skills and behaviours, etc.

In Lewin's (1947) theory of force field-analysis, there will be two sets of forces in operation within a social system, one driving the force to operate for a change and the other trying to increase the resisting forces. In order to maintain a successful change, the implementation team either should increase the driving forces or decrease the resisting forces. If the forces are equal there will be an equilibrium (or stability) in the organisational change, hence Lewin (1951/2) identified three stages for implementing successful management of change.

- Unfreezing is a stage in which the organisation prepares for a change. Recognition for change occurs, by reducing the resisting forces rather than increasing the driving forces.
- Moving stage occurs in which the new systems and procedures of operation are implemented.
- Refreezing, action has to be taken to reinforce the changes that have occurred and to ensure that the new ways of doing things become habitualised. Recognition for change occurs, by increasing the driving forces for change.

However, orthodoxy approaches and Lewin's model are most suitable in an organisation, which operates under a stable environment. These approaches are questionable to be implemented in organisations that are operating in a continuously and rapidly changing environment.

4.6.2 Contingent Theory

If the organisations are operating in an increasingly unpredictable global environment, then their ability to manage change becomes increasingly central to their survival and competitive position. For the organisations to adapt to this turbulent environment, a number of **contingent theories** have evolved (Dunphy et al 1990, Galbraith 1973, Burns et al 1961).

Burns and Stalker's (1961) approach highlights the importance of organisation's ability to adapt to the turbulent environment and includes two-contrasted type of management system.

- Mechanistic system, which is appropriate for organisations using unchanging technologies and operating in relatively stable market conditions. It is characterised by

hierarchical structure of control, abstract nature of tasks, vertical interaction between people, biased towards internal issues, etc. (Burns et al 1961)

- Organic form, which is appropriate to changing conditions giving rise to fresh problems and unforeseen requirements. It is characterised by network structure of control, realistic nature of tasks, lateral interaction between people (more horizontal), biased on both internal and external issues, etc. (Burns et al 1961)

This theory also suggests firstly, large-scale changes occur very rapid. Secondly, organisation management system (organic form) is a condition for accommodating substantial change. However, both these suggestions are proved to be wrong from a number of cases reported (Dawson 1994). However within an organization, research and development departments have organic form and production departments, which have mechanistic form (Galbraith 1973).

Dunphy and Stace (1990) proposed a two dimensional model based on the scale of change on x-grid and the style of leadership on y-grid as shown in Figure 4.5. The authors argue that Participation Evolution can be used when organisations are in-fit but need minor adjustments, or are out-of-fit but time is available and key interest groups favour change. Charismatic Transformation is used when organisations are out-of-fit, there is little time for extensive participation but there is support for radical change within the organisation. Forced evolution is used when organisations are in-fit but need minor adjustments, or is out-of-fit but time is available and key interest groups oppose change. Dictatorial Transformation is used when organisations are out-of-fit, there is little time for extensive participation and no support within the organisation for radical change, but radical change is vital to organisational survival and fulfilment of basic mission.

	Incremental Change Strategies	Transformational Change Strategies
Collaborative Modes	Participative Evolution	Charismatic Change Strategies
Coercive Modes	Forced Evolution	Dictatorial Transformation

Figure 4.5 Dunphy and Stace (1990) Model for Contingency Theory

The two major weaknesses of this approach are firstly, the model does not tackle the political dimensions of change. Secondly, no attempt is made to provide a typology of change strategies and conditions for their use during actual process of organisational change (Dawson 1994).

4.6.3 Contextualist Approach

However, both the orthodoxy and contingent approaches discussed above are considered as planned change models in which change agents are the main source of organisational change, who intentionally implement changes anticipating potential benefits. Most of these approaches do not contextualise research by examining the content and process of change (Pettigrew 1987, Child et al 1987). Hence, there is a requirement for an alternative approach called **contextualist** approach to manage change.

According Pettigrew 1990, 1987 and Child et al 1987, the study of contextualist approach includes three elements as shown in Figure 4.6, which are:

- Content or substance of strategy for the change programme. It refers to the particular areas of transformation under examination such as technology, manpower, products, geographical positioning, corporate culture, etc.

- Process of change programme. It refers to the actions, reactions, and interactions from the various people (involved in the change process) as they seek to move the firm from its present to its future state.
- Context in which changes occur. Outer context refers to the social, economic, political, and competitive environment in which the firm operates. Inner context refers to the structure, corporate culture, and political context within the firm through which ideas for change have to proceed.

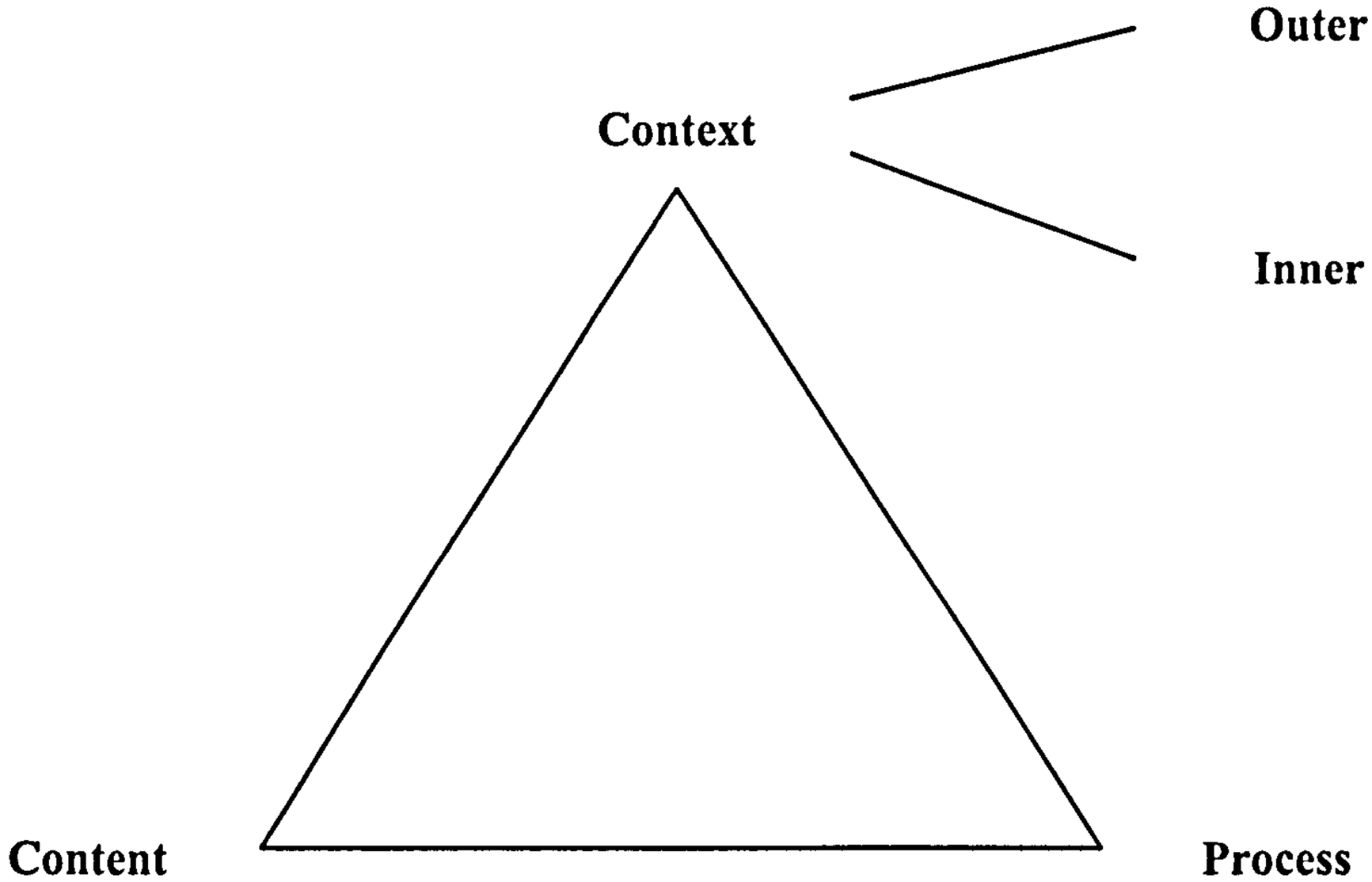


Figure 4.6 The broad framework for Contextualist Approach *(Pettigrew 1987)*

Both Child et al (1987) and Pettigrew's (1990) studies are based on longitudinal case studies and the collection of in-depth qualitative data. Pettigrew's (1987) analysis also identified a need for both vertical and horizontal level of analysis. Vertical level of analysis includes outer and inner environmental contextual factors. The horizontal level refers to the interpretation between historical events, present events and future expected events. Holloway (2001) as a part of his research programme, using Toulmin's model (Toulmin 1958) claimed that both context and process influenced performance measurement effectiveness.

There is one significant drawback for contextualist approach for its richness and complexity of multi level analysis. However, the approach is accepted and adopted by many researchers in UK (Dawson 1994).

4.6.4 Soft Systems Methodology (SSM)

It was developed in the 1970s from the failure of established methods of 'system engineering' when faced with complex problem situations (Checkland et al 1991). One of the obvious characteristics of human beings is their readiness to attribute meaning to what they observe and experience in reality.

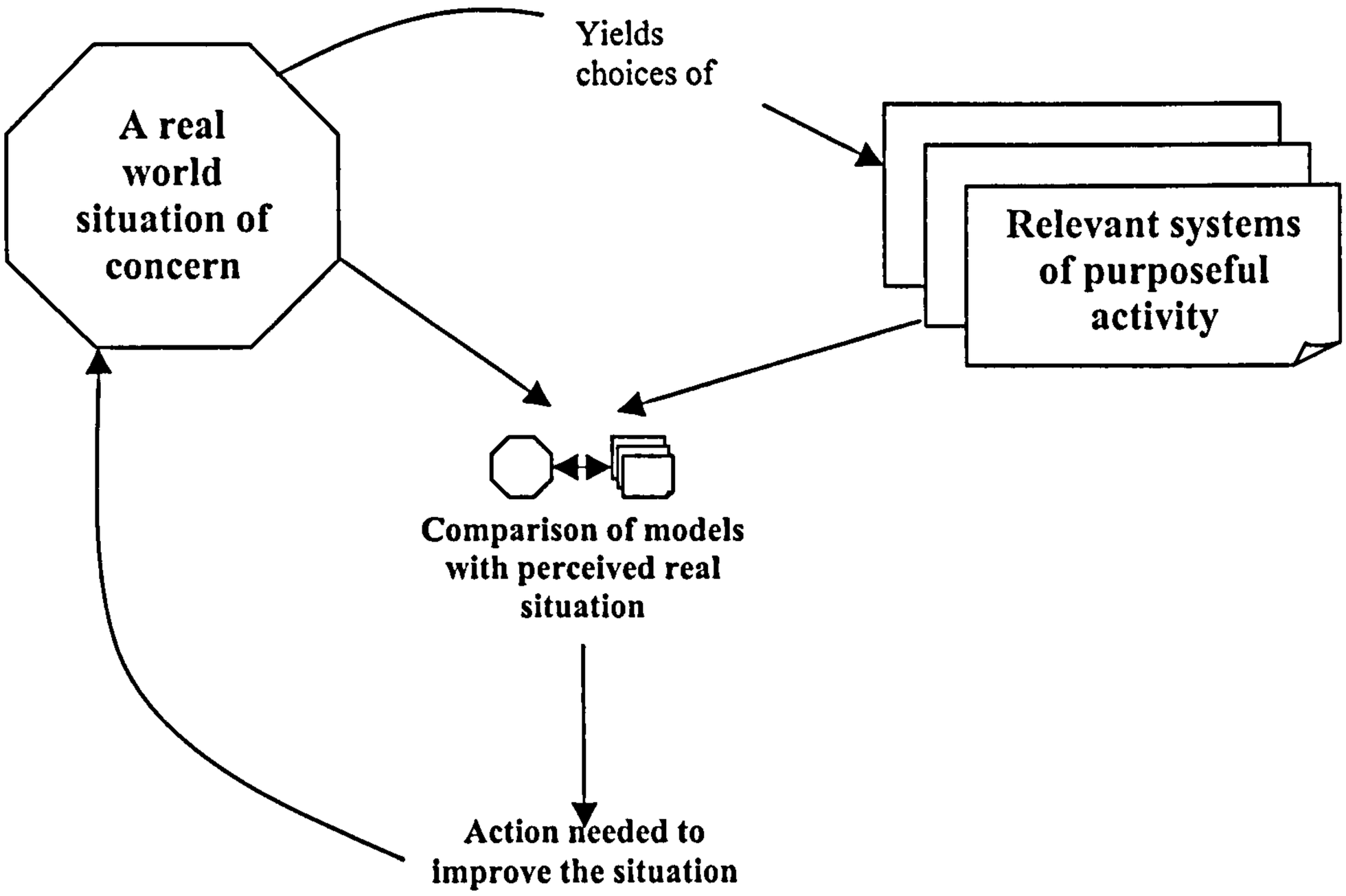


Figure 4.7: The basic shape of SSM *(Checkland et al 1981)*

The basic idea of the approach is finding out about a problem situation and its causes from stakeholder, cultural, and political perspectives. Formulate the models using influence diagrams, process flowcharts, etc, which are relevant to the real world situation identified by the person or group of people as shown in Figure 4.7. Use these models by setting them against perceptions of the real world in a process of comparison by both observation and discussion(s). This comparison will further initiate the action(s) needed for improving the situations in the real world.

Even though the presented approach is very simple, the methodology can be used to solve very complex situations in different industries as demonstrated by Checkland et al (1991). The purpose as a whole has two more long-term benefits. The first one is the process itself, it can be seen as a cyclic learning system. The second one is the process within which, the systems models initiate the debate and argument for supporting the purposeful change.

4.6.5 Theoretical insights to technology based organisational change

This section provides the insights to change management literature that includes studies on technology-based organisations. According to Orlikowski (1996), there are three perspectives that have influenced studies of technology-based organisational transformation:

- Planned change, as discussed in the above sections, includes Lewin's (1951) force field analysis, contingency frameworks, innovation theories and practitioner-oriented prescriptions for organisational effectiveness. These models are criticised for taking change as a discrete event by the managers and separating it from the organisation ongoing processes (Pettigrew 1987, Child et al 1987).

- Technological imperative, in which technology is seen as a primary autonomous driver for the organisational change. It emphasises that adoption of a new technology will bring in changes in the organisation's practices, structures, work routines, information flows and performance (Leavitt et al 1958).

- Punctuated equilibrium models assume change to be rapid, episodic and radical. When a technology is implemented, the large periods of stability (so called equilibrium) are punctuated by compact periods of qualitative metamorphic change (Child et al 1987, Miller et al 1984).

All three perspectives are criticised for neglecting the so-called distinction between deliberate and emergent changes (Mintzberg 1987). Deliberate refers to the new pattern of organising change as intended where as emergent change refers to the new pattern of organising change in the absence of prior intentions. However, this emergent change can only be realised in action and cannot be anticipated or planned (Orlikowski 1996, Mintzberg 1987).

Orlikowski (1996) proposed a situation change perspective, in which organisation transformation is grounded in the ongoing practices of organisational actors and emerges out as experiments with every day contingencies, breakdowns, exceptions, opportunities, and unintended consequences that they encounter. This transformation is seen as an ongoing improvisation endorsed by organizational actors trying to make sense of and act logically in world. This ongoing improvisation is nothing but focusing on a particular situated action (context) taken by action researchers.

Hence through a series of ongoing improvisations, alterations or adaptations, sufficient modifications are performed over time that fundamental changes (metamorphosis) are achieved.

4.7 Discussion

We have seen IT has been a big success in many companies in the recent years. In the past, only few companies have IT, which was a competitive critical success factor, but soon the competition has increased in other companies and the situation has become so saturated that IT has now become a normal part of most businesses. Now, IT is no more a competitive success factor but it is just an essential element of most companies. Section 4.2 of this chapter has demonstrated that the future success lies not only by delivering good IT practices but also by delivering good information practices and information behaviour within the business. Section 4.2 also provided strong theoretical foundations for the predictions, technical and people factors identified in Chapter 3.

How good are the MIS available in the organisations to deliver performance information practices and behaviour? Most of the organisations already have MIS in place for collecting and storing information but as demonstrated in Section 4.3, they are not sufficient enough to exploit that information in real-time basis (near real-time basis). i.e. most of these available MIS in enterprises are not sufficient to support performance measurement.

The enterprises could buy an IT platform readily available in the market as demonstrated in the Section 4.4. However, as concluded in Section 4.4 we require heavy investment in performance measurement for the supporting IT platforms. This investment has to be justified and proved that the organisation had enough benefits for the amount of investment made in performance measurement implementation. It is also demonstrated that a cost benefit analysis is very difficult, as it is difficult to separate the operation costs of implementation once it is made as a routine part of the business. However, finding the impacts of IT-PMS implementation on business and management will enhance the confidence of senior managers for investing in these implementations.

After a careful review of literature, Enabler-Effect Mapping, a proven model was found for explaining the impacts of IT on business and management. The same model will be used in

the current research to achieve the objectives identified in Chapter 3. Section 4.5 explained this model in detail.

When IT-PMS is implemented in collaborating companies, it brings in change within the company. This will also lead to the impacts of IT-PMS on management and business. Hence a review was presented in Section 4.6 covering the basic models explaining the change management theory. From the insights of technology based change management models, it is evident that there will be a transformation in the organisation as result of implementing technology. This transformation is seen as an ongoing improvisation endorsed by organizational actors trying to make sense of and act logically in world. This ongoing improvisation can be realised and observed by action researchers.

The review presented in Section 4.6 gives a strong support to adopt action research as the main research domain for doing this research in studying the impacts of IT-PMS. However in addition to action research, there are several research domains, methods, tools and techniques available, that are essential to achieve the research objectives identified in Chapter 3. The following methodological issues should be taken into account to do this research:

- Emphasis should be placed on problem-finding or establishing research objectives as the entire quality of research outcome is based on the research objectives identified
- Understand and establish the basic beliefs about the world, in the context of this research (Philosophical sense)
- Understand and establish different guidelines on how to do this research by identifying research mode, strategy and domain (Social sense)
- Understand and establish different tools and techniques used in this research (Technical sense)

The next chapter addresses these methodological issues by reviewing different research paradigms, modes, strategies, domain, tools and techniques in general and finally establishes a methodology to achieve the objectives identified in Chapter 3.

Chapter 5: Research Methodology

5.1 Introduction

Chapter 3 demonstrated the positive impact of IT-PMS on business and management and hence identified two research objectives as follows:

- To test the predictions (impact as well as technical and people factors), and hence prove

  Impact of IT-PMS on Management and Business $\propto$ ***Impact of IT-PMS on Technical and People Factors***

  (Impact on management and business is proportional to impact on technical and people factors. i.e. if the impact of IT-PMS on technical factors increases/decreases, the impact on management and business also increases/decreases respectively)

- Understand and build the relationship between technical factors, people factors as well as impact

Chapter 4 reported the essential literature to implement IT-PMS in collaborating companies. However this research needs a structured methodology to implement IT-PMS at collaborating companies and achieve the above objectives.

> Methodology is defined as "*the set of principles, methods, procedures, practices, tools and techniques applied to any specific activity or branch of knowledge*". However if it is applied to do a piece of research then it is called *research methodology*. (Universal, Oxford and Webster Dictionaries)

In order to achieve the above research objectives it is necessary to do the following tasks at the collaborating companies:

- To construct IT-PMS and implement it
- To make people use IT-PMS
- To study the impact of IT-PMS on business and management
- To identify the critical success factors of the impact
- Understand the relationship between impact and success factors

According to Buckley et al (1976), there should be a distinction between problem finding and problem solving for doing any research. Hence the following chapter is structured to explain most of the theoretical frameworks (methods, tools, techniques, concepts etc.) for problem finding and problem solving in Sections 5.2 and 5.3 respectively. In Section 5.4, the methods, tools, techniques, etc. used for this research are justified against the tasks mentioned above, and an overall methodology is presented. Towards the end of this chapter in Section 5.5, a set of quality criteria is established to assess the quality of this research.

5.2 Problem finding

Problem-finding methodology is defined as "a set of principles, methods, procedures, practices, tools and techniques applied to identify problem(s)". More emphasis on problem-solving had veiled the importance of problem-finding. According to Buckley et al (1976) the problem is identified as a result of problem genesis as shown in Figure 5.1. The formal and informal approaches (Buckley et al 1976) are explained in the following sections.

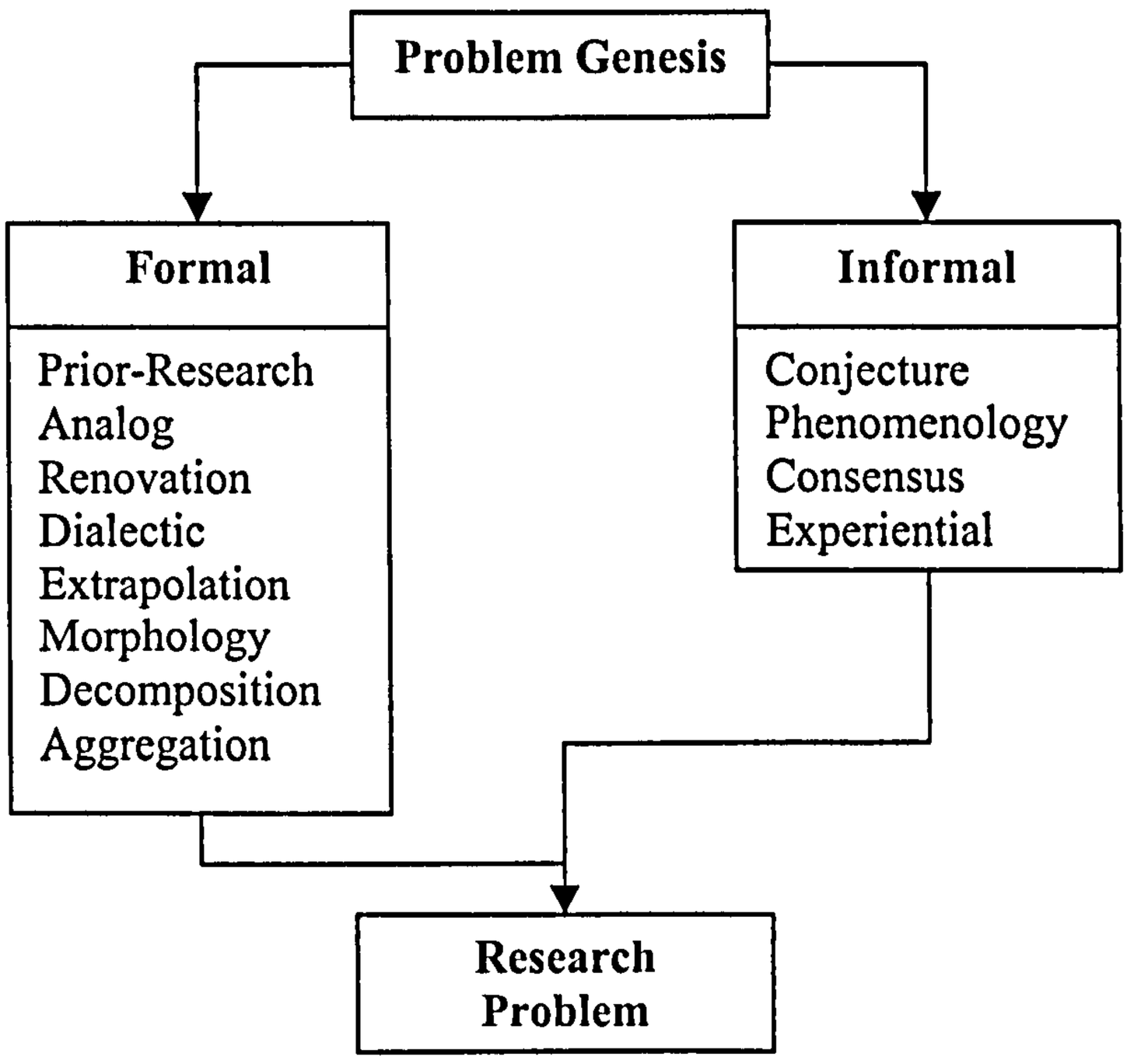


Figure 5.1. Problem-finding methodology

5.2.1 Formal Approaches

The formal approaches imply the use of meticulous and methodological procedures. Usually the scientific genesis of problems requires a formal approach. In these cases a well and structured system of analysis is used in the process of problem-finding. Some of the approaches are explained below:

- *Prior-research* is one of the most productive forms of finding problems. The prior-research can be either theory testing or theory building. For example, observations at a company can be formulated into hypothesis, which can be tested through subsequent examination. Hunting a chain of research and reformulating new problems is a productive way of doing research. This approach was used in this research for formulating the research hypothesis.
- The *analog* method is a formal procedure, which uses knowledge gained in one problem area to formulate a research question in a similar area.
- *Renovation* is a method used to replace or change the existing theory to make it more effective.
- *Dialectic* method is developing counter-plans for the purpose of challenging, refining, deposing existing theories for a better one. It is about investigating truths or facts in that area. Although this method was not used in identifying the main problems (objectives) of the research, it was used in identifying the IT solution for the companies (Is there a better IT solution available for implementing Performance Measurement in companies, other than the existing ones in the market?)
- *Extrapolation* is a method of extending current trends in future and formulating questions related to the predicted or expected outcome. It is usually used to estimate the future outcome on the basis of existing data.
- *Morphology* is a formal method for analysing the combinatorial possibilities inherent in complex problems. It is usually used in all areas where the combinations of problems arise from a complex problem.
- *Decomposition* is a method of breaking a problem into several component parts. It is usually used in areas where there is a requirement of breaking complex problems.
- *Aggregation* is a method of collecting research findings from different areas and applying them to resolve the complex problems.

5.2.2 Informal Approaches

The informal approaches imply the use of subjective and non-repeatable procedures. Some of the approaches are explained below:

- *Conjecture* is a method frequently used in problem-finding. It is used in a situation where the decision-maker has a gut or intuitive feel regarding the potential problem area.
- *Phenomenology* is a method of philosophy that concentrates on what is perceived by the senses in contrast to what is independently real or true about the world. Most of the problems identified in management are accountable to this method.
- *Consensual* method is used to identify the problems in management by a policy group, research committee or any other formal or informal group.
- *Experiences* sometimes generate problems in need of research. For example customer reaction can prompt change in production, service or marketing.

5.2.3 Problem-finding framework used in this research

The research started with a gap, which identified that there was no solid research available for finding the impact of performance measurement. The problem finding methodology as shown in Table 5.1 was used in arriving at objectives of the research. The researcher developed an intuitive feeling from anecdotal evidence at four companies that performance measurement when supported with appropriate IT platforms, appropriately used in the companies resulted in many positive impacts. This problem/issue was decomposed into smaller components as shown below:

- What is the impact of IT-PMS on business and management?
- What are the critical success factors of IT-PMS design and implementation, which causes the impact identified earlier?

Table 5.1 Problem-finding methodology used in this research

Problem Genesis		
No	**Problem finding activities**	**Approach used**
1	Previous research done at four companies	Prior-Research (formal)
2	Do appropriately designed performance measurement systems, if supported through appropriate IT platforms, appropriately implemented and used bring positive impact on business and management?	Conjecture Phenomenology (informal)
3	▪ What is the impact of IT-PMS on business and management? ▪ What are the critical success factors of IT-PMS design and implementation, which causes the impact identified earlier?	Decomposition (formal)

5.3 Problem solving

Problem-solving methodology is defined as "a set of principles, methods, procedures, practices, tools and techniques applied to solve the problem(s) identified". In order to answer the questions posed in the previous section, it is necessary for research design, an overall configuration of a piece of research.

> "Research design is the science (or art) of planning procedures for conducting studies so as to get the most valid findings" (Vogt 1993).

Determining the research design gives a detailed plan, which will give the researcher to guide and focus on the research (Collis et al 2003). For designing and configuring research, knowledge of philosophy or paradigms[1], methods, tools and techniques is essential for the researcher to understand which methodologies will work and which will not (Easterby-Smith et al 1991). This knowledge will also help the researcher to create a methodology, which may be out of his/her experience. Burrell et al, (1979) and Morgan (1979) presented three broad senses for the use of a research paradigm as follows:

- *Philosophical sense*, which reflects basic beliefs about the world
- *Social sense*, which relates the social organisation of science in terms of schools of thought built around the scientific habits connected with particular kinds of scientific achievements. It provides guidelines on how to do the research

[1] Paradigm refers to the progress of scientific practice based on peoples' philosophies and assumptions about the world and the nature of the knowledge such as concept hypothesis, theory or an idea (Collis et al 2003).

- *Technical sense*, which specifies the methods and techniques adopted in doing the research

5.3.1 Philosophical sense

According to Easterby-Smith et al (1991), there are two traditions in philosophy from which the methodology design can be derived, they are:

5.3.1.1 Positivism

According to Easterby-Smith et al (1991), the idea of positivism is that a social world exists externally, and its properties should be measured through objective methods. The knowledge is only of significance if it is based on observations of this external reality. It is a quantitative approach dominating the objective aspects of human activity concentrating on the measurement rather than meaning of social phenomena (Collis et al 2003).

- It seeks fixed universal laws that provides explanation, permit and anticipation of behaviour
- It establishes causal relationships between variables

5.3.1.2 Phenomenology

According to Easterby-Smith et al (1991), the idea of phenomenology is that reality is socially constructed rather than objectively determined. It is about understanding and explaining why people or organisations have different experiences, rather than for external causes and fundamental laws to explain their behaviour. It is a qualitative approach dominating the subjective aspects of human activity concentrating on the meaning rather than measurement of social phenomena (Collis et al 2003)

- It seeks the individual's own understanding and interpretation of the world as a basis for behaviour
- It establishes shared understanding and awareness of human, social and organisational reality

According to Easterby-Smith et al (1991), the main differences between positivist and phenomenology paradigms are tabulated as shown in Table 5.2

Table 5.2 Key features of Positivistic and Phenomenological paradigms (Easterby-Smith et al 1991)

	Positivist paradigm	Phenomenological paradigm
Basic beliefs	• The world is external and objective • Observer is independent • Science is value-free	• The world is socially constructed and subjective • Observer is part of what observed • Science is driven by human interests
Researcher should:	• Focus on facts • Look for causality and fundamental laws • Reduce phenomena to simplest elements • Formulate hypothesis and then test them	• Focus on meanings • Try to understand what is happening • Look at totality of each situation • Develop ideas through induction from data
Preferred methods include	• Operationalising concepts so that they can be measured • Taking large samples	• Using multiple methods to establish different views of phenomena • Small samples investigated in depth or over time

Even though there have been a lot of people moving away from positivism, towards phenomenology in the last few decades, there are many researchers in the management field, who adopt a practical view by intentionally combining methods from both traditions (Easterby-Smith et al 1991).

5.3.1.3 Philosophical sense for this research

In achieving the objectives of this research, i.e., finding the impact of IT-PMS on business and management from a *philosophical view*, it is required to do the tasks shown in Table 5.3. From the philosophical sense in Table 5.3, it became clearly evident that this research is dominated for phenomenological paradigm. However, at this level, it is unclear to decide whether the research uses only phenomenological methods, tools and techniques.

Table 5.3 Philosophical Sense for this research

Research Tasks	Philosophical Sense
▪ To construct an IT-PMS in reality and implement it in collaborating companies ▪ To make people use IT-PMS ▪ To study the impact of IT-PMS on business and management ▪ To identify the critical success factors for the impact ▪ Understand the relationship between impact and success factors	▪ The companies *are socially constructed and subjective* ▪ *Observer is part of what observed* to implement and enables people to use it as well as to study the impact ▪ *Use multiple methods to establish different views of phenomena* ▪ *Try to understand what is happening* to identify success factors for the impact ▪ *Develop ideas through induction from data* to understand the relationships ▪ *Small samples investigated in depth over time* because it takes long time to do the study at each company

5.3.2 Social sense

Being biased towards phenomenological paradigm, Easterby-Smith et al (1991) suggested that the researcher should focus on meanings, understand what's happening, and develop ideas through induction as shown in Figure 5.3. Buckley et al (1976) provided the following guidelines on doing research:

- How does the problem lend itself to the deductive or inductive mode of inquiry? (What is the Mode of the research?)
- What research strategies are available to the researcher and which are best suited to the research problem under consideration? (What is the research Strategy?)
- Where are the data sources that can be accessed in order to answer the research questions? (What is the Domain for data source in the research?)

5.3.2.1 Research Mode

It is essential to decide whether the research is primarily inductive or deductive because both modes are present to some degree in most of the research (Buckley et al 1976). Induction is the process by which theory is generated. Deduction is the process by which theory is tested. Often a researcher uses both modes for his/her research, however he/she should be aware of the mode present at each stage of the research. The same

classification is also known as "fact-finding" versus "testing" (Buckley et al 1976). It is also known as ideographic and nomothetic approaches as follows (Burrell et al 1979):

5.3.2.1.1 Ideographic Approach (Induction)

The ideographic approach to social science is based on one view of understanding the social world by obtaining knowledge of the subject under investigation. Glaser et al (1967) described this approach as "the discovery of grounded theory", i.e. the discovery of theory from data, which is systematically obtained and analysed through social research. It emphasises the analysis of subjective accounts, which one generates by going into situations and involving oneself in the everyday flow of life (Burrell et al 1979). According to Gill et al (1991), induction research is the observation of the empirical world to the construction of explanations and theories about what has been observed. It is shown as right hand side of Kolb's experimental learning cycle as shown in Figure 5.4. The importance of inductive research is the formulation of abstract concepts, theories and generalisations that explain past and predict future.

5.3.2.1.2 Nomothetic Approach (Deduction)

The nomothetic approach to social science is the importance of basing the research on systematic protocol and technique. Ball (1971) referred to a number of examples of this research mode. It focuses on the process of testing hypothesis in accordance with the canons of scientific rigour (Burrell et al 1979). According to Gill et al (1991), deductive research entails the development of a conceptual and theoretical structure prior to its testing through empirical observation. It is shown as left hand side of Kolb's experimental learning cycle as shown in Figure 5.2. The importance of deductive research is the testing and operationalisation of the process.

5.3.2.1.3 Justification of research mode for this research

In this research, a mixture of both induction and deduction will be used as demonstrated by Kolb et al (1979) experimental learning cycle as shown in Figure 5.2. In initial stage, the data (observations and reflections) was collected from induction, which is grounded in theory from literature review and formed the basis for generating predictions[1]

[1] Predictions are the cautious explanation of certain behaviour or set of events, which will occur. It should be based on theory, previous research or experience of the behaviour or the events

(formation of abstract concepts and generalisation). The predictions are tested using deduction (testing implications of concepts in new situation), which will be explained through action cases in next chapter.

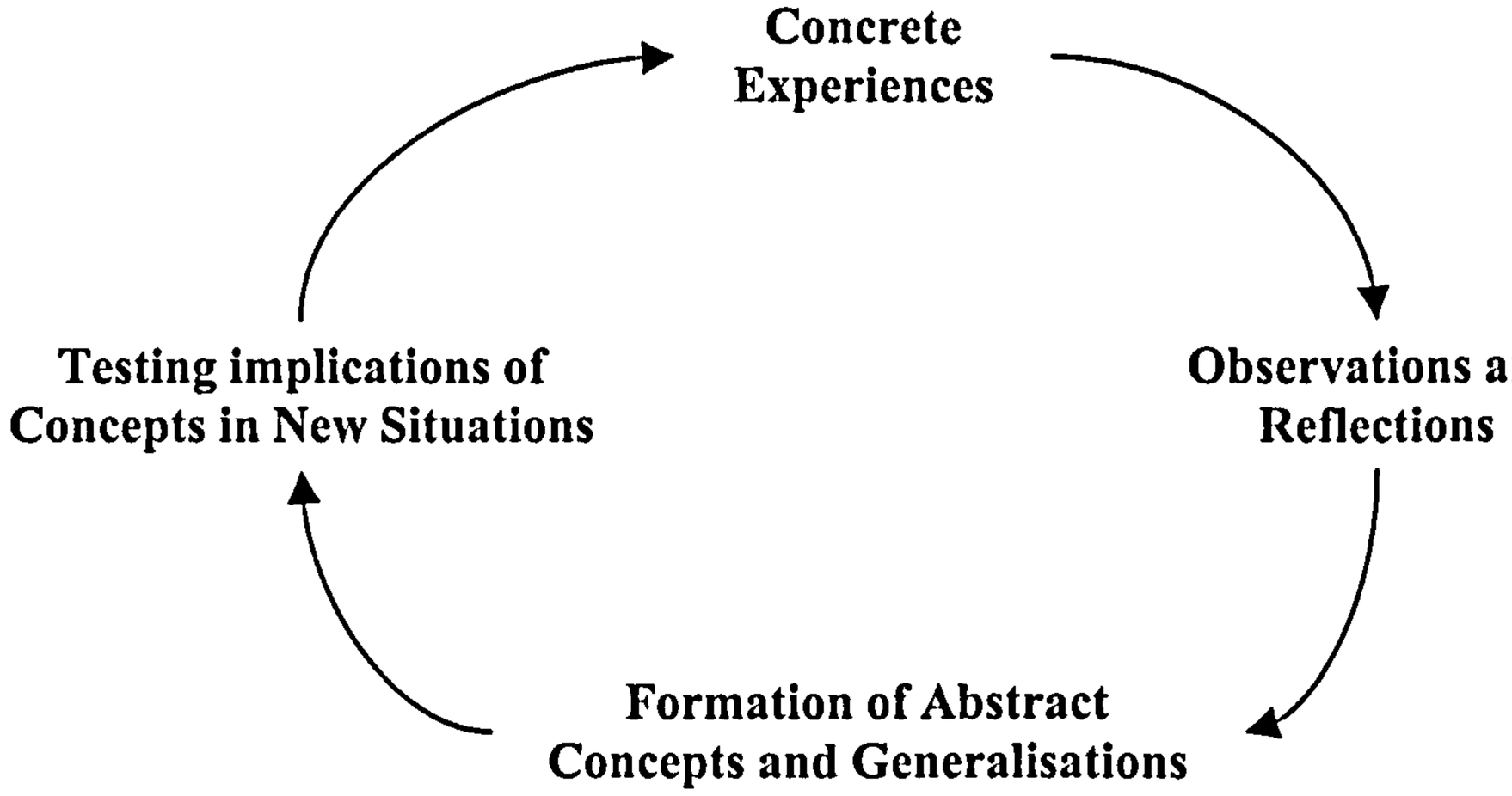


Figure 5.2 Kolb's experimental learning cycle *(Kolb et al 1979)*

5.3.2.2 Research Strategy

According to Buckley et al (1976), research strategy refers to the essential nature of the outcome and the process by which data is found and analysed. It is concerned about the way the researcher approaches a generating or testing theory. Kasanen et al (1993) and Collis et al (2003) proposed a two-dimensional model of approaches based on data source (outcome of the research) and process (of the research) as shown in Figure 5.3.

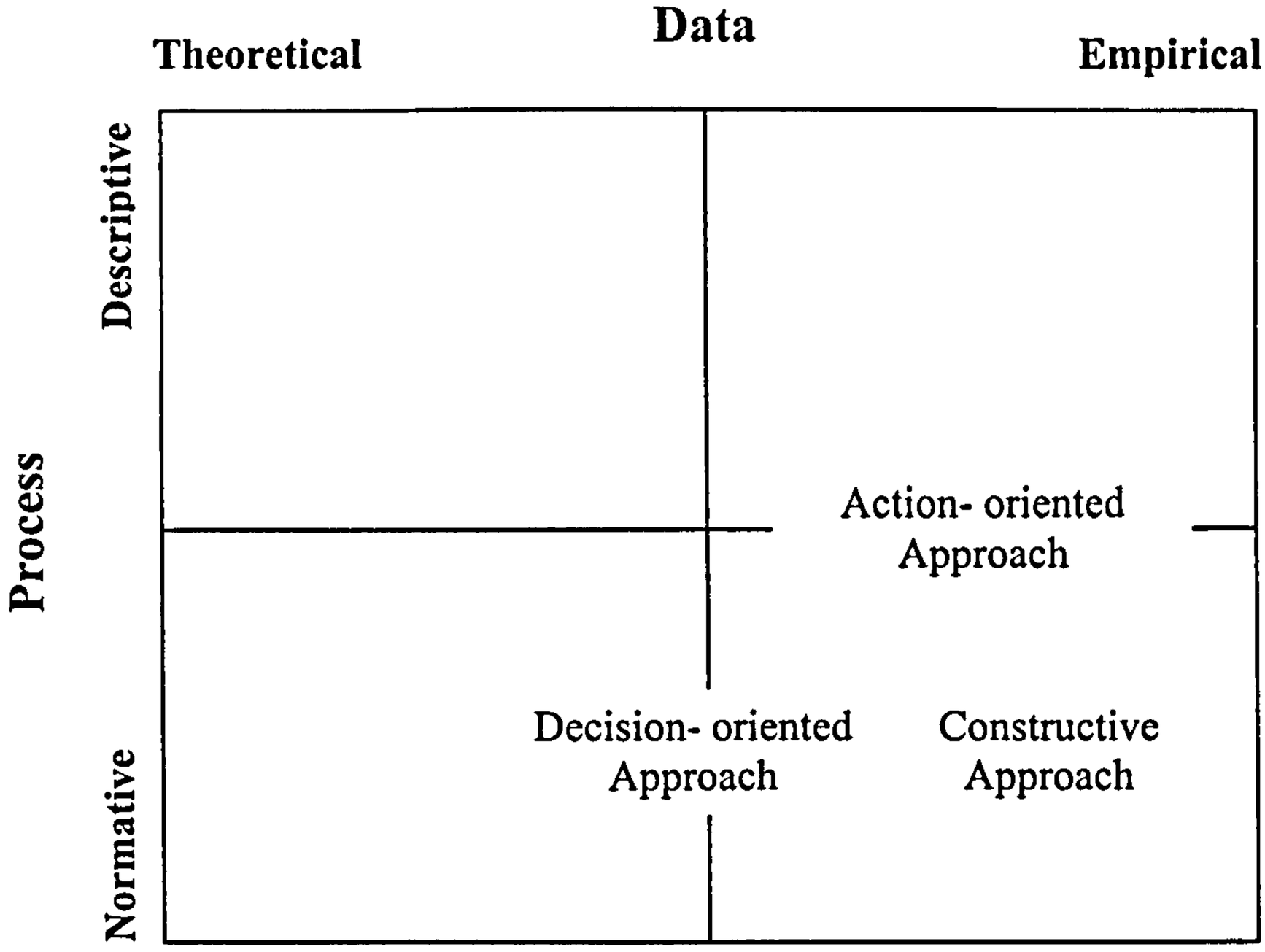


Figure 5.3 Two-dimensional model for determining strategy

Extreme Approaches on X-dimension:

The following approaches fall on the X-dimension of the model as shown in Figure 5.3. This dimension of the model refers to data source for the research.

5.3.2.2.1 Theoretical Research

If the researcher seeks to solve a problem, which is less specific in nature and conducting the research to improve the understanding of general issues, without emphasis on its immediate application, then the researcher is engaged in theoretical research (Collis et al 2003). It is also known as pure, fundamental or basic research. It is used in the most form of academic research without including solving a specific problem for one organisation. It includes a set of interrelated variables, definitions, constructs, propositions, etc. that presents a systematic view of phenomena by specifying relationships among variables with the purpose of explaining natural phenomenon (Kerlinger 1979)

5.3.2.2.2 Empirical Research

If the researcher seeks to experience, practise or observe things for himself/herself, rather than through the mediation of others, then the researcher is engaged in empirical research (Buckley et al 1976). Green (1966) and Scudder et al (1998) had quoted number of examples of empirical studies. It is the use of real-world data in the application of research. Both empirical and opinion research approaches has the real-world data origin, however the data is directly collected in empirical research and it is mediated through others in opinion research. The sources of the data for any empirical research are shown in Table 5.6, which are basically distinguished against each other on experimental design, control, data access and the context for which the research is planned (artificially built environment or naturally occurring environment). They are further discussed in next section. Surveys, questionnaires, interviews, observation etc. are the common data collection techniques used within empirical research (Coughlan et al 2002).

This approach is used when a research problem has to be solved by observation or experience. This research requires identifying critical success factors involved in implementing and using IT-PMS as well as observing the impact of IT-PMS on business and management. Therefore this approach will be used for the data access (one dimension of strategy) of this research.

<u>Other Approaches on X-dimension:</u>

5.3.2.2.3 Opinion Research

If the researcher seeks the views, judgements, appraisals or opinions of the experts with respect to the research problem, then the researcher is engaged in opinion research (Buckley et al 1976). The source for this data can be either an individual or a group of individuals who are experts in that field. Surveys, questionnaires, opinion polls and interviews are the famous data collection techniques for individuals under this approach. However the Delphi technique is the most widely known method for gathering data from a group of experts in the field.

This approach is used when the research problem requires access to group opinion. However the problem in this research does not require a group opinion. Hence this approach is not used in this research.

5.3.2.2.4 Archival Research

If the research is concerned with the examination of facts, then the researcher is said to be engaged in archival research (Buckley et al 1976). The source for the data could be primary, secondary or physical sources. Primary archive is defined as the source of original documents or official documents. Secondary sources are published works of other people or investigators. Some times data is also available in physical environments such as water level in dams, wear and tear of the machine, etc. Scanning, observation and sampling are usually used techniques for data collection.

This approach is used when the research problem requires access to the information archives usually literature searches, identification of gaps, etc. This approach was used in this research during the literature review.

Extreme Approaches on Y-dimension:

The following approaches fall on the Y-dimension of the model as shown in Figure 5.3. This dimension of the model refers to the process of the research.

5.3.2.2.5 Descriptive Research

If the researcher seeks to describe phenomena as they exist and if he/she uses the research to identify and obtain information on characteristics of a particular problem or issue, then the researcher is engaged in descriptive research (Collis et al 2003). An effective descriptive research is marked by a clear statement of the decision problem, specific research objectives and detailed information needs. It is carefully planned and structured research design. Its purpose is to provide information regarding specific questions or hypothesis (Kinnear et al 1979). The techniques used for this research include, surveys, histories, questionnaires, interviews, etc. (Yin 2003, Kinnear et al 1979).

This approach is used when the research problem requires answering the specific research objectives or testing hypothesis. This approach will be used in this research for testing the predictions observed in the pilot case through empirical evidence and describe them as they were.

5.3.2.2.6 Normative Research

If the research includes setting standards or rules of language, setting behaviour, which should be followed, or creating an explicit managerial construction then the researcher is said to be engaged in normative research (Kasanen et al 1993). Most of the researchers are engaged in either designing a model or a framework, based on their organisational experience with a system, opinion or synthesis of existing literature. The constructs or models build in normative research should usually be satisfied by the user, used for decision-making or even building software.

This approach is used by many consultants in their commercial projects and collaborative research with organisations. Even though this research used IT-PMS (a construct using normative approach) for implementing in case studies, the designing of IT-PMS was not included in this research.

<u>Other Approaches on Y-dimension:</u>

5.3.2.2.7 Explanatory (Analytical) Research

If the research is solved analytically by breaking the problem into its components by discovering its true nature and the causal relationship between variables then the researcher is engaged in analytical (explanatory) research (Buckley et al 1976). It is the continuation of the descriptive research, the researcher goes beyond merely describing the characteristics, to analysing and explaining why or how it is happening (Collis et al 2003). Internal logic and formal reasoning are the domains for this research. Techniques used in this research are mathematical logic, mathematical modelling, formal organisation techniques, cross-case analysis etc.

This approach is used when the research problem requires being solved analytically or mathematically using internal logic or explaining causal relationships between variables. This approach will be used in this research for understanding and building the relationships between success factors (variables) as well as implications (variables) and hence explain the behaviour of these variables observed through empirical evidence.

5.3.2.2.8 Exploratory Research

If the research problem or issue had very few or no earlier studies to which the researcher can refer for information about the issue or problem then the researcher is said to be in exploratory research (Collis et al 2003). The main aim of this research is to look for patterns, ideas or hypothesis, which can be tested at a later stage. In exploratory research, the focus is on gaining insights and familiarity with the subject area or research issue for more precise investigation at later stage. *There is no formal or structured research design for exploratory research (Kinnear et al 1979).* The data source for this research could be data archives (primary or secondary data), case histories, interviews with knowledgeable people, etc.

This research approach is used where there is requirement of a literature review or generation of hypothesis/predictions. This approach was used in this research in generating predictions from a structured pilot case study and literature review as already discussed in Chapter 3.

5.3.2.2.9 Pre-defined Research Strategies

As mentioned earlier research strategy refers to the essential nature of the outcome and the process by which data is found and analysed. In the earlier section we have seen different approaches, which fall on either of the two-dimensions as shown in Figure 5.3. However this section discusses some of the pre-defined research strategies by Kasanen et al (1993), which fall within the two-dimensional model as shown in Figure 5.3:

- Decision-oriented strategy is about management construction (normative), which can be obtained from empirical evidence and theoretical knowledge (empirical and theoretical). The obtained management construction will be used to help management in running the firm
- Action-oriented strategy is about gaining a thorough understanding of studied subjects through active participation and empirical evidence (empirical), which can be done by testing a hypothesis and explaining the causal relationship between variables studied (descriptive and normative)
- Constructive research strategy is a about a management construction (normative), which is obtained through active participation and empirical evidence (empirical). A construct is defined as solution (in the form of framework, model etc.) to explicit

problems. In other words, if the output of decision-oriented research is empirically tested then it is constructive research. If the output of an action-oriented research is a management construct, which can be used by the management in real-world then it is called constructive research.

5.3.2.2.10 Justification of research strategy for this research

As demonstrated in Table 5.4, based on the problem identified some of the key-findings are obtained from real-world using empirical and exploratory approaches. Based on the key-findings and more specific literature review, research objectives (including predictions) were established using empirical and explanatory approaches. The predictions are tested in the real-world using empirical and descriptive approaches. Finally theory is built using empirical and explanatory approaches

Table 5.4 Research strategy used in this research

Research activity (stage)	Outcome oriented approach	Process oriented approach
1. To construct an IT-PMS in reality and implement it in collaborating companies	Empirical	Descriptive
2. To make people use IT-PMS	Empirical	Descriptive
3. To study the impact of IT-PMS on business and management	Empirical	Descriptive
4. To identify the critical success factors for the impact	Empirical	Descriptive
5. Understand the relationship between impact and success factors	Empirical	Explanatory

5.3.2.3 Research Domain

Buckley et al (1976) defined research domain as the data source and environment. As demonstrated in the previous section, this research uses empirical approach together with exploratory, descriptive and explanatory approaches. In Table 5.6, different environments and data sources are distinguished. Deciding domain for this research is very important because it is in this environment the research will be conducted and data collected where necessary. Hence, in this section these domains are described in detail together with their implications for this research.

5.3.2.3.1 Laboratory Study

It is accompanied by experimental design and control. Detailed planning precedes the experiment and there is cognisant effort to isolate and manipulate variables so as to study certain causal relationships (Buckley et al 1976). A true experiment is that where effort is made to control all the variables except the variable under study. This is often easier if it is conducted in a laboratory and hence true experiments are considered to be a laboratory studies. Usually experimental design of this study falls on the deduction end of the continuum of research methods. The building of experimental design in this study is as follows (Gill et al 1991):

- To outline or mark out carefully the research question(s) attempted to tackle and identify the factor(s) whose variation is studied (measured). These are called theoretically dependent variables. The experimenter does not control this variable.
- To identify the factor(s) (theoretically independent variables) whose variation will bring changes in the dependent variables found in the first step. The experimenter controls and manipulates this variable.
- In order to monitor any variation in the dependent or independent variables, it is necessary to operationalise them. This involves the researcher varying or manipulating the incidents and observing or measuring the variation in the dependent and independent variables.
- To identify extraneous variables, which are not included in the research design as independent variables, which caused the variation.

Gill et al (1991) classified a true experiment by creating two groups called experimental and control groups. An experimental group is composed of dependent variables, which are experimentally treated by independent variables. A control group is composed of same dependent variables, which are not experimentally treated to give base line performance for comparison. Any difference between the two groups, in terms of independent variable are identified and noted. The characteristics of experimental design are as follows:

- The researcher / experimenter is able to allocate subjects to control and experimental groups in a systematic or random manner.

- The researcher / experimenter is able to manipulate the incidence of one or more independent variables and observer any consequent changes in dependent variables

Since the true experiment occurs through direct intervention of the researcher, it is usually restricted to laboratory conditions. It is restricted to the artificiality of the context in which the research takes place. Even though the results of the true experiment are highly valid, they have very low ecological validity (Gill et al 1991).

Due to the artificiality of the context in which the true experiment is carried, many researchers attempted to retain the logic of designing true experiments but applied outside the laboratory in the real-world without the investigator's direct intervention. However, some researchers violated the characteristics of true experiment and adopted a new approach called quasi-experiment, which is explained in next section.

5.3.2.3.2 Field Study (Quasi-Experiment)

The aim of quasi-experiment is the same as true experiment but the quasi-experiment will take place in the real-world with naturally occurring events (*Real-world*). However since the experimental and control groups are identified in the field, they are also known as field studies (Gill et al 1991). Kerlinger (1986) defined field study as *non-experimental scientific inquiries aimed at discovering the relations and interactions among sociological, psychological, and educational variables in real social structures.*

The identified experimental and control groups are naturally changing variables. The experimenter identifies people who will naturally experience notional experiment treatment. Then compares the consequential behaviour with people who have not experienced that event (or the notional experimental treatment). (Gill et al 1991) The researcher enters the field with a notion of what he wants and the manner in which he/she wants to collect and analyse data (*have control over experimental design and data access*). No attempt is made by the experimenter to control the variables in the field (*no experimental control*) (Buckley et al 1976)

5.3.2.3.3 Case Study

It is a study in which the researcher observes a subject, group of subjects or an organisation without intervening in any way. The researcher can gather personal

observations through their presence, participation or just involvement with the actual process (without intervening) (Gummesson 2000). No independent variables are manipulated, no dependent variables are measured, no control over intervening variables. A case study has neither experimental design nor experimental control. There is no attempt to manipulate or structure the research setting (Buckley et al 1976).

The central tendency of a case study is that it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result (Yin 2003). Few other definitions include topics such as individuals, organisations, processes, programs, neighbourhoods, institutions, events etc. According to Yin (2003), a case study is an empirical inquiry that:

- Investigates a contemporary phenomenon within its real-life context.
- Copes with the situation in which there will be many more variables of interest than the initially identified variables.
- Relies on multiple data sources of evidence, which is converged in a triangulating fashion.
- Merges with exploratory, explanatory or descriptive approaches to act as a research strategy

According to Gummesson (2000) and Eisenhardt (1989) case studies vary in character. First is to derive general conclusions from a limited number of cases. Second is to arrive at specific conclusions from a single case study. However, both types produce results of general interest. It no longer seems so obvious that a limited number of cases (or one case) cannot be used as a basis for generalisation. In the same way, it is not obvious that properly designed statistical studies based on large number of cases will lead to meaningful generalisations. If the study is a good descriptive or analytical approach by which the researcher can really grasp the interaction between various parts and characteristics of the system, the generalisation made from very few (or one) case studies is also good. However in a few exceptional occasions, the results cannot be generalised from few cases.

According to Yin (2003), there is another classification of case study called *pilot case study*. It is a final preparation for data collection. It is more formative, assisting the researcher to develop relevant lines of questions, conceptual clarification for the research

design, generate hypothesis, explore the research questions (Collis et al 2003), etc. It also helps the researcher to refine the data collection plans such as content of data and procedures to be followed to collect it.

The main obstacle in a case study is potentially a large number of variables, which may impinge upon results. The variation can differ in variables between different cases. The extraneous variables can differ in different cases. The researcher can be biased on few occasions by generalising results from limited cases. It also leads to a lack of statistical reliability and validity (Gummesson 2000). The validity of results is limited to those subjects involved (Gill et al 1991). The other limitations or obstacles include getting the required sample of case studies, cost involved, time required, etc.

5.3.2.3.4 Action Research

Action research is defined as a study of social reality (*real-world*) with social practitioner, who is not only an engaged participant but also incorporates the perspective of the critical and analytical observer integral to the practice (Riordan 1995). It is a research that involves practical problem solving (with e*xperimental design*), which has theoretical relevance (Mumford 2001, Coughlan et al 2002, Gill et al 1991). It is an approach, which aims both at taking action and creating knowledge or theory about that action (Coughlan et al 2002). Gill et al (1991) described action research as a study in which *researchers/practitioners, from their interventions and subsequent evaluation not only contribute to the existing knowledge but also solves the practical concerns of the people.*

The action researcher will have full control over the project being implemented (*Experimental control*). Gummesson (2000) and Coughlan et al (2002) described the major ten characteristics of action research as follows:

- Action researchers intervene by making it happen, apart from observing something happening.
- Action research always has two goals, solving a practical problem and contributing to knowledge (Collis et al 2003, Mumford 2001, Gill et al 1991).
- Action research requires co-operation between the researchers and clients (Collis et al 2003).

- Action researchers should have broad view of how the dynamic socio-technical systems work (Collis et al 2003, Mumford 2001).
- Action research is about change, hence knowledge and skills in the dynamics of organisational change management is essential for the action researchers (Collis et al 2003).
- Action research requires understanding of ethics of that context. These ethics involve the authentic relationships between action researcher and the members of the client system and take significant action (Collis et al 2003).
- Action research includes all types of data gathering methods from traditional research, including qualitative and quantitative tools.
- Action researchers should have a broader knowledge of the organisational system, in which the study takes place.
- Action research should be conducted in real-time. It is also considered as a live case study.
- Action research requires its own quality criteria to assess the quality of the research (Collis et al 2003).

Action research is appropriate when the researcher is in the process of understanding as a member of the group, how and why their actions can bring change or improve the working of some aspects of a system as well as behaviour of a group, community or organisation (Coghlan et al 2001). In most of the cases, the action researcher acts as the facilitator for the change within an organisation. According to Coghlan et al (2001) and Coughlan et al (2002), if the action researcher is enrolled in an academic programme, then there are two action research projects co-exist in parallel:

- Project in which student researcher is working within the organisation, irrespective of whether or not it is being studied.
- Project involves student researcher's inquiry into the organisational project, which will be submitted for examination irrespective of whether or not the project is successful.

The emphasis on hypothesis or prediction testing is still prevalent in action research (Eden et al 1996). Data in action research can be collected (*data access*) in different ways depending on the context such as personal observation, interviews, financial

reports, marketing reports, etc. However, directly observable behaviour is an important source for action researcher.

Even though action research has high ecological validity, their population validity is limited to the subjects involved (Gill et al 1991). Some times it can be limited to the organisation where it is implemented. Loss of control over extraneous variables, which affect the dependent variables. The action research is also criticised for its lack of repeatability in designing the experimental situations, in which we could be clear about confirmation or disconfirmation. The politics of organisational change is a force acting against getting fully reliable data from all concerned (Eden et al 1996). Other limitations or obstacles include (Mumford 2001):

- getting required sample of action cases with organisations
- getting into the organisations
- huge amount of time required for each action case

5.3.2.3.5 Justification of research domain for this research

Initially in this research, the key-findings on the problem issue were inducted from real-world using a structured *Pilot Case Study.* The findings obtained from the pilot case, which were grounded in literature were used to create predictions. The predictions include independent[1] variable IT-PMS implementation, semi-dependent[2] variables such as technical factors and people factors, which will bring variation in dependent[3] variables such as management and organisational behaviour. Even though the researcher had demonstrated the positive impact of independent variables on dependent variables from pilot case study, it is not enough to generalise and validate these results. Hence in order to test these predictions and understand the relationships between dependent, semi-dependent and independent variables, the research established a set of domain characteristics against each activity as shown in Table 5.5

---

[1] Even though IT-PMS is dependent on several other factors such as resources available, skills available, etc. it is independent of technical and people factors as well as management and business implications, which are being studied in this research. Hence it is classified as independent variable

[2] Although some of the factors are dependent on IT-PMS implementation, there are also independent factors. Hence they are classified as semi-dependent variables

[3] All the factors are dependent on both IT-PMS implementation as well as technical and people factors. Hence they are classified as dependent variables

Table 5.5 The research domains used in this research

	Research Activity	Domain Characteristic
1	To construct an IT-PMS in reality and implement it in collaborating companies	Experimental Design in Real World
2	To make people use IT-PMS	Experimental Control
3	To study the impact of IT-PMS (independent variables) on business and management (dependent variables)	Personal Observation/ Interviews with other Participants
4	To identify the critical success factors for the impact (semi-dependent variables)	Personal Observation/ Interviews with other Participants
5	Understand the relationship between impact and success factors (dependent, semi-dependent and independent variables)	Facilitation of IT-PMS Personal Observation
6	Identify other factors (other than the ones selected in predictions), which might influence the business and management implications (extraneous variables)	Facilitation of IT-PMS Personal Observation

The alternative domains that can be used to fulfil these research activities are summarised in Table 5.6. However, from the domain characteristics identified in Table 5.5 and alternative domains available in Table 5.6, *Action Research* is chosen as the best domain for this research.

Table 5.6 The empirical domains for the research (Buckley et al 1976, Yin 2003, Gill et al 1991 and Coughlan et al 2002)

	Case Study	Field Study	Laboratory Study	Action Research
Context/ environment of research	Real world	Real world	Artificial set up	Real world
Role of researcher	Participant observer / non participant observer	Participant observer / non participant observer	Facilitator	Facilitator
Experimental design	Absent	Present	Present	Present
Experimental control	Absent	Absent	Present	Present
Data Access	Present	Present	Present	Present

5.3.3 Technical sense

According to Morgan (1979) and Easterby-Smith et al (1991), technical sense of a paradigm relates to the concrete use of specific kinds of tools and techniques used for problem-solving.

From the social sense (described above), it is clear that the research uses a mixture of induction and deduction modes, empirical approach with exploratory, descriptive and explanatory approaches as the strategy as well as case study and action research as the domains for this research. This section includes the various potential methods, tools and techniques that could be used with in the social sense of paradigm adopted. Finally, it includes a justification of the methods, tools and techniques used for this research.

According to Buckley et al (1976) and Collis et al (2003) the methods, tools and techniques refer to the instruments used to find (data collection) and analyse data (data analysis) as well as to assess the quality of outcome, which are further explained under following sections.

5.3.3.1 Data Collection

Whether the research philosophy is phenomenological or positivistic paradigm, it always uses a mixture of qualitative and quantitative data (Collis et al 2003). The main advantage of quantitative approaches is the relative ease and speed of data collection. However the data analysis, which uses statistical analysis, sometimes increase the difficulty of quantification and the danger of reductionism. On the other hand qualitative approaches provides a more real basis for analysis and interpretation. However, qualitative methods can be expensive and time consuming. The following section describes a mixture of these methods.

5.3.3.1.1 Dairy methods

A dairy is a daily record of events or thoughts and is typically used to capture and record what people do, think and feel (Collis et al 2003). This method is used when the researcher is absent and would like to have a record of events through managers. It can be useful in collecting both qualitative and quantitative data (Easterby-Smith et al 1991). This method allows the perspectives of several peoples' views to be compared against each other simultaneously (Mintzberg 1973). It allows the researcher to concentrate and collect other relevant data during the study. However there are practical problems to dairy methods, which include selecting participants who can express themselves well in writing, providing encouragement during the record-keeping period and maintaining confidentiality (Collis et al 2003, Easterby-Smith et al 1991). Because of the poor quality of data collected this approach is not adopted in this research.

5.3.3.1.2 Participant Observation

Participant observation is a method of collecting data where the researcher is fully involved with the participants and the phenomena being studied (Collis et al 2003). This approach is best suitable when the researcher is bringing a change in the organisation and investigating its usability and impact on the people and organisation (Gummesson 2000). However, it is difficult for a student researcher until he/she holds a position within the organisation. The researcher should be very clear about his role of participation. Easter-by Smith et al (1991) classified the degree of participation at four levels:

- Complete participation, it is used by the researcher who is an employee within the organisation
- Participation as an observer, it is used by the researcher who can be present every day over a period of time. This time frame would be negotiated with the management at the start of the research.
- Observer as participant, it is used by the researcher who can be present sporadically over a period of time, moving in and out of the organisation to do other activities.
- Complete observer, which is also called non-participant observer. It is used by the researchers who can observe and record what people do in terms of their actions and behaviour without the researcher being involved. The observer is completely separate from the activities taking place and the subject may or may not be aware that they are being observed (Collis et al 2003).

The important point behind all of them is that the researcher must operate at two levels: becoming an insider while remaining an outsider. They must avoid becoming over socialised, or going naive. The problems associated with participant observation are that the researcher cannot control the variables in the natural setting. There are problems concerned with ethics, visibility and technology for recording what people say (Collis et al 2003, Gummesson 2000). The researcher/observer can be biased due to distractions. Direct observation can also be time-consuming requiring resources not available to the researcher (Gummesson 2000). Since the researcher adopted action research as the research domain, he acts as facilitator. Hence the researcher will be present in the company for implementation and acts as participant observer.

5.3.3.1.3 Questionnaires

Questionnaires are used very widely in many branches of the research in large-scale investigations (Easterby-Smith et al 1991). A questionnaire is a list of questions carefully designed after considerable testing. It is essential that questionnaires be piloted before distributing it to the respondents. Positivistic approach suggests to include closed questions where as phenomenological approach suggests to include open ended questions (Collis et al 2003). A questionnaire survey is cheaper and less time consuming than most of the other methods. The questionnaires can be distributed to the respondents in different ways including, post, telephone, face-to-face, group or individual distribution, etc. (Collis et al 2003). The questionnaires can be filled at their leisure and the researcher cannot be biased. However the limitation of questionnaires is very low (less than 10%) response rate. The respondents sometimes could be biased on their understanding of the questions and hence questionnaires should be simple and crystal clear. They include missing responses. There will be no opportunity for new questions. If the questionnaires are not distributed throughout the population, the results could be biased. Since the questions included in this research are complex and need explanations, this approach is not used in this research.

5.3.3.1.4 Interviews

Interview is a method of collecting data from people in order to find out what they do, think or feel (Collis et al 2003). Interviewing is conversation with a purpose. Generally interviews are conducted face-to-face, although there are other methods such as through the telephone, third-party agents, etc. Interviews are often claimed to be the best method of gathering information (Easterby-Smith et al 1991). For using this method the objectives of the research should be clearly defined. Interviewing is an opportunity for the researcher to investigate deeply to uncover new clues, open new dimensions of discussion on the problem based on their experience. Interviews permit the researcher to ask more complex questions and ask follow up questions, which is not possible with questionnaires and surveys. However, the investigation or discussion depends on the type of interview as classified by Collis et al (2003):

- Structured interviews, usually suggested by positivistic approach. It includes closed questions, where the researcher is very clear about what he/she wants from the respondent. It is mostly used with empirical and descriptive approaches.
- Semi-structured interview, usually suggested by phenomenological approach. It includes un-structured or open-ended questions, where the researcher is not very clear about what he/she wants from the respondents. It is mostly used with empirical and exploratory approaches.

Just as other methods, interviewing has its own limitations. The whole process of conducting interviews can be very time consuming and very expensive. It is very difficult to get managers' time for an interview. The researcher should make sure that the interviews are conducted in consistent approach and he/she is not biased while talking to the interviewee. Since the questions included are complex and need explanations, this approach is used in this research for testing the predictions obtained from the pilot case study.

5.3.3.1.5 Justification of data collection methods used in this research

All the potential data collection methods that could be used in this research are summarised in Table 5.7, with their advantages and disadvantages. In this research, participant observation will play a major role in studying technical and people factors (semi-dependent variables) as well as business and management implications (dependent variables). Since the relationship between these variables is complex, participant observation will suit better than the other methods. However interviews are also used with the other participants (management) to collect their perceptions on these variables as well as to crosscheck with the results obtained from personal observations.

Table 5.7 Data Collection Methods

Method	*Appropriate Use*	*Major Advantage(s)*	*Major Disadvantage(s)*
Dairy methods	When data has to be collected from different management practices	Saves lot of researchers time, data can be collected from different managerial jobs at the same time	Poor quality of data, there will not be consistency in collected data
Participant observation	To study different dependent variables, independent variables as well as extraneous variables in action	Can understand complex problems and issues	Time-consuming, difficulties in getting a role in the company, researcher can be distracted
Questionnaire	To collect information from people's perception on dependent variables or independent variables	Cheaper and quicker way of collecting information, respondents can fill at their leisure time, researchers cannot be biased	Very less response rate (less than 10%) Respondents can be biased, no opportunity for new questions
Interviews	To collect information from people's perception on dependent variables or independent variables	Can investigate deeply to uncover new clues, opens new dimension for discussion, can add new questions if necessary	Time consuming and expensive, the researcher should have the skills to do it

5.3.3.2 Data Analysis

The choice of data analysis depends on the type of data collected in the research. Since the data collected in the research is qualitative in nature the following section includes a discussion on qualitative data analysis. The main confront to phenomenological research and qualitative data analysis is that there is no clear and accepted classification for data analysis (Robson 1993, Collis et al 2003, Easterby-Smith et al 1991). It generates a large quantity of interview notes, jottings or other records all of which have to be analysed. Analysis is messy, as data doesn't tend to fall into categories and there can be many ways of linking between different parts of discussions or observations. However, Collis et al (2003) and Easterby-Smith et al (1991), attempted to classify data analysis as:

5.3.3.2.1 Content Analysis

It is a systematic way of converting qualitative data into quantitative data for quantitative analysis. It involves certain keywords or phrases, which are counted and the frequencies are established for further analysis (Easterby-Smith et al 1991). According to Collis et al 2003 and Silverman (1993) the content analysis is based on theoretical understanding of the substance of the text. First stage of the analysis is sampling if the researcher had a large volume of written, oral or visual data. The researcher has to make a decision for

extracting a sample. If the data is less substantial then it may be possible to analyse all of it. The next stage begins by determining the coding units such as particular words/phrases, item, themes found in the material. A coding matrix is then created with coding units on one axis and analysis of communication on the other axis. The coding frame once established should be piloted with experts or veterans for any inconsistencies (Easterby-Smith et al 1991). It is also suitable where the data is collected through structured interviews. The limitations of content analysis are the results obtained can often be stale (Silverman 1993). If all the code words are not identified the analysis can be biased or incomplete. Since, it is very tedious and time consuming (Collis et al 2003), this method is not used in this research.

5.3.3.2.2 Cognitive Mapping

Cognitive mapping is a method used to structure, analyse and make sense of written or verbal accounts of problems. It is particularly used and suitable for action research. Researchers attempt to model the complexity of organisational problems as they see them, so that they can be subsequently analysed and solved (Easterby-Smith et al 1991). According to Collis et al (2003) the main stages of cognitive mapping are as follows:

- A problem is broken into phrases, which retain the language of the researcher (or problem provider). These are treated as distinct concepts. These concepts are reconnected to present the problem in graphical format.
- Pairs of phrases can be united to form a single concept in such a way that each concept provides a meaningful contrast to the other.
- These distinct concepts are linked to each other to form hierarchy of means and ends like explanations leading to consequences.

There is also software available in the market for doing cognitive mapping (Collis et al 2003, Easterby-Smith et al 1991). Since the data in this research is qualitative, this method is used to code the interviewed data and classify into different technical and people factors as well as business and management implications. Then a hierarchy of relationships is established starting from IT-PMS implementation, to technical and people factors finally leading to business and management implications.

5.3.3.2.3 Grounded Theory

Large amounts of non-standard data obtained from qualitative studies make the analysis very difficult. With qualitative data, the structure used has to be derived from data. The data has to be systematically analysed to draw out themes, patterns and categories (Easterby-Smith et al 1991). Grounded theory fits in very well because the structure of framework used for data analysis is derived (grounded) from concepts and categories used by researcher(s) themselves to interpret and organise their words. According to Easterby-Smith et al 1991 and Glaser et al (1967) there are seven main stages for this method:

- Familiarisation: Read and re-read the transcripts (collected data) again and again until it enables the researcher with some thoughts. The researcher can scribble down these thoughts or ideas.
- Reflection: Evaluate data in the light of previous research, academic text, etc. Cataloguing is important so that previous research can be considered and evaluated. Ideas and thoughts should be formulated and reformulated in the light of previous work.
- Conceptualisation: Identify the concepts and variables, which are important in understanding what is going on. The researcher should go back through the transcripts (collected data), methodically highlighting when these concepts appear in transcripts.
- Cataloguing concepts: Transfer the concepts identified onto cards as a quick reference guide. The entry on the card needs to give reference to its source in the transcripts
- Recoding: Notice that some concepts are used within different contexts or used to explain different phenomena. It may be necessary to redefine and recode some of the structures, which is called laddering.
- Linking: Notice that the analytical framework and explanations should be becoming clearer, with patterns emerging and concepts identified that could fit together. The researcher can now begin to link all the variables, which have been identified as important into a more holistic theory. It can be piloted with experts and veterans
- Re-evaluation: Identify the areas needed for re-evaluation in the light of the comments of others.

The limitation of grounded theory is that the research and analysis in qualitative data is about feel and the understood component of the research is the honesty of the researcher. The approach is time consuming and costly. Since the transcripts used in this research are in the form of structured interviews as well as due to the complexity of this approach, it is not adopted in this research.

5.3.3.2.4 Miles and Huberman view of Qualitative Data Analysis

According to Miles and Huberman's (1984) view, data analysis consists of three concurrent flows of activity:

- ***Data Reduction***: It is a process of selecting, focusing, simplifying, abstracting and transforming the raw data that was previously written or documented. It is also a process that sharpens, sorts, discards and organises data to enable the researcher to draw conclusions. It is an iterative process, which starts after the raw data is collected in the company, until a final report is complete. It also includes doing summaries, coding, teasing out themes as well as making clusters, partitions, etc.

- ***Data Display***: It is an organised assembly of information, which permits the researcher to draw conclusions. Humans are not very powerful as processors of large amounts of complex information, hence the cognitive tendency is to reduce complex information into selective and simplified configurations. The usual data displays used in a research are matrices, graphs, networks and charts.

- ***Conclusion Drawing***: It starts from the beginning of the data collection by noting down the regularities, patterns, explanations, possible configurations, causal flows, propositions etc. It is also an iterative process and ends once the data collection is stopped. Even though the conclusions are vague in the beginning, they become explicit and grounded towards the end.

Since the data collected through personal observations in this research is very unstructured and complex, initially data reduction is used to convert the raw data into coded information. Data displays are used to convert the qualitative data captured in interviews into charts and graphs. Based on the outputs of data reduction and displays, the conclusions are drawn.

5.3.3.2.5 Triangulation

Triangulation is widely recognised as a way of providing enhanced research validity and reliability. It is achieved through deploying more than one research method, so that the findings of the study are not biased and as a means to increase validity and richness of the data collected and also the confidence of the researcher with the results (Yin 2003, Eden et al 1996). Denzin (1970) and Eden et al (1996) suggests that triangulation can be applied for five aspects of the research:

- *Methodological triangulation*: The researcher uses different research methods (such as interviews, personal observations, questionnaires, etc.) to study a particular case
- *Data triangulation*: The researcher studies a particular case from different data sources (such as literature, pilot case studies, action case studies, etc.)
- *Investigator triangulation*: Different investigators (such as facilitator, internal observer, external observer, etc.) studying the same case
- *Theoretical triangulation*: Different investigators studying the same study from different theoretical backgrounds (such as backgrounds from IT, consultancy, implementation, etc.)
- *Multiple triangulation*: Different studies (such as case studies at Company 1, Company 2, Company 3, etc.) are used in research where each study acts as a cross-check on others

Eden et al (1996) suggested that, action research provides an opportunity for cyclical data collection through exploiting more continuous and varied opportunities. Since this research adopts action research, triangulation will be exploited in validating the results from the above five perspectives.

5.3.3.2.6 Cross-Case Analysis

Cross-case analysis specifically applies to multiple cases. The analysis is likely to be easier and the findings are likely to be more robust and valid than having single case. Having more than two cases will also strengthen the results (Yin 2003, Miles et al 1984). One possibility of doing this analysis is to create word tables that display data from the individual cases according to some uniform framework. The overall framework obtained from all the cases will lead to a conclusion. Additional word tables reflecting other processes and outcomes of interest were also examined in the same way. The challenge

in a cross-case analysis is to know how to develop strong, plausible and fair arguments that are supported by data (Yin 2003, Miles et al 1984). Another possibility for this analysis is by developing a framework by pulling themes, which occur in individual cases by identifying patterns. Choosing dimensions of the framework is very important for cross-case analysis. Since this research includes multiple cases, this approach will be used in data analysis.

5.3.3.2.7 Informal Methods

Many researchers often use informal methods for data analysis, which include: rating frequencies to identify patterned behaviours, assigning scales to identify important data, examining duplicated data or patterned behaviours, reducing data to draw conclusions, etc. (Collis et al 2003). However, it is more important to justify these methods while using them in any research. A researcher should make sure that he/she will not loose the richness and quality of the data. Since the outcome of this analysis is poor, they are not adopted in this research.

5.3.3.2.8 Justification of data analysis methods used in this research

The research involves implementation of IT-PMS (independent variables), identifying its impact (dependent variables), as well as the technical and people factors (semi-dependent variables) and understand the relationship between them. The degree of existence of these factors and degree of impact on these implications will be obtained by the results obtained (using informal techniques) from the interviewed data by comparing before and after scenarios of implementation. However, in order to understand the relationship between these variables, a hierarchical, diagrammatic, causal relationship will be established, with IT-PMS (independent variables) in one end and its impact on business and management (dependent variables) on the other end. Hence, the best tool used to do this analysis is by cognitive mapping, which represents these dependent and independent variables in the diagrammatic causal relationships. However this analysis is also supported by enabler effect mapping mentioned in Chapter 4.

5.4 Methodology adopted for this Research

This research already involved exploring literature, doing case studies, establishing research objectives (including predictions). It now involves doing action case studies and building

theory. The different stages of this research are described in Table 5.8, each of which is explained in the following sections. Although the research is dominated by phenomenological paradigm (as demonstrated in Section 5.2.1.3), many authors suggested that the philosophical view of a research would be positivistic, if the researcher involves in testing the predictions. However, since the predictions generated in this research are tested using phenomenological tools, techniques, methods, etc., this research is described as phenomenological paradigm as a whole.

Table 5.8 Methodology adopted for this research

Research Stage	Philosophical Sense	Social Sense			Technical Sense	
		Mode	Strategy	Domain	Data Collection	Data Analysis
Pre-understanding	*Phenomenology*	*Induction*	*Exploratory & Archival*	*Department, Library & Internet*	*Primary & Secondary Sources*	
General Literature Review			*Exploratory & Archival*	*Department, Library & Internet*	*Secondary Sources*	*Informal Methods*
Case Studies			*Exploratory & Empirical*	*Case Study*	*Semi-structured Interviews*	---
Establishing Research Objectives			*Explanatory & Empirical*	*Department*	---	*Data Triangulation*
Specific Literature Review			*Exploratory & Archival*	*Department, Library & Internet*	*Primary & Secondary Sources*	*Informal Methods*
Action Cases		*Deduction*	*Descriptive & Empirical*	*Action Research*	*Facilitator, Participant Observer, Structured Interviews*	---
Theory Building			*Explanatory & Theoretical*	*Department*	---	*Cognitive Mapping, Miles and Huberman's Analysis, Data Triangulation, & Cross-Case Analysis*

5.4.1 Pre-understanding

Pre-understanding is the researcher's knowledge, insights and experience before starting the research (Gummesson 2000). This is also an exploratory stage, hence it does not a have

structured research design (Kinnear et al 1979). In this research, the pre-understanding for the researcher was obtained from:

- Previous knowledge and experience gained in mechanical, production, industrial, and manufacturing engineering backgrounds
- Previous knowledge and experience gained in manufacturing management background
- The research proposal made to EPSRC (UK local research council for funding)
- Visiting a number of companies in Scotland and talking to people, where similar work was implemented

5.4.2 General Literature Review

Initially the researcher started with a general literature review in the field of performance measurement using exploratory and archival approaches as a research strategy. The main objective of this review is to find the gaps in this field. The researcher collected information from secondary sources such as journals, magazines, conference proceedings, books that were available within the department, library and on-line material available on Internet and analysed the collected information using informal[1] methods as follows:

- Described the past research
- Identified different schools of thoughts
- Identified different issues locating gaps
- Selected the issue with relevant gap to do this research (Chapters 1 and 2).

5.4.3 Case Studies

Explored real world for practical relevance to the selected issue, i.e. "*the impact of appropriately designed and implemented IT based performance measurement system on business and management*" using exploratory and empirical approaches as the research strategy. The researcher identified four anecdotal evidences, which had relevance to the selected issue. In order to explore the selected issue in more detail, the researcher conducted a structured pilot case study to identify the following:

[1] There is no formal or structured research design for exploratory research (Kinnear et al 1979)

- What is the impact of IT-PMS on business and management?
- What are the critical success factors of IT-PMS design and implementation, which causes the impact identified earlier?

Based on these initial research questions, semi-structured interviews (with open ended questions) are done with 34 managers at AFE. (The results are included in Section 3.3.3).

5.4.4 Establishing Research Objectives

From the above results and general literature review, the research objectives were established (See Section 3.5) using data triangulation (from anecdotal evidence in Section 3.2, literature review in Chapter 2 and pilot case study in Section 3.3). Hence at this stage, it is very important to assess the predictions (research objective) against five quality criteria (see Section 5.4):

- Construct Validity: The predictions had passed this test because:
  - It identified the type of impact on business and management due to IT-PMS
  - It also identified the factors, which would cause that impact on business and management
- Internal Validity: The predictions had passed this test because, when "before" scenario of implementing IT-PMS at Pilot Case Study is compared with "after" scenario, there was an improvement in business and management behaviour. This improvement or change was caused due to the technical and people factors of IT-PMS. There was also causal relationship between these variables (chain of evidence)

The other three tests, external validity, generalisability and contribution are not applicable at this stage (as the predictions are based on results obtained from one pilot case study), which are explained in detail later in this chapter (see Section 5.4).

5.4.5 Specific Literature Review

Having created the research objectives, more literature was reviewed in the following areas using exploratory and archival approaches as the research strategy:

- General IT to support performance measurement
- A review on the problems of existing management information systems in organisations to support performance measurement

- A review on commercial IT platforms available in the market to support performance measurement
- A review on models and frameworks, which explain the impacts of IT on business and management
- A review on change management literature in general including technology based change management

The objective of this review was to achieve the research objectives in the light of theory existing in literature. The information is collected both from primary (documented industrial case studies) and secondary sources such as journal, magazines, books, etc. that are available within the department, library and on-line material available on Internet.

5.4.6 Action Cases

Having selected the semi-dependent variables (technical and people factors) as well as dependent variables (impact on business and management), the research is set to identify any extraneous variables (factors other than selected), which could affect the selected dependent variables. However, these external variables can only be realised in *action* and cannot be anticipated or planned. The researcher should be *part of an organisation* to observe the extraneous variables. The research is also set to understand and build the complex relationship between these variables (independent, dependent and semi-dependent), which is very difficult with other domains such as case studies or field studies. Moreover, the researcher seeks to *describe* phenomena as they exist as well as identify and obtain information on characteristics (extraneous and independent variables) of a particular problem or issue (dependent variables). Hence empirical with descriptive approaches are chosen as the research strategy with action research as the domain to do this research. In order to test the degree of presence of both dependent variables and independent variables, interviews will be conducted with people who are directly or indirectly linked with the presence of these variables. The researcher has established the following criteria to select companies/organisations to do the action research:

- Medium to Large Scale Organisations (employees ranging between 40-1500). The study is not suitable for Small Scale Organisations with less than 40 employees for the following reasons:
  - IT-PMS is not essential for them, i.e. it will have less impact on business and management

- The cost invested in the project may not be justified

On the other hand, organisations with employees of more than 1500 are not selected as it takes longer to find out the impact (over 2 to 4 years). Due to the time restrictions for the researcher, these organisations are also avoided.

- The cases are restricted to manufacturing, production and process industries for the following reasons:
  - The anecdotal evidence was from these industries and the prediction were built based on a process industry
  - The IT-PMS designed is based on SPC Software, which is more relevant for these organisations
- The companies, which are in genuine need of IT-PMS rather than companies just supporting a student research project.

In three companies, the researcher facilitates the IT-PMS where as in one company they implement IT-PMS themselves. In all four companies, the researcher plays a role as a participant observer. The researcher established the following abstract guidelines to implement IT-PMS in each company:

- *Orientation Phase:* Defining the scope of the business for implementing IT-PMS. Identifying the team of members to implement IT-PMS.
- *Assessment Phase:* Understanding business direction and drivers. Establishing a view of benefits of IT-PMS for the business and management. Outlining the future requirements for the business in terms of IT-PMS. Establishing a brief description of current IT resources used in the company. Identifying a gap between what is desired and what is required by the company.
- *Strategic Phase:* Establishing vision for the company in terms of IT-PMS. Conducting an optional analysis with different alternative solutions for the company (A review of alternative solutions is provided in Section 4.4). Finally, develop a strategy by justifying it. Out of the four cases selected, three companies decided to implement IT-PMS with SPC Software as a pilot, for six months. However in one company, it was decided that they implement IT-PMS as a long-term solution using Cognos Reporting Tool.

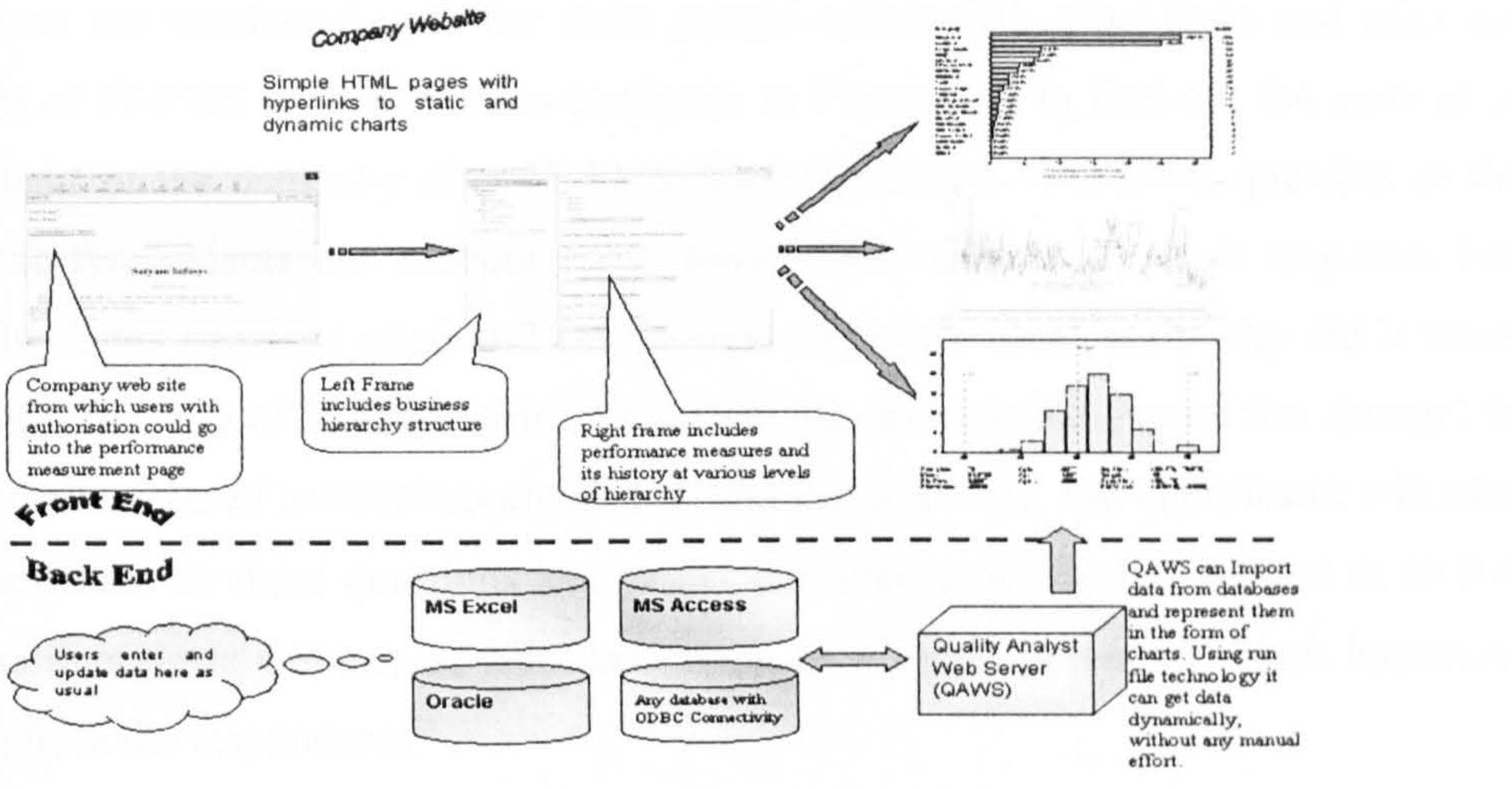


Figure 5.4 The architecture of IT-PMS implemented at three companies *(For clearer view, see Appendix A)*

- *Tactical Phase:* Developing a tactical plan for the strategy. Recommend monitoring and control process. Since the data is existing in several places in all the companies, SPC software is used to collect data, analyse it and distribute the information to different audiences in the specified format such as simple trend charts, control charts, p-charts, process histograms, Pareto analysis, reports etc. as shown in Figure 5.4

The data will be collected using structured interviews as well as personal observations. The interview questions are structured based on the predictions obtained in Chapter 3. For each question the answers are captured using Likert Scale (see Appendix B for interview questions). The Likert technique presents a set of perception statements. Interviewees are asked to express their perceptions at a five-point scale. Each degree of agreement is given a numerical value from one to five. Thus a total numerical value can be calculated from all the responses (Crawford 1997, Hatch et al 1991, Brown 1988).

However, the researcher's idea of using Likert scale in the interviews is to show the difference between before scenario and after scenario of IT-PMS implementation. The degree of agreement for perceptions with its numerical value is shown in Figure 5.5.

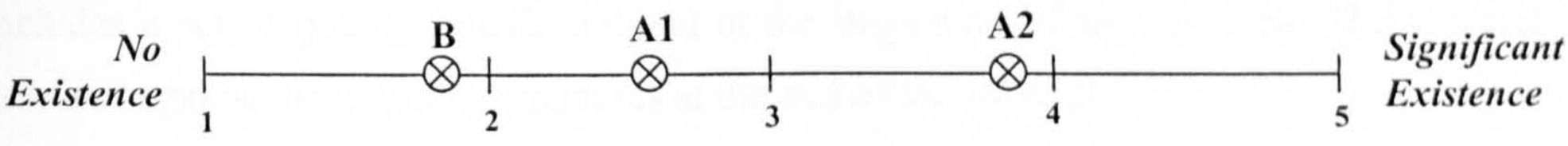


Figure 5.5 Likert Scale used in the Interviews

The interviews are conducted with the same people before (B), after (A1) and after six months (A2) of IT-PMS implementation as shown in Figure 5.5, to find out the amount of change brought in the company after IT-PMS implementation. For each question in the interview, the respondents are encouraged to answer the reasons for their response. For instance, why is the response rated at 2 (in the case of before scenario)?, why did it move from 2 to 4 (in the case of after scenario)? What are the reasons that caused the change? In addition to the structured answers received from the interviewees, the interviewer will also encourage a debate on these questions and gather the information and document it. In this research, the interviews will not be recorded (tape), as it might potentially limit important information from the respondents.

Personal observations are documented informally in a table (see Appendix C for reporting personal observations). Since the researcher acts as a facilitator and personal observer, potentially there is access to a great deal of information, which distracts the researcher from his objective of this research. Hence a table (see Appendix C for reporting personal observations) is created in order to reduce the distraction of the researcher and document the observations.

5.4.7 Theory Building

The data collected in the above section will be analysed for each case using data reduction, data coding, data displays, cognitive mapping and data triangulation (will be described in detail in Chapter 6). After the analysis will be done for each case, the researcher uses cross-case analysis between all four cases to build theory using explanatory and theoretical approaches as the research strategy. The obtained result will be assessed against all five-quality criteria established in Section 5.4 (will be tested and demonstrated in Chapter 7)

5.5 Assessing the Quality of Research

A key question often asked about any research is that, "how valid is the research?" and "what contribution did it make?" Hence a discussion about assessing the validity and contribution of the research is provided as a separate section in this chapter. This section includes a set of quality criteria defined at the beginning of the research. The research is assessed against these quality standards at the end of the research.

5.5.1 Construct Validity

Establishing the correct operational measures (variables) for the concepts being studied. To meet this test construct[1] validity, Yin (2003) has suggested two steps:

- Select the specific types of changes that are to be studied and obtain multiple source of evidences for these changes identified (Eden et al 1996)
- Demonstrate that the selected measures (variables) of these changes do indeed reflect the specific types of changes that have been selected (establish chain of evidence)

The problem with phenomenological approach is that there are a number of phenomena, which are not directly observable, such as resistance, behaviour, satisfaction, anxiety, pro-active management style, etc. (Collis et al 2003). In such cases, there will be an existence of some hypothetical construct of the factors, which explain these observable phenomena with causal links. The researcher should be able to demonstrate that his/her observations and research findings can be explained by the hypothetical construct. However the major limitation of this test is that it fails to recognise the bias introduced by the expectancies of the researcher.

For action researchers, Eden et al (1996) suggested the following characteristics as a third step to pass construct validity test:

- In action research opportunities for triangulation that cannot be offered with other methods should be exploited

5.5.2 Internal Validity

Establishing a cause and effect relationship, such as certain conditions are shown to lead to other conditions (Yin 2003). This test is applicable only to the explanatory approach and not for descriptive or exploratory approaches. For instance, if a research has a pre-test, implementation and post-test, and the researcher demonstrated that the factors A and B of implementation had caused the difference between pre-test and post-test. It is then said to be internally valid. However, this test fails to recognise that the research findings can

[1] Construct is defined as a solution (such as model, framework, etc.) to explicit problems (Kasanen et al 1993)

sometimes be wrong if some other factor C of implementation is the reason for the difference between pre-test and post-test and not A and B.

For action researchers, Eden et al (1996) suggested the following characteristics of outcomes, to pass internal validity test:

- Action research will generate emergent theory, in which the theory develops from synthesis of data, which is obtained from the use of existing theory in practise. In short, action research usually retests the theory and develops it further
- Theory building in action research is incremental, moving from the particular to the general in small steps
- Action research requires a high degree of method and orderliness in reflecting on the emerging research content of each episode of involvement in organisation
- In action research opportunities for triangulation that cannot be offered through other methods should be exploited

5.5.3 External Validity (Generalisability)

Establishing the domain to which the research results can be applied. Generalisability is defined as the extent to which a researcher can come to a conclusion about a population based on the results obtained from a sample (Collis et al 2003). However, Gummesson (2000) and Kasanen et al (1993) argue that it is one type of generalisability often used with positivistic approach. However the phenomenological approach is concerned with whether the patterns, concepts and theories generated in a particular environment can be applied for other environments.

For action researchers, Eden et al (1996) suggested the following characteristics to pass external validity test:

- Beyond theory generation in the current situation, action research should envisage talking about the theories developed in relation to other situations
- Action research should be presented in the form and style, that is appropriate to the consumer (readers of theory generated and the practitioners for whom the research was done)
- In action research opportunities for triangulation that cannot be offered through other methods should be exploited

- The history and context in action research for intervention must be taken as critical to the interpretation of the range of validity and applicability of results

5.5.4 Reliability

Demonstrating that the operations of a research such as implementations, data collection procedures, etc can be repeated, with same results (Yin 2003). In phenomenological research, the emphasis is on repeating the case rather than having the same results in two cases (Collis et al 2003). The ultimate goal of this test is to reduce biases within the study. For a case to be repeated it is very important to document the previous case in order to test its reliability. The most ideal way of approaching the reliability of a case is to make many steps as operational as possible and conduct the research very carefully.

For action researchers, Eden et al (1996) suggested the following characteristics to pass repeatability test:

- For action research, the process of exploration of data, in the detection of emergent theories, must be replicable or demonstrable through argument
- There are several forces, which act against getting reliable data through action research. However it should be demonstrated that the method used is likely to produce insights, which cannot be gleaned with any other method. Hence it is necessary to justify the use of action research rather than other approaches.

5.5.5 Contribution

Demonstrating that the research has contributed either to theory or practice (knowledge). However in most of the researches, an evidence of both the contributions is essential (Kasanen et al 1993). The research should propose something new, which is not known before, hence this criteria also tests the authenticity of the research (Martinez et al 2003). If the knowledge contributed is in the form of a construct (such as model or framework or a causal diagram) then it should also have a practical relevance. It should demonstrate the practical usability of the construct that enables management to use it in the organisation or practice (Kasanen et al 1993).

For action researchers, Eden et al (1996) suggested the following characteristics to pass authenticity/contribution test:

- In addition to the contribution made to practise, action research should make a clear contribution to theory by characterisation and conceptualisation of the particular experiences in a way meaningful to others

5.5.6 Summary of Quality Criteria

The criteria used to assess the quality of this research are summarised in Table 5.9.

Table 5.9 Summary of quality criteria

No	Criteria	Pass/Fail?
1	**Construct Validity** ▪ Demonstrate changes being studied should have multiple source of evidences ▪ Demonstrate selected measures of these changes do indeed reflect the specific types of changes that have been selected ▪ Demonstrate opportunities for triangulation that cannot be offered with other methods are exploited	
2	**Internal Validity** ▪ Generate emergent theory, in which the theory develops from synthesis of data, which is obtained from the use of existing theory in practise. ▪ Demonstrate theory building is incremental, moving from the particular to the general in small steps ▪ Demonstrate high degree of method and orderliness in reflecting on the emerging research content of each episode of involvement with the organisations ▪ Demonstrate opportunities for triangulation that cannot be offered through other methods should be exploited	
3	**External Validity** ▪ Demonstrate the theories developed in relation to other situations ▪ Present the results in the form and style, that is appropriate to the consumer (readers of theory generated and the practitioners for whom the research was done) ▪ Demonstrate opportunities for triangulation that cannot be offered through other methods should be exploited ▪ Demonstrate the history and context was taken as critical to the interpretation of the range of validity and applicability of results	
4	**Reliability** ▪ Demonstrate that the process of exploration of data, in the detection of emergent theories are replicable or demonstrable through argument ▪ Demonstrate that the methods used are likely to produce insights, which cannot be gleaned with any other method.	
5	**Contribution** ▪ Demonstrate that the research contributed to practise ▪ In addition to the contribution made to practise, the research should also make a clear contribution to theory	

5.6 Discussion

This chapter has provided a brief description on different research paradigms, modes, strategies, domains, tools and techniques available in literature justifying whether each of them is useful to do this research. All the models, tools and techniques presented here can be broadly classified into a philosophical sense, social sense or technological sense. For example, each activity of this research will have all three senses. Each activity in this research is viewed against all these three senses as presented in Table 5.8. In achieving the research objectives in this research, it is required to:

- construct IT-PMS and implement it (independent variables)
- make people use IT-PMS (semi-dependent variables)
- study the impact of IT-PMS on business and management (dependent variables)
- identify the critical success factors of the impact (semi-dependent variables)
- understand the relationship between implementation, impact and success factors (all three variables)

The selected variables in this research are IT-PMS implementation, impact on business and management implications as well as technical and people factors. IT-PMS implementation is not dependent on either implications or factors, hence they are classified as independent variables. Some technical factors are dependent on IT-PMS implementation and some people factors are not dependent on IT-PMS implementation or implications hence they are classified as semi-dependent variables. Business and management implications are completely dependent on technical and people factors and hence they are classified as dependent variables. However all these dependent, semi-dependent and independent variables are predetermined from a pilot case study and established as predictions.

However in order to study these variables and identify other extraneous variables effecting the dependent variables, it is necessary for the researcher to be present in the cases being studied. These external variables can only be realised in *action* and cannot be anticipated or planned. The researcher should be *part of organisation* to observe the extraneous variables, which is possible through action research. The researcher should facilitate the IT-PMS implementation to get reliable observations on dependent variables, which is only achieved through action research. Since the semi-dependent and dependent variables depend on independent variable (IT-PMS implementation), the researcher needs control over design and implementation of IT-PMS to study these dependent and independent variables. This can

only be achieved through action research. The research also involves building complex relationships between these variables, which can be studied by facilitation of IT-PMS and personal observations on these variables through action research. Moreover triangulation can be exploited in action research to validate the results obtained in this research.

Based on the above discussion, action research was chosen as the main domain for this research and established collaboration with four companies to implement IT-PMS and study the results. The criteria used in selecting these four companies were already explained in Section 5.3.6. Hence the next chapter presents the results obtained from individual cases. Finally cross-case analysis is also presented based on the results obtained across all the four companies.

Chapter 6: Action Research

6.1 Introduction

In Chapter 3 and 4, the pilot cases and specific literature review, provided some insights in identifying the predictions and pre-conditions, i.e. where the impact of IT-PMS would be on management and business. Chapter 5 explains different methods, models, techniques, and tools available in general and finally justified an overall methodology to test these predictions in this research.

This chapter begins with explaining these predictions. It also explains all the necessary pre-conditions, i.e. the technical and people factors of IT-PMS, which finally impact on the predictions. It continues to explain the methodology for analysing each action case in detail. In order to assess and test the predictions and pre-conditions, four action case studies were conducted with Labelling Company (SLC), Mineral Water Company (HSL), Warehousing Company (HWL). and Distillers Company (ADL), as shown in Figure 6.1. It explains each action case as follows:

- Introduction and Background to each Company: It includes a brief introduction to the company, its history, the number of employees working, etc. Later it explains the initial situation of the company in terms of exiting performance measures, data collection and dissemination, IT resources available, peoples' behaviour with the existing information resources, etc.
- Implementation Plan for IT-PMS at each Company: It includes four phases. Orientation phase, which defines the scope of business within which IT-PMS is implemented and identifies overall methodology to implement IT-PMS. Assessment phase, which establishes a brief description of current IT resources used in the company and hence establish a gap between what is desired and what is required by the company. Strategic phase, which defines vision for the company in terms of IT-PMS. Conduct an optional analysis with different alternative solutions for the company. Finally, develop a strategy by justifying it. Tactical phase, identify and specifies all the projects required to implement each strategy, prioritise these projects. Develop a tactical plan for each project. Recommend monitoring and control process.

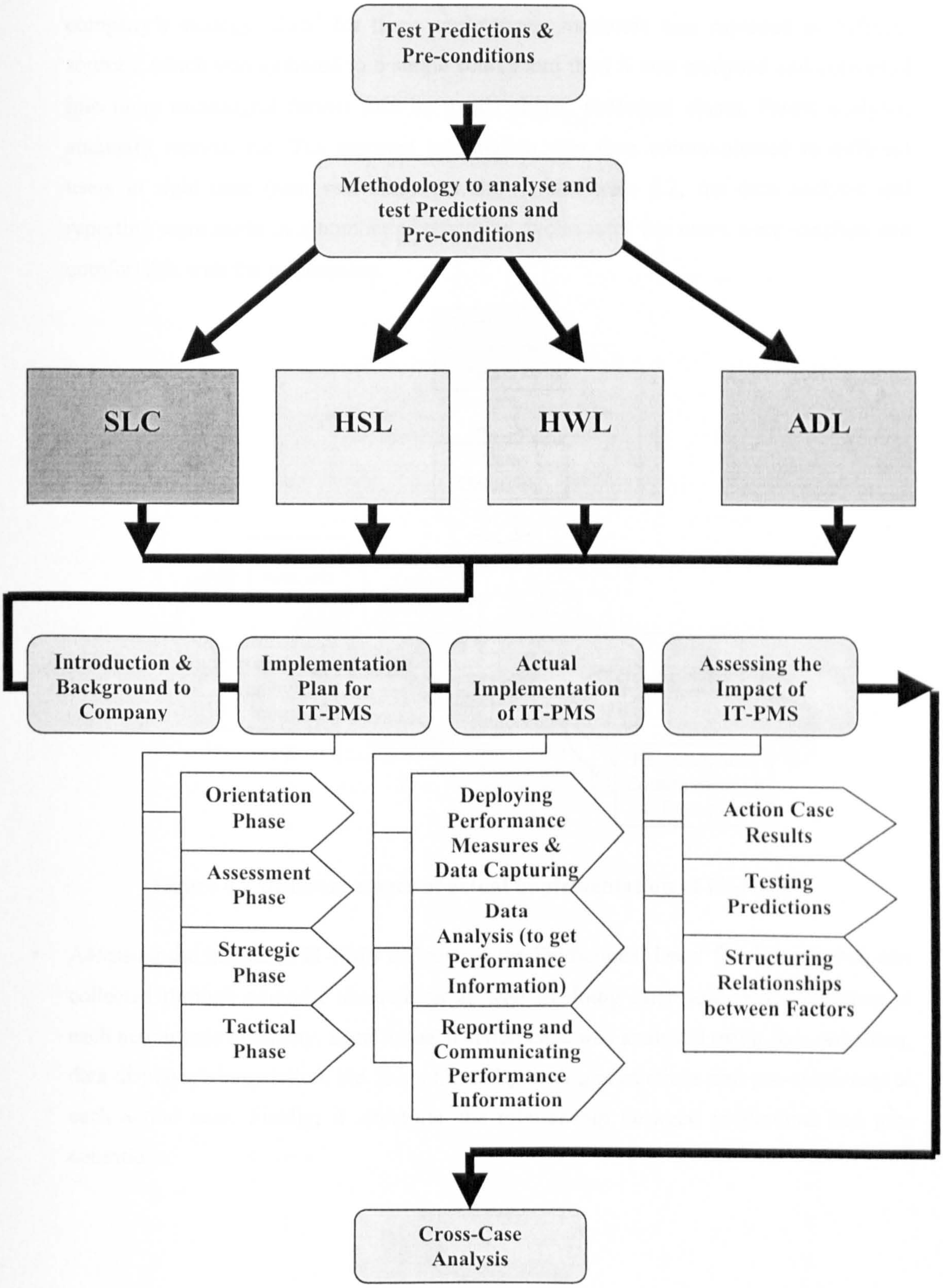


Figure 6.1 The Structure of this Chapter

- Actual Implementation of IT-PMS at each Company: The actual implementation of IT-PMS at each company started with deploying performance measures from the company's strategy. Data[1] for these performance measures was captured at different sources, which was gathered to a single source and then it was analysed and converted into more meaningful format such as trends charts, statistical charts, Pareto analysis, summary reports, etc. The reported information was then communicated to different users in right time (near real-time). As shown in Figure 6.2, the data analysis and reporting were made in a number of repetitive cycles until the users were satisfied and comfortable with the information.

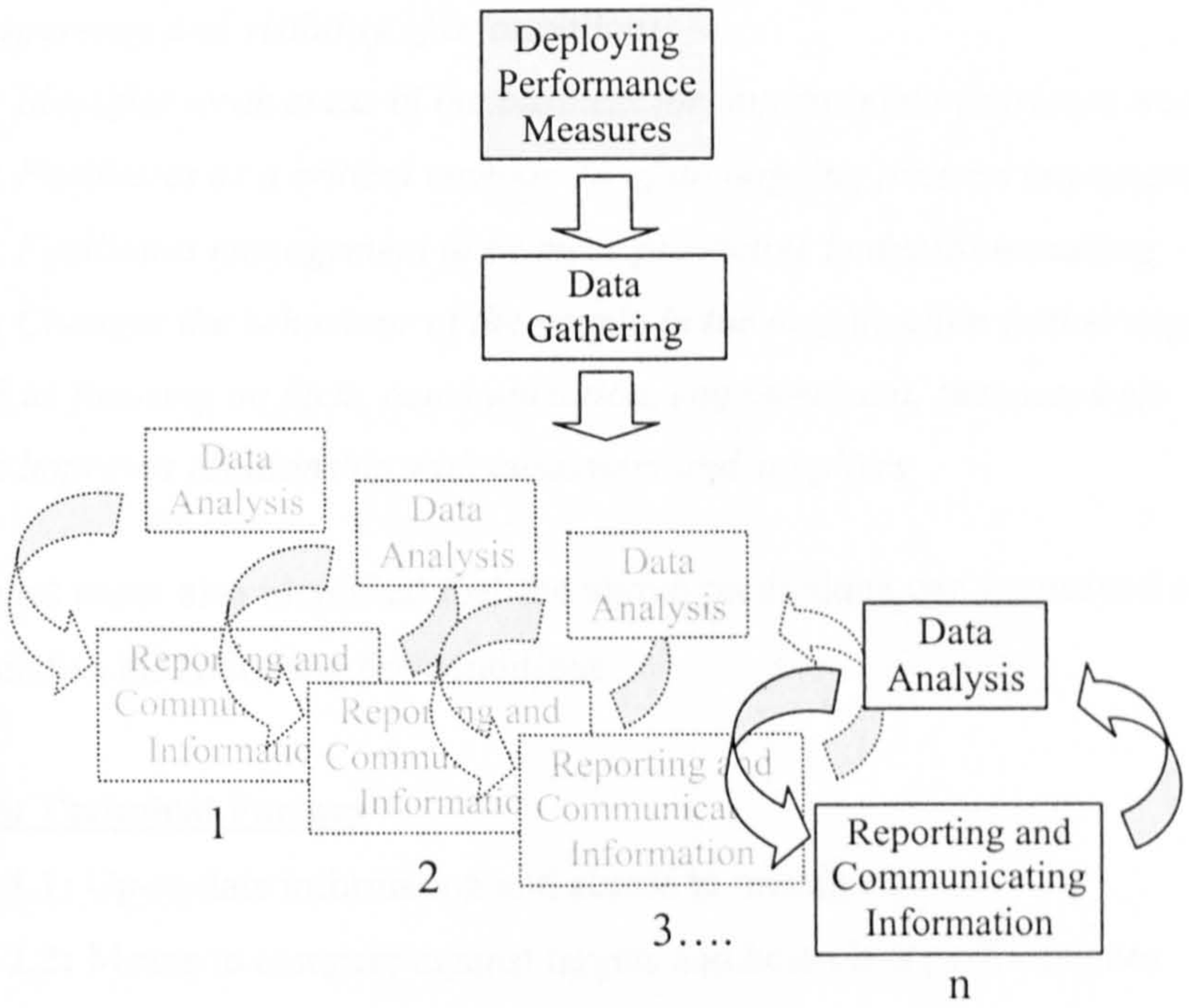


Figure 6.2 Different stages of actual implementation of IT-PMS

- Assessing the Impact of IT-PMS and testing the Predictions: Data[2] for this research was collected through personal observation as well as doing interviews with managers at each action case company. Data for each action case was analysed using data reduction, data displays, triangulation, etc. It continues by testing predictions and pre-conditions at each action case. Finally, it structures the relationship between predictions and pre-conditions.

---

[1] Data existing in the companies for implementing performance measures
[2] Data collected through personal observation and interviews for doing research analysis

The last part of this Chapter includes cross-case analysis between different action cases analysed in the earlier sections of this Chapter.

6.2 Predictions and Pre-conditions

As mentioned in Chapter 3, the pilot case study had provided insights to identify the following predictions:

Predictions: Management and Business Implications

Prediction 1.1: *Disseminates the performance information throughout the organisation (improved transparency and visibility of information)*

Prediction 1.2: *Identifies weak areas of the business for improvement (business weaknesses)*

Prediction 1.3: *Facilitates as a critical component of an ongoing process improvement*

Prediction 1.4: *Facilitates management to be more pro-active in decision-making*

Prediction 1.5: *Changes the behaviour of the people in the organisation (either negatively or positively) such as focusing on facts, communication, empowerment, teamwork etc.*

Prediction 1.6: *Improves relationship with customers and suppliers*

However the pilot cases also identified that the above predictions can be proved only if the organisation satisfies the following pre-conditions:

Pre-conditions: Technical Factors

Pre-condition 1.1: Up-to-date information and access to managers

Pre-condition 1.2: Means to compare against targets and best-class performances

Pre-condition 1.3: Open communication of information throughout the organisation

Pre-condition 1.4: Secured access to customers and suppliers

Pre-condition 1.5: Provides consistent and accurate information

Pre-condition 1.6: Reduces the time and effort required in data collection and analysis

Pre-condition 1.7: Statistical analysis for controlling and monitoring processes

Pre-condition 1.8: Simple and easy for the users

Pre-conditions: People Factors

Pre-condition 2.1: Senior management commitment and drive

Pre-condition 2.2: Using the system in identifying business trends

Pre-condition 2.3: Using the system for decision-making

Pre-condition 2.4: Acting as teams to solve the issues

Pre-condition 2.5: Using the system as a routine part of their business

Pre-condition 2.6: Not resistant to use the system

Pre-condition 2.7: Knowledgeable enough to use the system

Pre-condition 2.8: Empowered to make decisions based on information

Pre-condition 2.9: Confident about the information

Pre-condition 2.10: Customers and suppliers are using the system

As a result of implementing IT-PMS in a company, the test is that the impact on management and business implications is proportional to the impact on technical and people factors

$$\textit{Impact of IT-PMS on Management and Business} \propto \textit{Impact of IT-PMS on Technical and People Factors}$$

(If the impact of IT-PMS on technical factors increases/decreases, the impact on management and business also increases/decreases respectively. If these factors do not exist then there will not be any impact on implications.

6.3 Methodology to assess and test Predictions and Pre-conditions

In order to test the predictions, pre-conditions and hence the equation, it is necessary to assess the impact on each prediction and the impact on each pre-condition. In order to achieve this, it is necessary to do the following at each company:

6.3.1 Data collection

A set of structured interviews were conducted with the management of each company at three stages of the research (The detailed methodology was discussed in Section 5.3.6):

- Before implementing IT-PMS
- After implementing IT-PMS (with in a month)
- After six months of implementing IT-PMS

The data was collected to validate the predictions, pre-conditions and the equation. Besides the numerical weightings (scores) for each question asked in the interview, the interviewees were also encouraged to give the reasons behind their scores. All the scores and reasons were well documented[1]. The personal observations during implementation and after the implementation were also captured and well documented[2].

---

[1] Data from interviews were documented

[2] Data from personal observation were documented

6.3.2 Data analysis

As mentioned in Chapter 5, the data is analysed using the following techniques data reduction, data displays, triangulation and finally tests the predictions, pre-conditions and proves the equation.

The process of observation, documenting and summarising is an iterative process and broadly classified as data reduction (Miles et al, 1994). In this research the data was reduced after several iterative steps and finally summarised and coded in line with predictions and pre-conditions as shown in Figure 6.3.

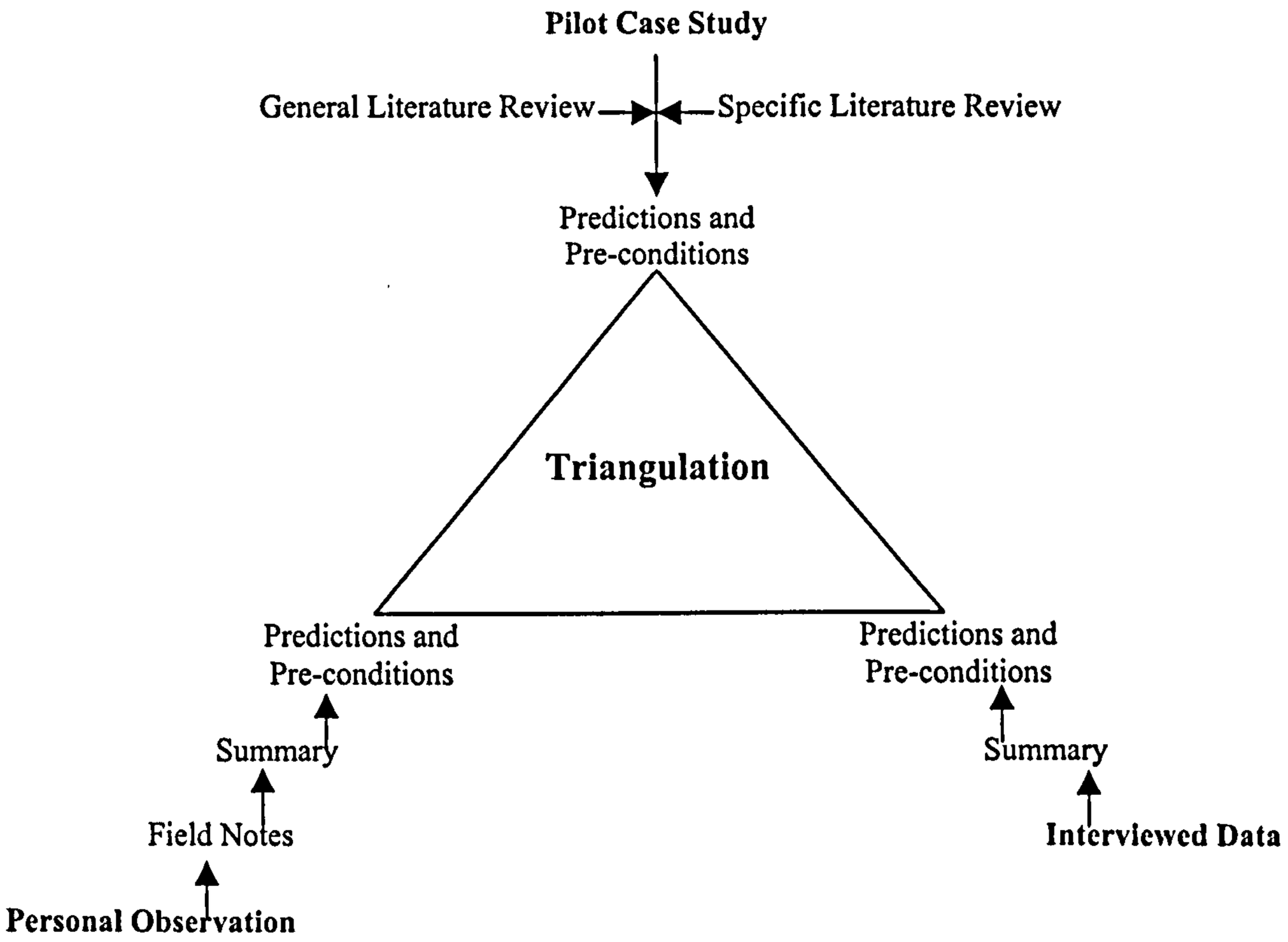


Figure 6.3 Data Analysis for each Action Case

The weightings obtained from the interviewed data are summarised and displayed as spider diagrams representing all the three stages of IT-PMS implementation (before, after and after 6 months). However the change in management perceptions for technical and people factors as well as management and business implications of before and after 6 months scenario is

represented in bar-diagrams[1]. From the data obtained from the interviews it is evident that Company A moving from 1 to 3 is not same as Company B moving from 2 to 4 as shown in Figure 6.4. In order to avoid this interpretation, the change is represented by the ratios[2], i.e.,

$$\text{Change/Impact} = \frac{\text{(Actual Change from the Management Responses)}}{\text{(Maximum Change Possible from the Management Responses)}}$$

$$\text{Change/impact at Company A} = \frac{(3-1)}{(5-1)} = \frac{2}{4}$$

$$\text{Change/impact at Company B} = \frac{(4-2)}{(4-1)} = \frac{2}{3}$$

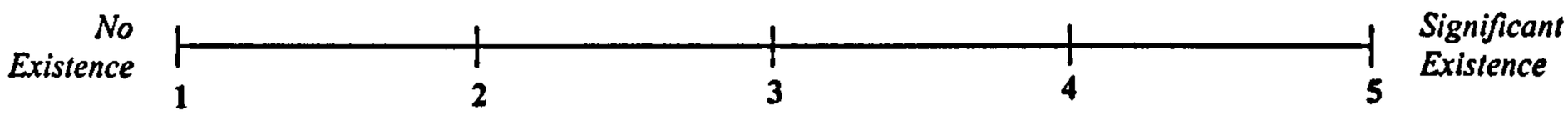


Figure 6.4 Likert Scale used in the Interviews

Since the values are calculated from subjective answers of managers, the results are not subjected to statistically accuracy. There can be variability in the values. Hence the bar-charts should be interpreted for comparison purposes between factors only.

Finally, the predictions and pre-conditions obtained from pilot case study are validated against personal observations and interviewed data, using triangulation as shown in Figure 6.3.

The research also includes understanding and developing the relationship between the technical and people factors as well as management and business implications using Enabler (Factors) Effect (Implications) Mapping (EEM) as discussed in Chapter 4, is shown in Figure 6.5. The idea of using this EEM diagram provides the basic descriptors of the terrain and a compass that can be used to travel from beacon of bearings, which acts as starting point of the effort (IT-PMS implementation) and beacon of benefits, which acts as the effects and benefits (management and business implications) of IT-PMS on management and

---

[1] The researcher's idea of using bar diagrams is to demonstrate the comparison between different factors and implications within a company.

[2] The ratios obtained in this research are solely for intra company comparison. Since they are calculated from perceptions, they should not be used for inter-company comparisons. The absolute values were not used to develop the EEM models

business. Amongst the beacon of bearings, there are four things that act as starting position on the way from IT-PMS to its impact on management and business, they are:

- The performance measures developed for the company
- The IT infrastructure and skills existing in the company
- The new technology brought into the organisation of implementation (SPC software, performance measurement software, etc.)
- The business processes in which the IT-PMS was implemented

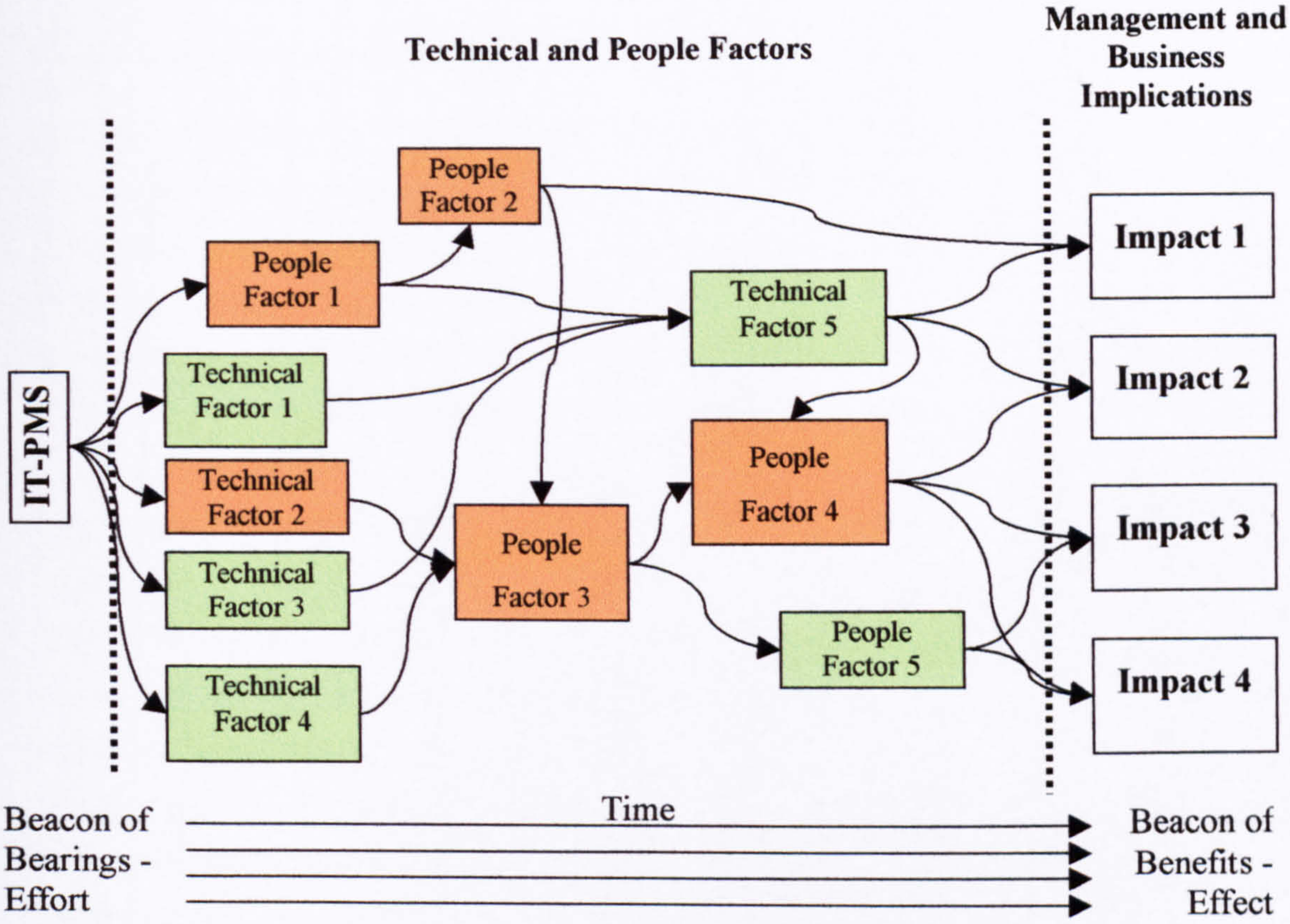


Figure 6.5 Mapping between IT-PMS implementation, technical and people factors as well as management and business implications

Amongst the beacon of benefits, there are five predictions (implications), on which IT-PMS will have the impact, they are:

- Creates transparency and visibility
- Identification of weak areas in the business
- Result in pro-active management style
- Lead to continuous improvement
- Initiate positive behaviour of people

However, the terrain and a compass used to travel from beacon of bearings and beacon of benefits would be different for each action case company. Hence the EEM diagram would be developed for structuring the relationship between factors and implications for each action case company.

6.4 The Main Action Cases

6.4.1 Company SLC

6.4.1.1 Introduction and Background

SLC, based in Edinburgh, UK, was founded in 1858, have long been recognised as a provider of self-adhesive labels and flexible packaging solutions to a wide range of market sectors throughout UK and Europe. SLC had a vast experience in producing different types of labels using digital and combinations press technology. Design, artwork, origination, print and conversion are all provided in-house and are subject to a rigorous quality control system in line with the latest ISO accreditation. There are 64 employees working in the company.

The company as a whole did not have many indicators, but the few indicators that they measured were financial indicators. The company has a scheduling and data collection system, Shuttleworth, which collects the data (such as Date, Shift No, Job No, Machine Speed, Raw Material Fed, Useful Output etc.) from the shop floor and stores it in a 17 year old Speed Base Development System (SBDS). SBDS is a non-relational database system, which was not user-friendly and the IT Manager was the only person who could use it effectively. This seriously limited access potentially, to a very useful data. Information had to be requested from the IT Manager in the specified format, but as SBDS was not a relational database, it was not always that easy to format data in specified fashion.

Although the company had an intranet, it communicated the raw data and static web pages. It did not include performance analysis, dynamic charts or reports. Even though raw data was available for most of the staff (managers and team leaders, raw data or information was not at all available for personnel on the shop floor) connected to the Intranet, different people used their own analysis to obtain the performance results. There was no standard tool and mechanism for the performance analysis. Generally, people spent lot of time and effort in doing performance analysis and reporting by downloading data into MS Excel. As there was no consistent approach to performance analysis, different people came up with different

results, which resulted in doubts on the validity of data and information. Manually produced Excel charts were displayed on boards.

The researcher presented his work with ***AFE*** (Pilot Case) to the management team in SLC, who decided to adopt and implement IT-PMS. Since the Company already had financial measures in place the management team wanted to deploy leading indicators (which directly effect their financial measures) and decided Overall Equipment Effectiveness (OEE) as a firewall. This meant measuring the availability, performance, quality and hence OEE of all the machines. Due to the lack of IT skills to support these measures, the Company decided to bring in the researcher, who played a leading role in implementing this project as well as in finding the impact of IT-PMS.

6.4.1.2 Implementation Plan for IT-PMS

Orientation Phase: *Defining the scope of the business for implementing IT-PMS and methodologies used to find the impact of IT-PMS on management and business.*

The reason the Company decided to implement IT-PMS was to promote continuous improvement as a part of TCS programme. There is evidence in literature and consultancy projects that performance measurement enhances continuous improvement. Performance measurement and continuous improvement are complementary projects to each other. Initially, a ***Steering Committee*** was established in the company for planning IT-PMS in the company. It consisted of David Hedley (Managing Director), Richard Brown (Operations Manager), Ron Bagnall (IT Manager), Stephen Maddocks (TCS Associate), Sai Nudurupati (Action Researcher), Umit Bititci (External Advisor) and Peter Ball (External Advisor). An ***Implementation Committee*** was established for implementing IT-PMS in the company. It consisted of Sai Nudurupati (IT-PMS Provider), Steven Maddocks (TCS Associate) and Simon Collins (Network Administrator). As a part of the TCS programme, the Steering Committee identified to improve their effectiveness in the operational site of the factory and hence the committee decided the scope to implement IT-PMS for the operational activities of the Company.

The committee decided to use personal observations and a set of interviews for assessing the impact of IT-PMS on management and business. The overall time for this project was decided to be one year.

Assessment Phase: *Establish business direction (operational site) and drivers and find its impact on IT-PMS. Establish a view of benefits of IT-PMS for the management and business. Outline the future requirements for the business (as a whole) in terms of IT-PMS. Establish a brief description of current IT resources used in the company. Finally establish a gap between what is desired and what is required by the company.*

The business direction for the Company was to promote continuous improvement in the operational site. If it does not happen within the planned time, the IT-PMS project would terminate in the Company. The anticipated list of benefits in implementing IT-PMS was given in Chapter 3 (as predictions and pre-conditions). The list was developed from both pilot cases and literature review of action researcher. The future direction of the business was to promote continuous improvement project in other parts of the business. Most of the IT resources used by the Company such as Shuttle Worth System, SBDS, MS access, Intranet etc. were described briefly in the Company background. Although raw data captured in the system was available on the Company intranet, the performance related information required to promote continuous improvement was not available. Hence *gap* identified was that performance measurement related information (such as information on availability, performance, quality, down times, OEE of each machine and the whole factory) was not available to the right people (at different levels of organisation) in the right time (in near real-time) in right format (such trend charts, Pareto analysis, reports, etc.) in the Company to promote continuous improvement.

Strategic Phase: *Establish vision for the company in terms of IT-PMS. Conduct an optional analysis with different alternative solutions for the company. Finally develop a strategy by justifying it.*

The vision for the Company was to automate the IT systems from data capturing to the data reporting and communication to different set of audience in different formats in (near) real time, which promotes continuous improvement. In order to achieve this vision, an optional analysis was done in the market on different software vendors for delivering modern (in contrast to the proprietary data capturing system available in the Company) automated data capturing system. Initially, these vendors were classified into three categories based on their solution costs such as very expensive, expensive and less expensive. But later this option was fringed to a less expensive solution.

For data analysis, reporting and communicating, the steering committee used the software review done by Nudurupati et al (2000). All the software products and solutions included in the report were either very expensive or expensive for SLC. Hence the committee decided to implement a less expensive solution, which could be built using existing IT resources available within the Company (MS Access and IIS Server) as well as a simple charting and reporting tool available in the market. The different options available include:

1. MS Access reporting tool (already available in the Company)
2. Ms Excel (available in the Company, but has to be automated and customised to act as statistical tool)
3. NWA QAWS (statistical charting and dynamic reporting tool)

The steering committee decided to use MS Access for data analysis and NWA QAWS (temporarily obtained on a pilot basis for one year) for charting, reporting and communicating information. This temporary decision made would work in conjunction with the old data capturing system existing as shown in Figure 6.6

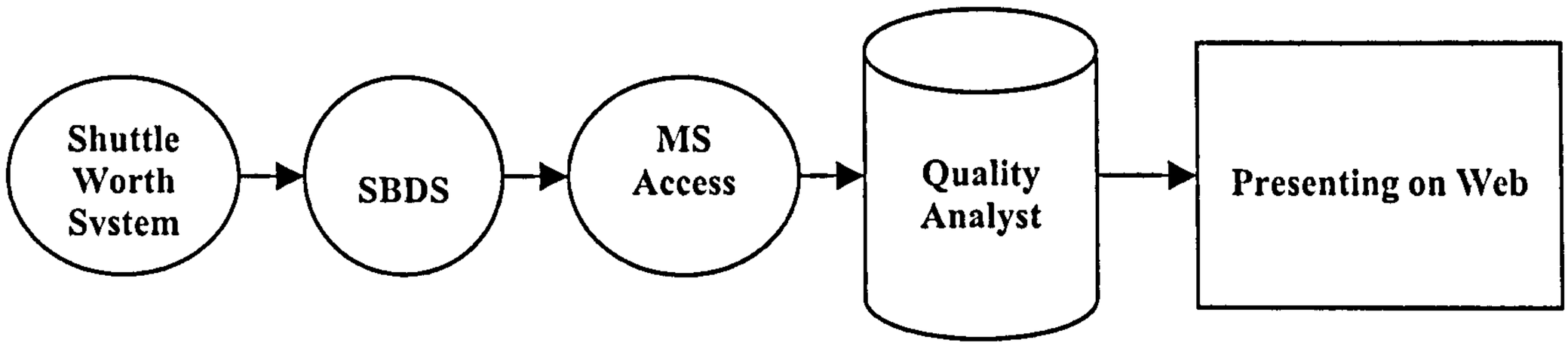


Figure 6.6. Architecture of the IT-PMS at SLC.

Tactical Phase: *Identify and specify all the projects required to implement each strategy, prioritise these projects. Develop a tactical plan for each project. Recommend monitoring and control process.*

The previous phase identified only one strategy i.e. only one project, which was small (one year). Before implementing this project, a set of interviews were conducted with a cross section of employees to capture the initial situation of the Company (this was already done in during assessment phase). This project (IT-PMS implementation) was planned to be implemented in four months, immediately after which another set of interviews would be made. Balanced Scorecard was decided to be the appropriate framework for deploying performance measures. Finally, the implemented system would be monitored for six months

after which another set of interviews would be conducted to find the impact of IT-PMS on management and business.

6.4.1.3 Actual Implementation of IT-PMS

Deploying Performance Measures and Data Capturing

A fully customised web site was designed for the operational site (at SLC) using Html, Java Script, VB Script, CGI Script, NWA Quality Analyst Web Server and Internet Information Server (IIS). As shown in Figure 6.7, the left pane includes a tree structure, which can be modelled to adapt any performance measurement framework. In this Company Balanced Scorecard was used as the performance measurement framework, although the Company initially decided to use only internal perspective (operational site) of the Balanced Scorecard and hence all other perspectives are deactivated.

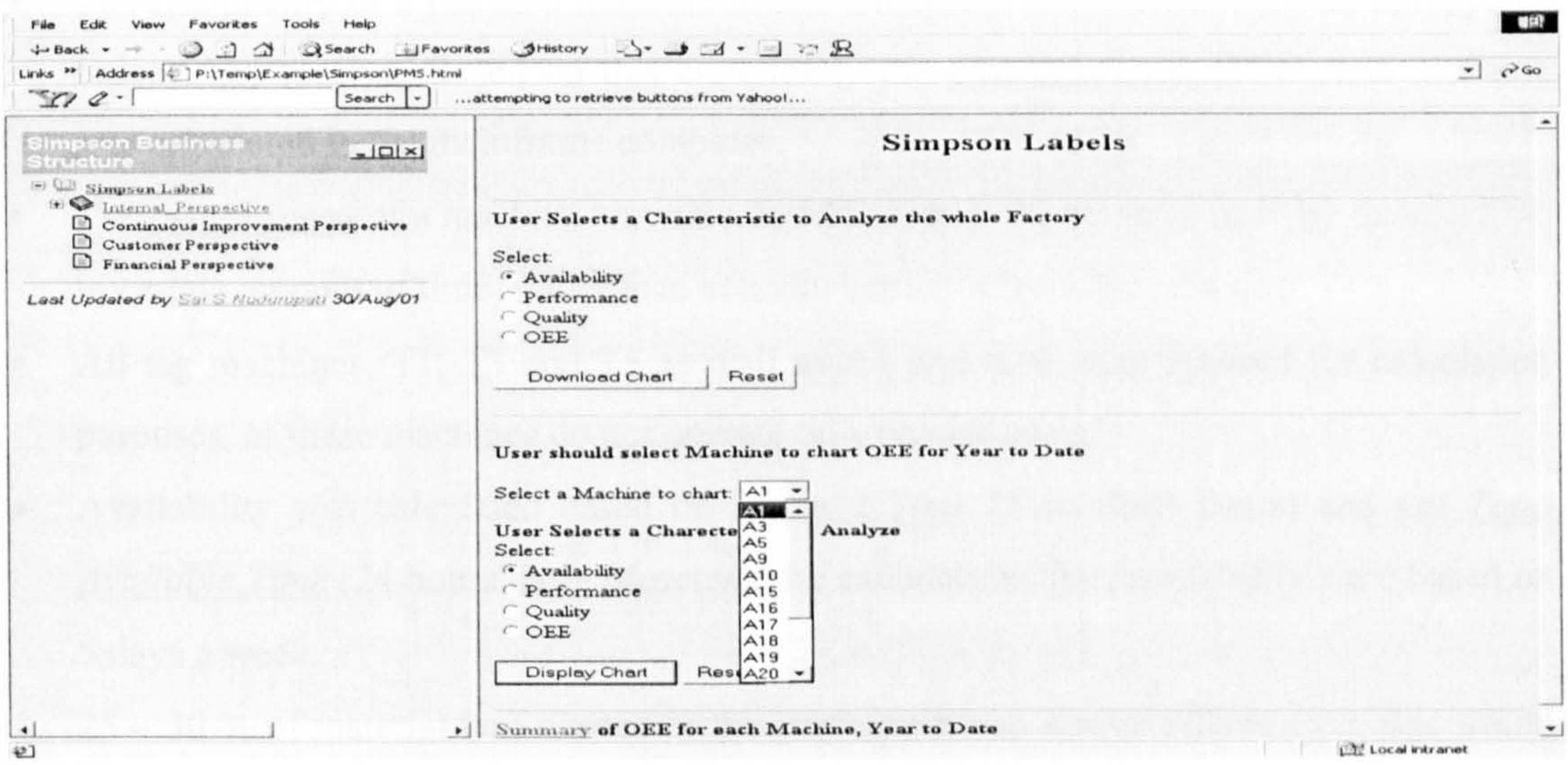


Figure 6.7 Web page displayed on the Intranet of SLC.

From the objectives of the operational site of the Company, the steering committee decided the performance measures (improvement measures) to be *Availability, Performance, Quality and Overall Equipment Effectiveness (OEE) for* each machine, whole factory on daily basis and weekly basis. The other measures (control measures) were, different types of down times such as Clear Time, Machine Break Down Time, Operator's Waiting Time etc. All these measures mentioned are shown in the right pane in Figure 6.7. Depending on the perspective or hierarchical level in left pane, corresponding measures are shown in right pane. It was almost simulating a Windows Explorer, which we generally use in Windows operating system.

The data source for the above measures was a mainframe computer connected to a data capturing system called Shuttle Worth System. This raw data was available for every computer, which was connected to the Intranet existing within the Company. However, due to the limitations of analytical and charting capabilities of this mainframe computer, the steering committee had decided to transfer data into Microsoft Access database, from which different calculations and analysis are performed.

Data Analysis (Calculations)

All the calculations in this section were carried out in several queries facilitated by MS Access.

Assumptions

- The complexity of a job on a machine in this Company varies depending on the type of orders they receive. Based on this complexity the *theoretical speed* for each machine was calculated in the mainframe computer.
- The *actual speed* of a machine was calculated based on the material used by the machine in certain amount of time, rather than actually getting it from the machine
- All tag machines, T1, T3 and T5 as well as A1 and A16 were ignored for calculation purposes, as these machines do not operate on a regular basis
- Availability was calculated based on *Planned Time* (Two Shift Basis) and *not Total Available Time* (24 hours day). Moreover the calculations for Availability were based on 5 days a week.
- 25 – 30 % of material was wasted in the start up (due to torque effects etc.), this would be reflected in poor *Quality* figures.
- There was one more complexity in calculating *Quality* figure. Occasionally, the material gets booked at one machine on a particular day and delivers the output next day and hence there will be a poor quality figure on one day and a very good figure on the other. This problem was eliminated by doing the calculations on a weekly basis. (For this reason the Company decided not to use Daily basis)

Availability, Performance, Quality and OEE were calculated for each machine

$$OEE = (Availability) * (Performance) * (Quality)$$

$$\textit{Availability} = \frac{(\text{Total Run Time}) + (\text{Set Up Time})}{(\text{Total Planned Time})}$$

Total Run Time: It is the actual time, when the job is running on a machine in Hours

Set Up Time: It is the actual time, when the machine is stopped for set up in Hours

Total Planned Time: It is the time, when the machine is planned to do the jobs in Hours

The Machines on Single shift basis were: A3, A5 and A9 (Hence planned time was 7.5 hrs per day for each machine)

The Machines on Two shift basis were: A10, A15, A17, A18, A19, A20, A21 and A22. (Hence planned time was 15 hrs per day for each machine)

$$\textit{Performance} = \frac{(\text{Actual Speed})}{(\text{Theoretical Speed})}$$

$$\text{where, Actual Speed} = \frac{(\text{Total Input})}{(\text{Total Productive Hours})}$$

Total Input: Total input going into the machines in Metres

Total Productive Hours: It is the actual time, when the job is running on a machine in Hours

Theoretical Speed: It is the maximum speed with which the machines are recommended to work (It comes from a separate table) in Meters/Hours

$$\textit{Quality} = \frac{(\text{Total Good Output})}{(\text{Total Input})}$$

Total Good Output: Total productive output coming out from machine, which can be delivered to the customer in Metres

Total Input: Total input going into the machines in Metres

Weekly Basis

Availability, Performance, Quality and OEE calculated for the whole factory

- The same calculations for OEE apply here as well.
- The total planned availability time for the whole factory was equal to the sum of individual planned availability time for each machine, i.e. in this case was 142.5 hours for each day and 712.5 hours for week.

- Performance for each job was calculated first and then an average value was obtained for all the jobs in the whole week.
- Quality for each job was calculated first and then an average value was obtained for all jobs in the whole week.

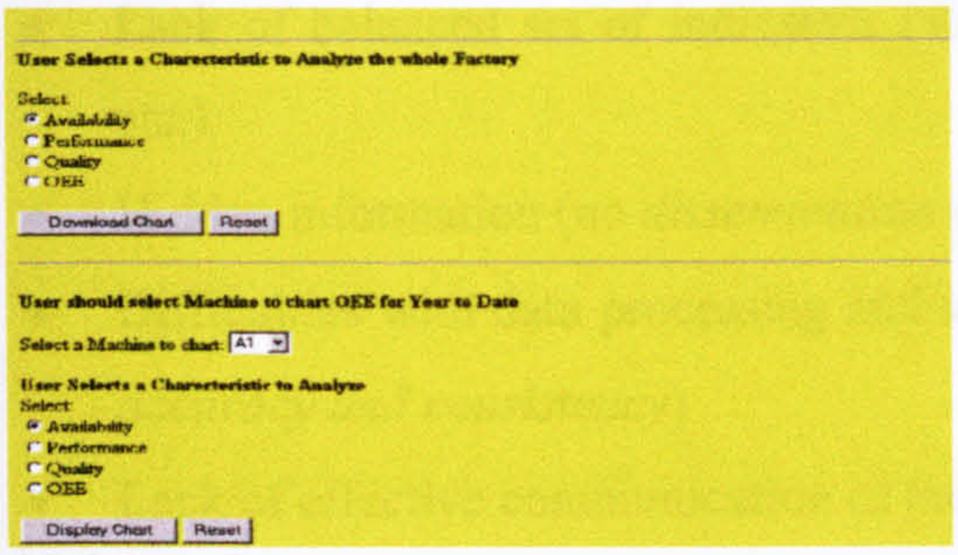
Availability, Performance, Quality and OEE calculated for each machine

- The same calculations for OEE apply here.
- The total planned availability time for each machine will come from a table based on its shift basis (whether it is single shifted or double shifted) i.e. in this case it would be 15 hours (two shift) and 7.5 hours (single shift) for each machine per day and 75 hours (two shift) and 37.5 hours (single shift) for each machine per week.
- Performance for each job on each machine was calculated in a week first and then an average value was obtained for all the jobs on that machine for the whole week.
- Quality for each job on each machine was calculated in a week first and then an average value was obtained for all jobs on that machine for the whole week.

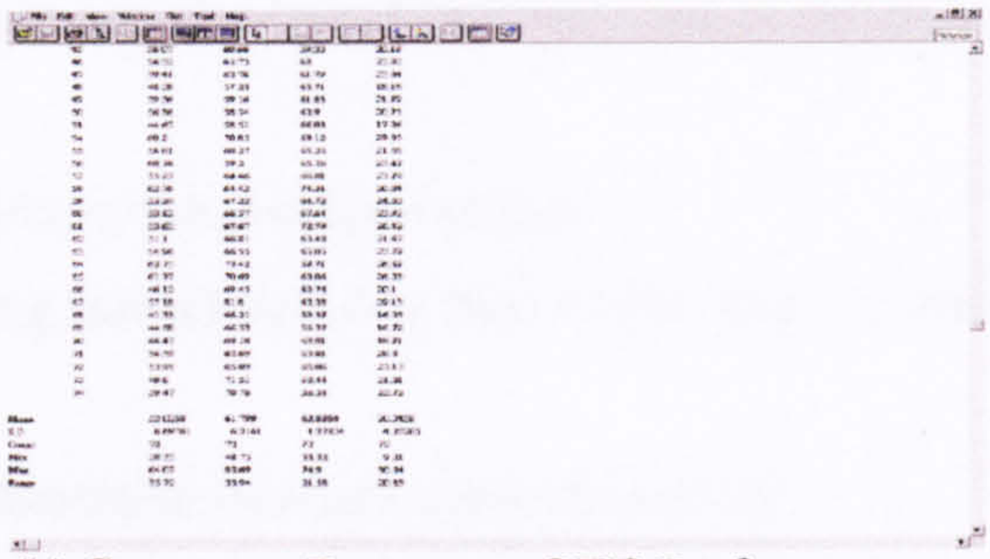
Reporting and Communication

As mentioned in the above sections, the same IT technologies (Html, Java Script, VB Script, CGI Script, NWA Quality Analyst Web Server and Internet Information Server) were used in reporting and communicating information as Normal Charts, Statistical Charts and Summary Reports. These reports and charts (information) were communicated to different people through the Intranet within the Company.

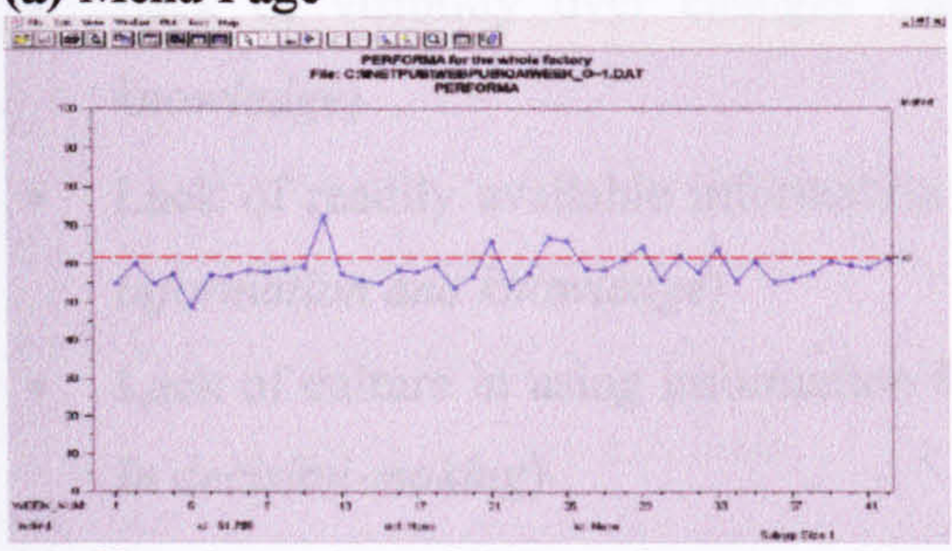
The information was dynamically available to the users. This was made possible with NWA QAWS Run file technology. Once the user selects an option and clicks a button on the web page as shown in Figure 6.8a the software platform automatically connects to the MS Access database and gets that information in the form of normal charts, statistical quality control charts as shown in Figures 6.8c and 6.8d as well as summary reports as shown in Figure 6.8b, which includes summary characteristics at the end of the report such as Mean, Standard Deviation, Best Value, Poor Value, etc.



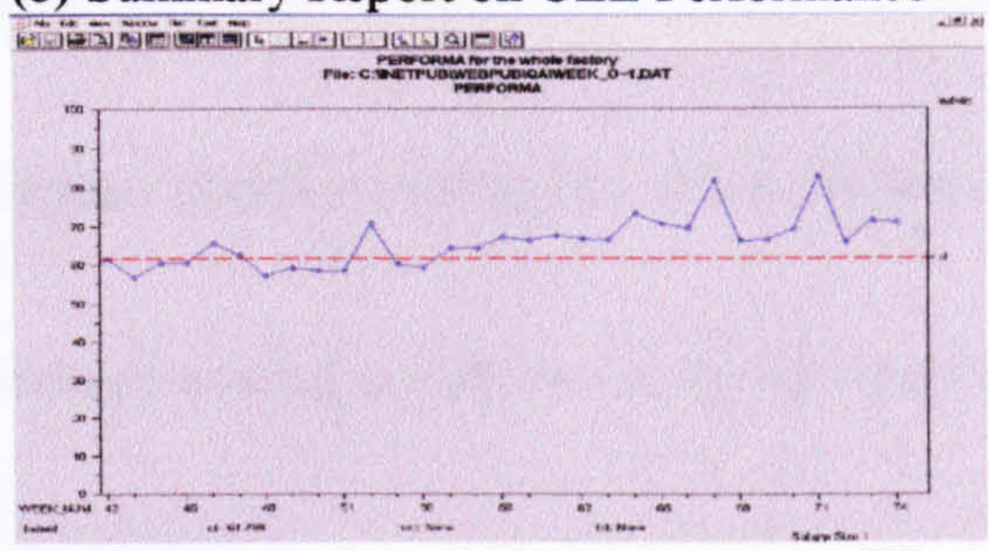
(a) Menu Page



(b) Summary Report on OEE Performance



(c) Shewhart chart OEE Performance (Week 1 to Week 42)



(d) Shewhart chart OEE Performance (Week 42 to Week 74 (next Year)

Figure 6.8: Sample pages available on the Intranet of SLC.

The examples of performance reports shown in Figure 6.8 are the OEE performance measures for the whole factory on a daily basis. The system provided the capability to drill down OEE (including availability, performance and quality) as follows for:

- each machine on daily basis and weekly basis (there were 11 key machines in the Company)
- the whole factory on daily basis and weekly basis
- different types of down times on daily and weekly basis.

It was the machine level information, which was being used to drive continuous improvement within manufacturing operations of this business.

6.4.1.4 Impact of IT-PMS on Management

6.4.1.4.1 Action Case Results

Summary of Personal Observation

Before IT-PMS was implemented at SLC:

- Managing director, operations manager, IT manager were committed to the project (there was *senior management commitment but no drive*)

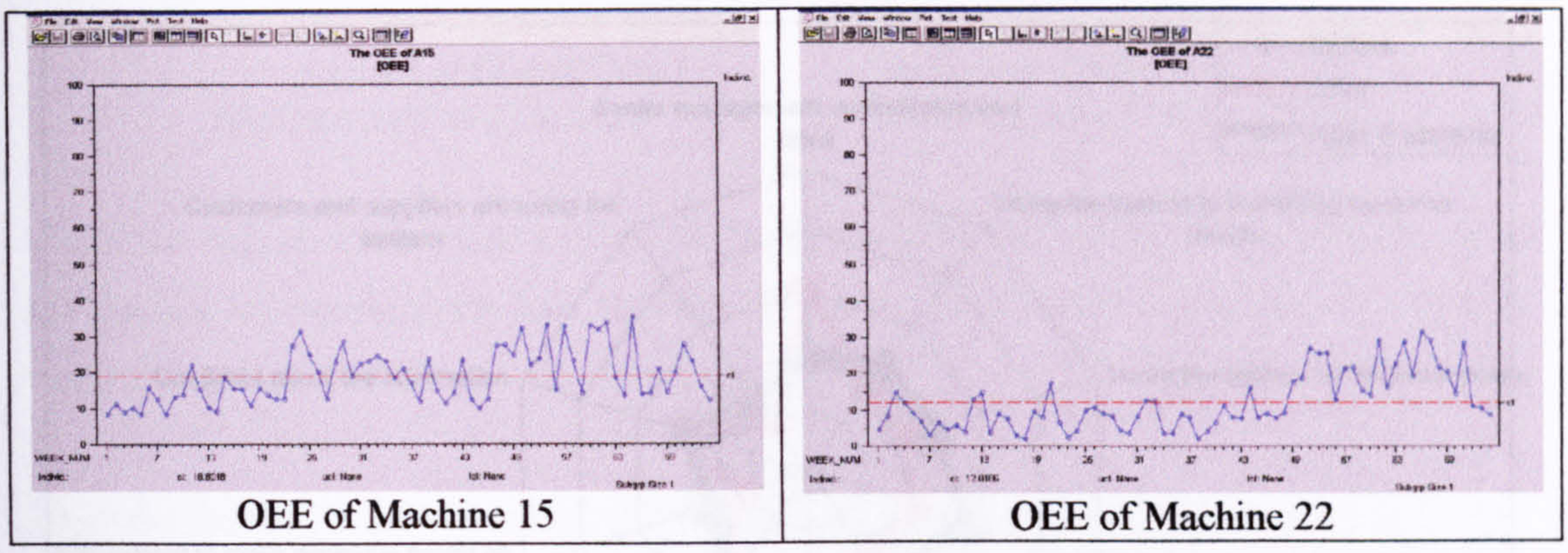
- Lack of balanced set of indicators (such as customer measures, operational measures, etc.)
- Hidden information (no *dissemination of information and knowledge*)
- Difficulties with data processing and sorting information in a meaningful way (no *data accuracy and consistency*)
- Lack of effective communication of the information (no *open communication*)
- Lack of visibility over changes and trends (no *dissemination of information and knowledge*)
- Lack of readily available information to support decision-making (no *dissemination of information and knowledge*)
- Lack of culture in using information for decision-making (*people not using information in decision-making*)

During and immediately after implementing IT-PMS in the Company, it was made available to all managers and some team leaders in the Company. However, the following observations were made by the researcher:

- The system was implemented for only operational activities of the Company. Hence the measures were based on operational activities, which did not draw any attention from the marketing manager, finance manager and managing director.
- The information was made available only to five managers and three team leaders in the Company, which limited its use by many people within the operational site of the Company (*up-to-date information and access* was provided for only management).
- Changes and trends occurring were visible for all the managers (there was evidence for *dissemination of information and knowledge*).
- There was some reduction in time for data analysis and data communication but this was not significant (*reduction in time and effort* to some extent)
- Most of the people were not knowledgeable enough to use IT-PMS (*not simple and easy to use*)
- Although the operations manager was very committed to IT-PMS, there was no drive from him (there was *commitment from senior management* but no *drive* from them).
- There was still lack of culture in people using information for decision making (*people were not using information in decision-making*).

For the next 3-4 months, the operations manager with the help of the TCS Associate took the drive into his hands in using the information from IT-PMS and driven the continuous improvement teams to use the information to improve the performance on certain machines. However after six months of implementation

- The implementation team identified that there were some flaws in the data capturing system on the shop floor. Some of these were:
  - There were some machines with single shift basis running double shifts occasionally. But the Availability calculations were based on single shift basis and hence the results were invalid occasionally during these incidents.
  - Few double shift based machines were running overtime occasionally, i.e. more than 15 hours. But the calculations were based on double shift basis and hence the results were invalid occasionally during these incidents.
  - Double shift machines run 7.5 hrs each in shift 1 and shift 2. However for two or three machines, the raw data it actually worked in a day (planned 15 hrs) was entered in either shift 1 or shift 2, which was very inconsistent during calculations.
  - The actual speed of machines generally varies based on the complexity of job. Hence when performance was calculated against a standard theoretical speed, the final figures were inconsistent and not useful.
- Due to the above discrepancies the final results reported on the Intranet in the form of charts showed a lot of variability in OEE every week as shown in Figure 6.9 (problems with *data accuracy and consistency*).
- This made all the senior managers, including operations manager lose their confidence in IT-PMS (*lost commitment and drive from senior management*).
- Hence as a whole, the Company did not use IT-PMS any further after six months of its implementation (*people stopped using IT-PMS*).
- IT-PMS was suspended until the data capturing system would be replaced.
- IT-PMS made much less (no) impact on transparency and visibility of information, identifying the weaknesses of the operational processes, continuous improvement of operational processes, pro-active decision-making and positive behaviour of people.



OEE of Machine 15

OEE of Machine 22

Figure 6.9: Variability in OEE

Summary of Interviews

The weightings obtained in the interviews are summarised into table as shown in Appendix D. This data is classified as data on technical factors, people factors as well as management and business implications as shown in Figures 6.10, 6.11 and 6.12 respectively.

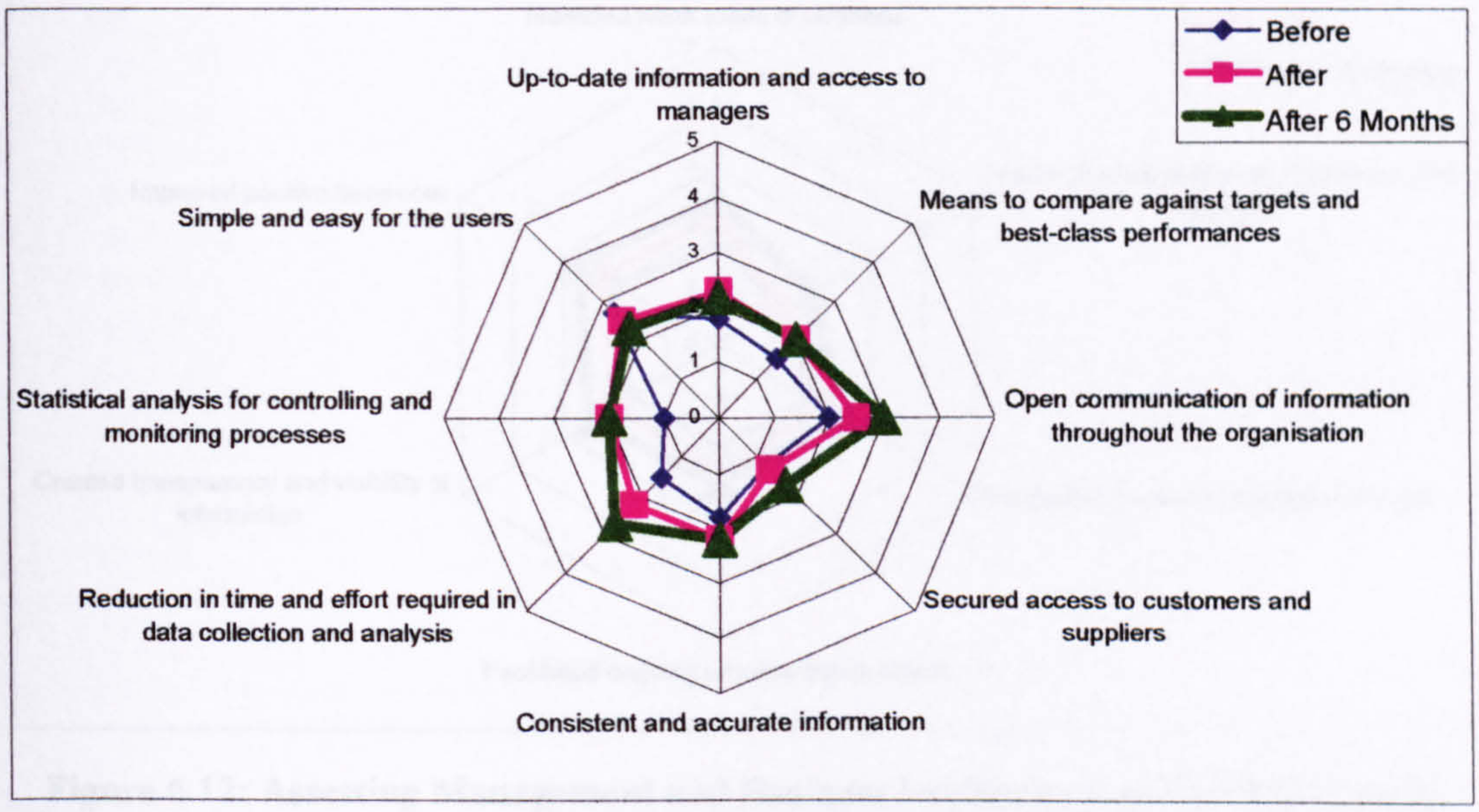


Figure 6.10: Assessing Technical Factors of IT-PMS: before, after and after 6 months of implementation

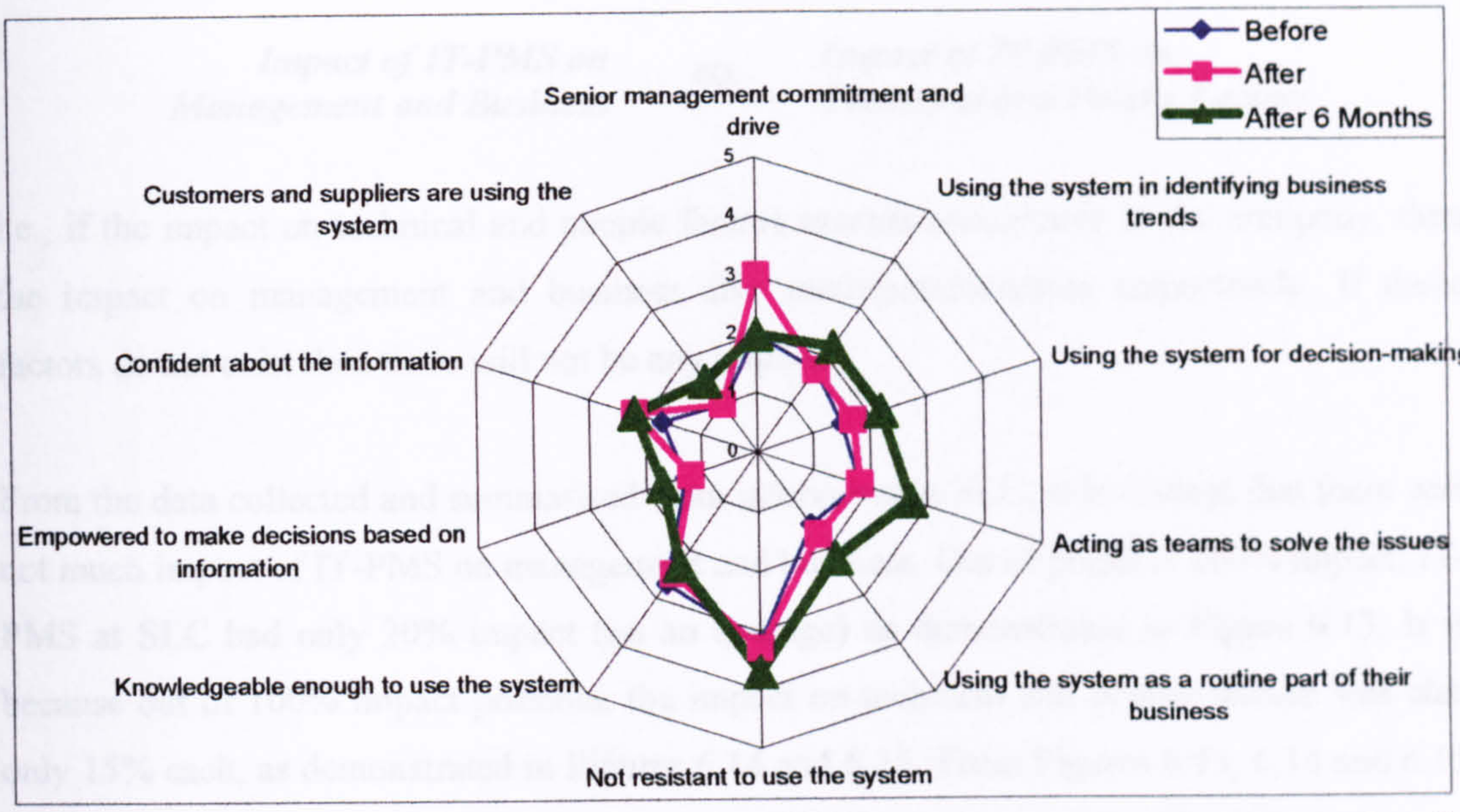


Figure 6.11: Assessing People Factors of IT-PMS: before, after and after 6 months of implementation

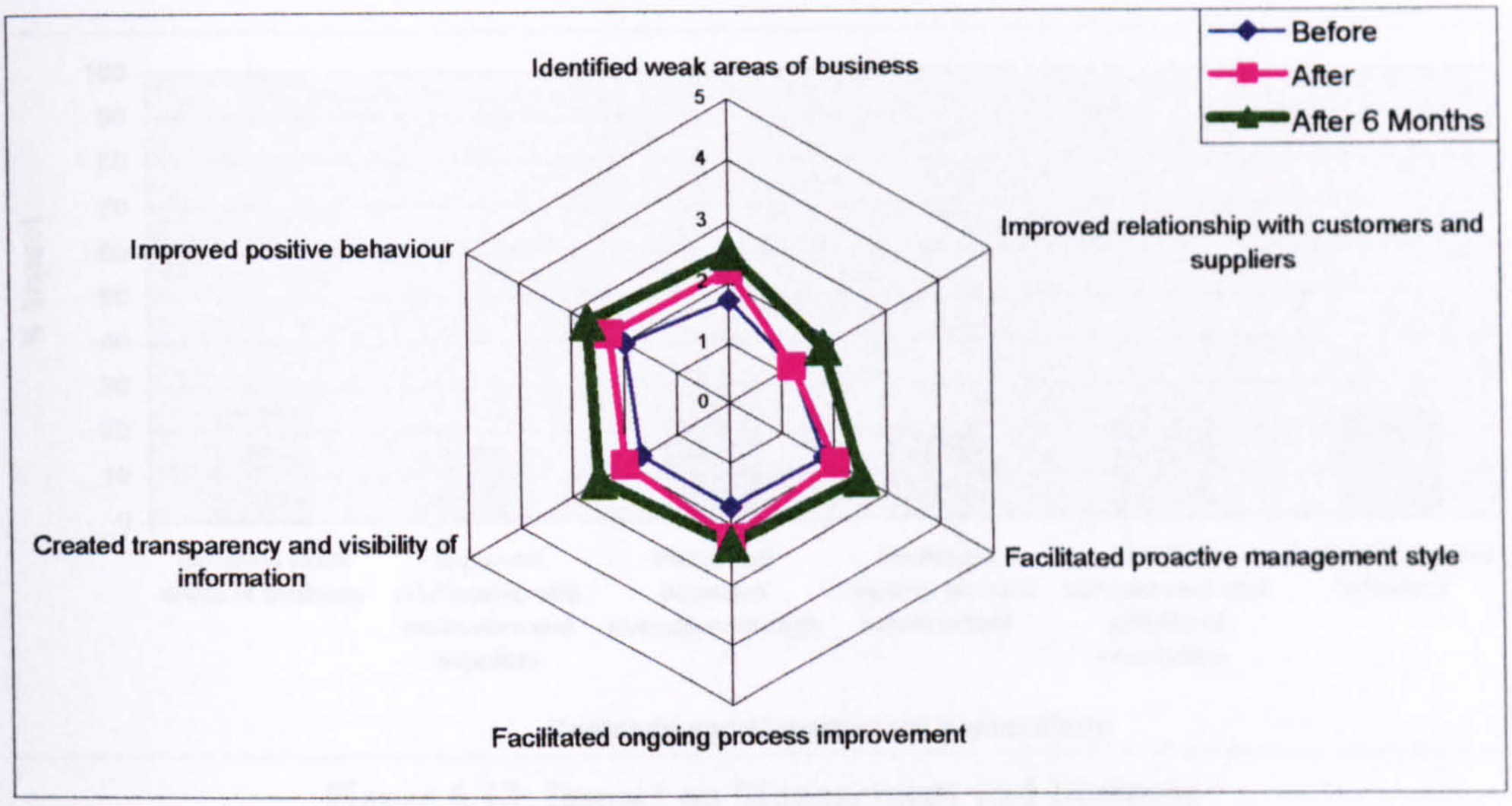


Figure 6.12: Assessing Management and Business Implications of IT-PMS: before, after and after 6 months of implementation

6.4.1.4.2 Testing Predictions

As mentioned in Chapter 3, according to the predictions and pre-conditions, IT-PMS will have significant impact on management and business, if the impact on technical and people factors identified in Chapter 3 is significant in the Company. As a result of implementing IT-PMS in a company, the test is that the impact on management and business implications is proportional to the impact on technical and people factors

$$\textit{Impact of IT-PMS on Management and Business} \quad \propto \quad \textit{Impact of IT-PMS on Technical and People Factors}$$

i.e., if the impact on technical and people factors increases/decreases in the company, then the impact on management and business also increases/decreases respectively. If these factors do not exist then there will not be any impact.

From the data collected and summarised from interviews at SLC, it is evident that there was not much impact of IT-PMS on management and business. Out of possible 100% impact, IT-PMS at SLC had only 20% impact (on an average) as demonstrated in Figure 6.13. It is because out of 100% impact possible, the impact on technical and people factors was also only 15% each, as demonstrated in Figures 6.14 and 6.15. From Figures 6.13, 6.14 and 6.15 it is evident that the impact on management and business is proportional to the impact on technical and people factors.

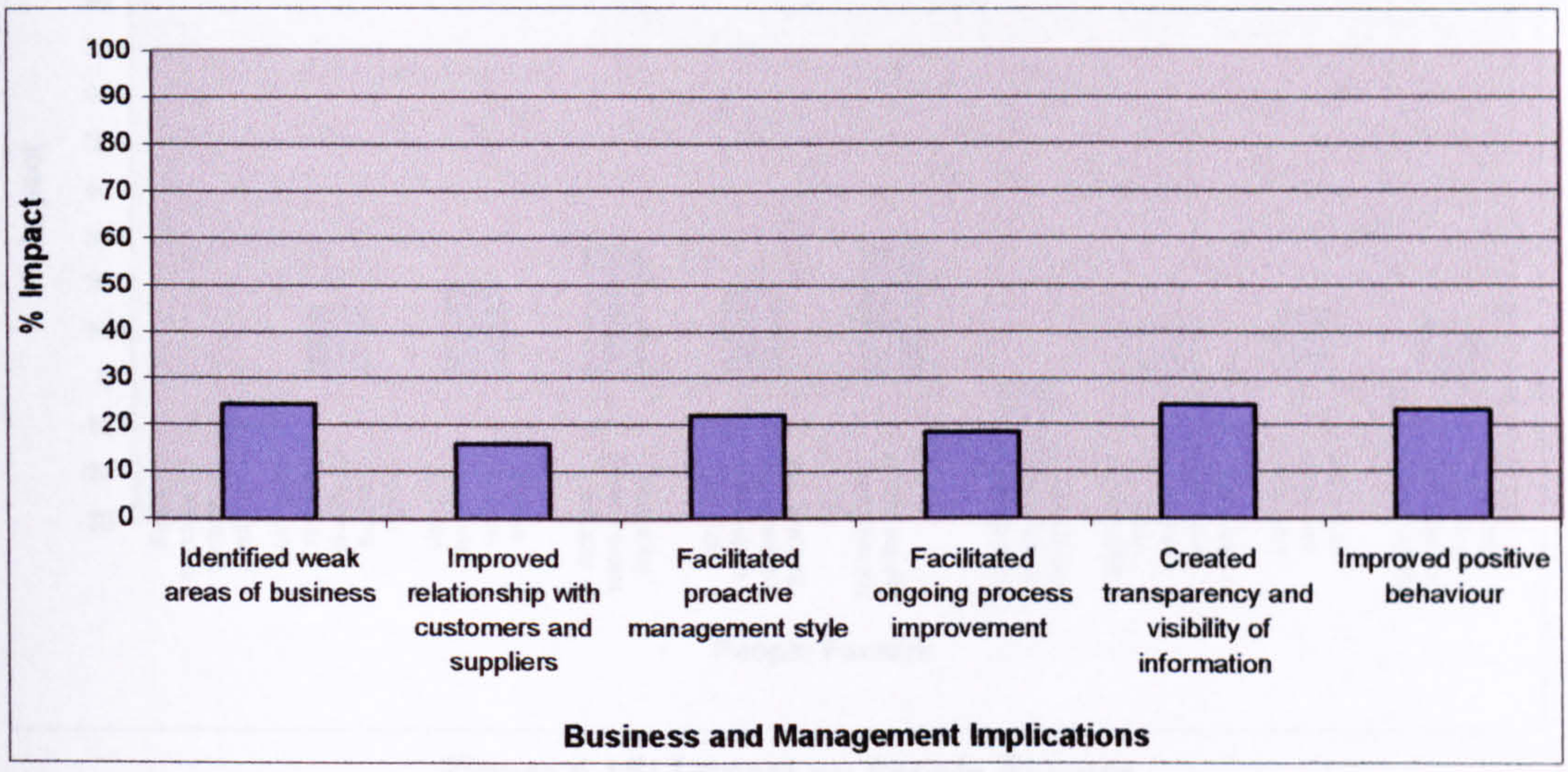


Figure 6.13: Impact on Management and Business

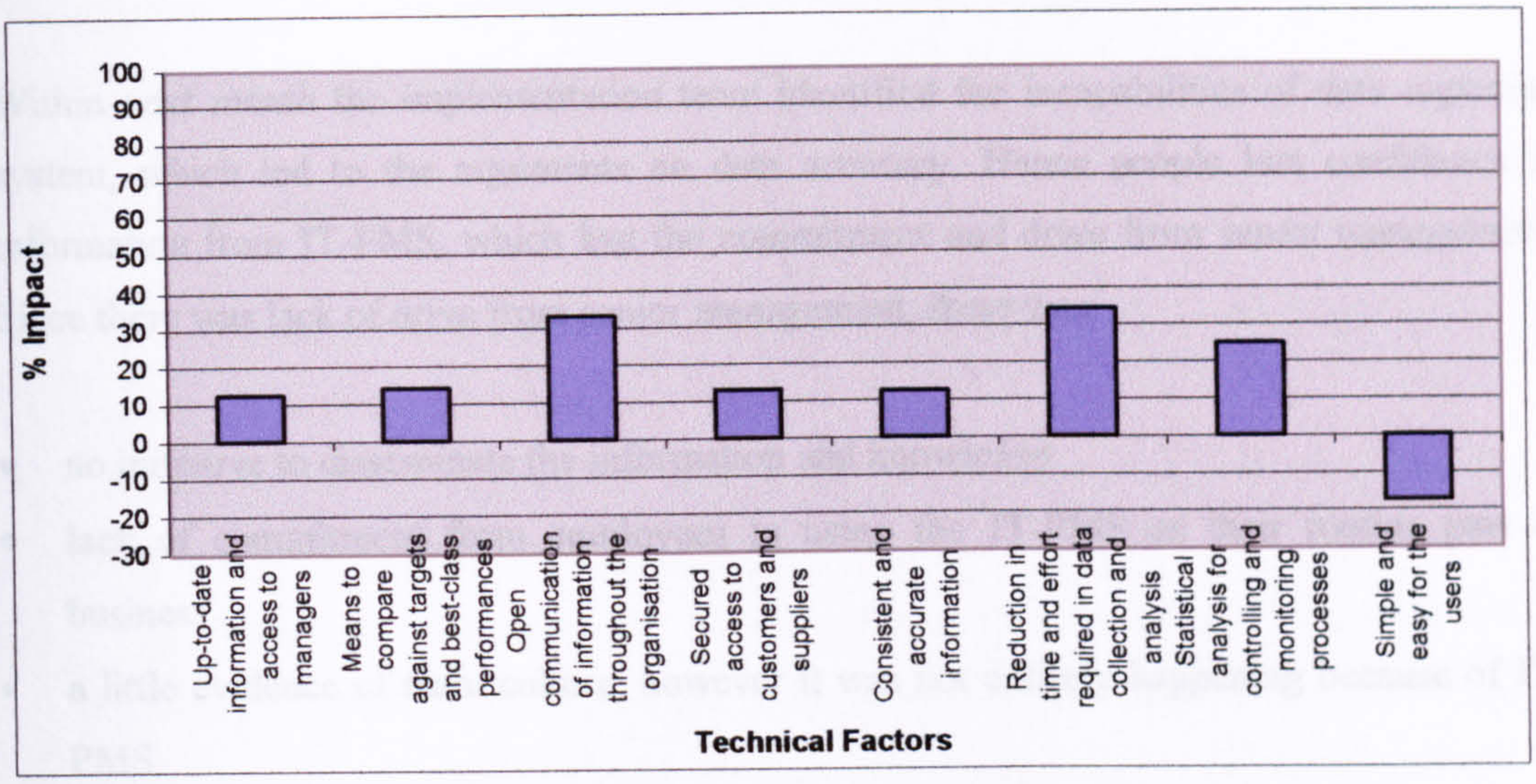


Figure 6.14: Impact on Technical Factors

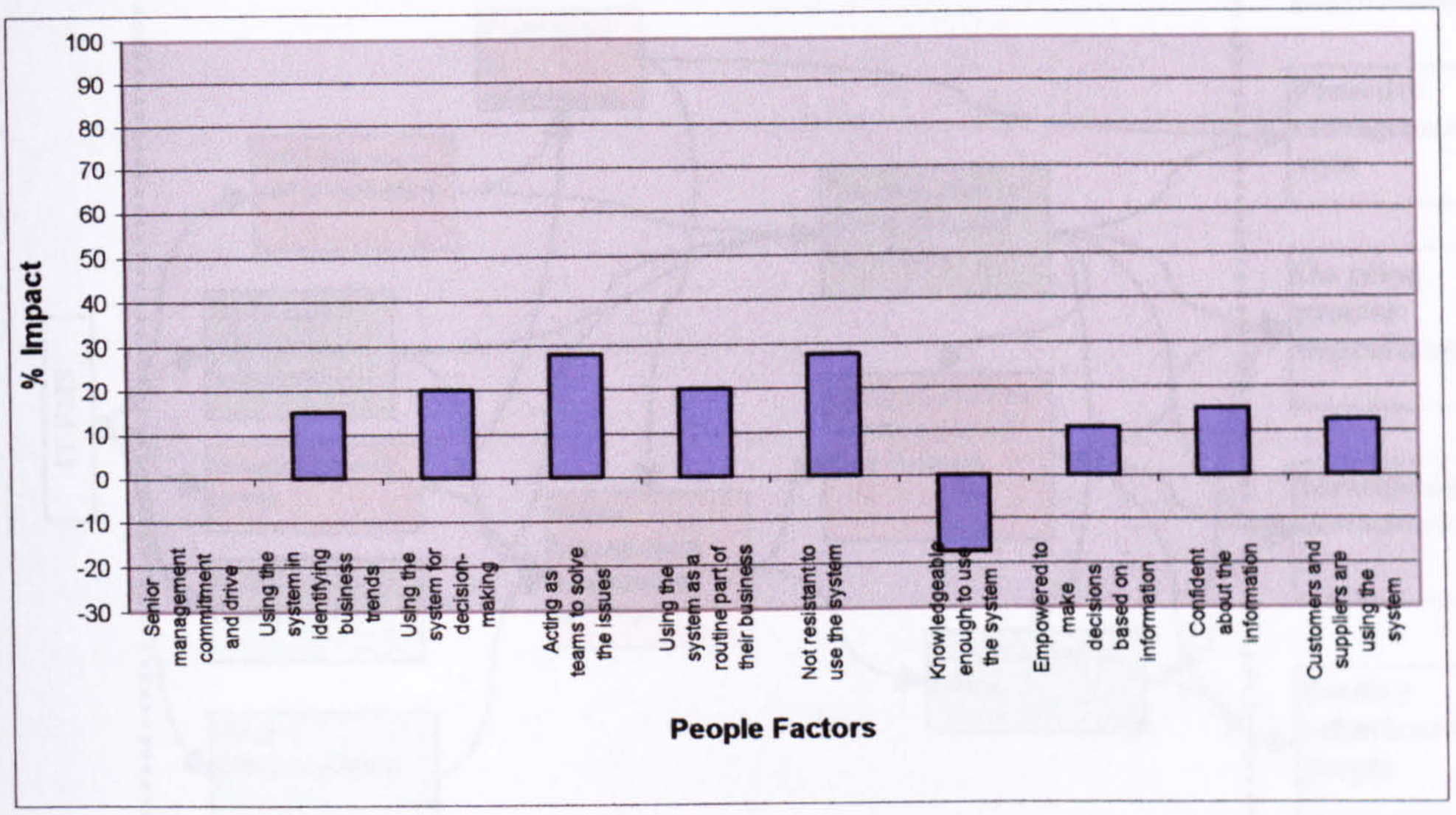


Figure 6.15: Impact on People Factors

6.4.1.4.3 Structuring the relationship between Factors and Implications

From the beacon of bearings, i.e., IT-PMS implementation as shown in Figure 6.16, the immediate factors, which evolved at SLC, were:

- presentation of up-to-date information and access to the people
- communication of information
- reduction in time and effort to do the data collection, analysis and communication
- information was *not* simple and easy to the users at SLC

Within next month the implementation team identified the incapabilities of data capturing system, which led to the arguments on data accuracy. Hence people lost confidence in information from IT-PMS, which lost the commitment and drive from senior management. Since there was lack of drive from senior management, there was:

- no initiative to disseminate the information and knowledge
- lack of commitment from employees in using the IT-PMS as their routine part of business
- a little evidence of team culture, however it was not entirely happening because of IT-PMS

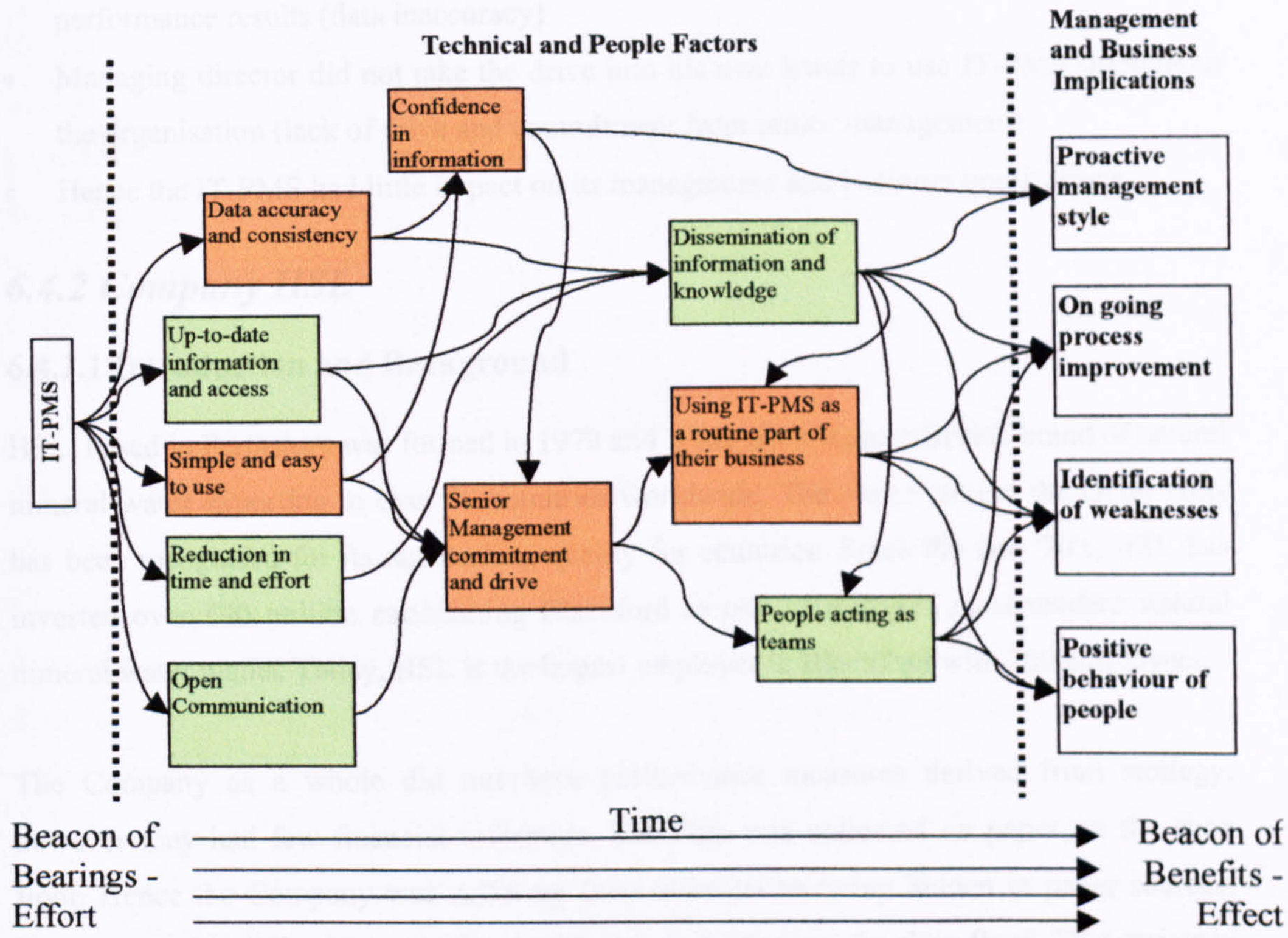


Figure 6.16: Structuring the relationships between technical and people factors as well as management and business implications

All these factors (technical and people factors) led towards beacon of benefits, i.e. implications on management and business as shown in Figure 6.16. However, since most of the factors evolved have negative[1] or little impact on one another, the final impact on

[1] Negative factors are shown in brown colour in Figure 6.15. All the rest are positive.

management and business (benefits) was also little. After six months, this was reflected with little impact on the four implications.

6.4.1.4.4 Conclusion

- The nature of SLC business was discrete manufacturing and hence OEE was not the best measure for it (improper measures)
- IT-PMS system was implemented only for the operational activities of the Company (not holistic approach throughout the business)
- The performance information was not communicated to everyone in the organisation, especially for team leaders and people on the shop floor (lack of proper communication)
- Managing director could not build confidence in the system due to discrepancies in the performance results (data inaccuracy)
- Managing director did not take the drive into his own hands to use IT-PMS throughout the organisation (lack of drive and commitment from senior management)
- Hence the IT-PMS had little impact on its management and business implications

6.4.2 Company HSL

6.4.2.1 Introduction and Background

HSL, based in Perthshire was formed in 1979 and is the UK's biggest British brand of natural mineral water exporting to over 50 countries worldwide. The water around the Ochil Hills has been recognised for its outstanding quality for centuries. Since the late '70's, HSL has invested over £40 million establishing Blackford as one of Europe's most modern natural mineral water plants. Today, HSL is the largest employer in Blackford with 200 employees.

The Company as a whole did not have performance measures derived from strategy, however they had few financial indicators. The data was collected on paper on the shop floor. Hence the Company was suffering from information being hidden in paper sources. There were also difficulties associated with data collection on the shop floor. This seriously limited access potentially, to a very useful data. Information was not communicated to the right people. This resulted in lack of visibility over changes and trends. Although the Company had an intranet, it communicated the financial data and static web pages. It did not include performance analysis, dynamic charts or reports. Generally people did not do performance analysis of the data collected on the shop floor.

The researcher presented his work with *AFE* (Pilot Case) to the management team in HSL, who decided to adopt and implement IT-PMS. Since the Company already had financial measures in place the management team wanted to deploy leading indicators (which directly effect their financial measures) and decided Overall Equipment Effectiveness (OEE), first hour efficiency, cost per case, down times, change over times, waste, etc. in the factory. HSL used Integrated Performance Measurement System (IPMS) for deploying these measures for the business.

6.4.2.2 Implementation Plan for IT-PMS

Orientation Phase: *Defining the scope of the business for implementing IT-PMS and methodologies used to find the impact of IT-PMS on management and business.*

The reason the Company decided to implement IT-PMS was to promote continuous improvement as a part of TCS programme. There is evidence in literature and consultancy projects that performance measurement enhances continuous improvement. Performance measurement and continuous improvement are complementary projects to each other. Initially, a ***Steering Committee*** was established in the Company for planning IT-PMS in the Company. It consisted of Wyllie Woodburn (Operations Director), David Watson (Projects Manager), Daniel Muir (IT Development Manager), Evangelos Charalampous (TCS Associate), Colin Brown (TCS Associate), Sai Nudurupati (Action Researcher), Umit Bititci (External Advisor) and Peter Ball (External Advisor). An ***Implementation Committee*** was established for implementing IT-PMS in the Company. It consisted of Evangelos Charalampous (TCS Associate), Colin Brown (TCS Associate), and Bryan McClusky (IT Developer). As a part of the TCS programme, the Steering Committee identified to improve their effectiveness in the whole factory. Hence the committee decided the scope to implement IT-PMS was for the whole Company.

The committee decided to use personal observations and a set of interviews for assessing the impact of IT-PMS on management and business. The overall time for this project was decided to be one year.

Assessment Phase: *Establish business direction (operational site) and drivers and find its impact on IT-PMS. Establish a view of benefits of IT-PMS for the management and business. Outline the future requirements for the business (as a whole) in terms of IT-PMS. Establish a*

brief description of current IT resources used in the company. Finally establish a gap between what is desired and what is required by the company.

The business direction for the Company was to promote continuous improvement in the operational site. If it does not happen with in the planned time, the IT-PMS project would terminate in the Company. The anticipated list of benefits in implementing IT-PMS was given in Chapter 3 (as predictions and pre-conditions). The list was developed from both pilot cases and literature review of action researcher. Most of the IT resources used by the Company were Intercept-NT, Exportmaster, Cognos Impromptu & Powerplay, Zetafax, Oracle 7 Workgroup Server, Oracle Programmer/2000, Oracle SQL*Plus, etc. In spite of all these software, still certain data was collected on paper, the performance related information required to promote continuous improvement was not available in real-time. Hence the *gap* identified was that performance measurement related information (such as information on availability, performance, quality, down times, OEE of each machine and the whole factory) was not available to right people (at different levels of organisation) in the right time (in near real-time) in right format (such trend charts, Pareto analysis, reports, etc.) in the Company to promote continuous improvement.

Strategic Phase: *Establish vision for the company in terms of IT-PMS. Conduct an optional analysis with different alternative solutions for the company. Finally develop a strategy by justifying it.*

The vision for the Company was to automate the IT systems from data capturing to the data reporting and communication to different set of audience in different formats in (near) real time, which promotes continuous improvement. For data collection, data analysis, reporting and communicating the steering committee used the software review done by Nudurupati et al (2000). For complete elimination of paper based data capturing, HSL purchased SCADA Server, an automated data capturing system.

The steering committee decided to use Oracle 7 Workgroup Server, Programmer/2000, SQL*Plus, Cognos Impromptu & Powerplay, etc., which were already existing in the Company for data collection, analysis, charting, reporting and communicating information as shown in Figure 6.17

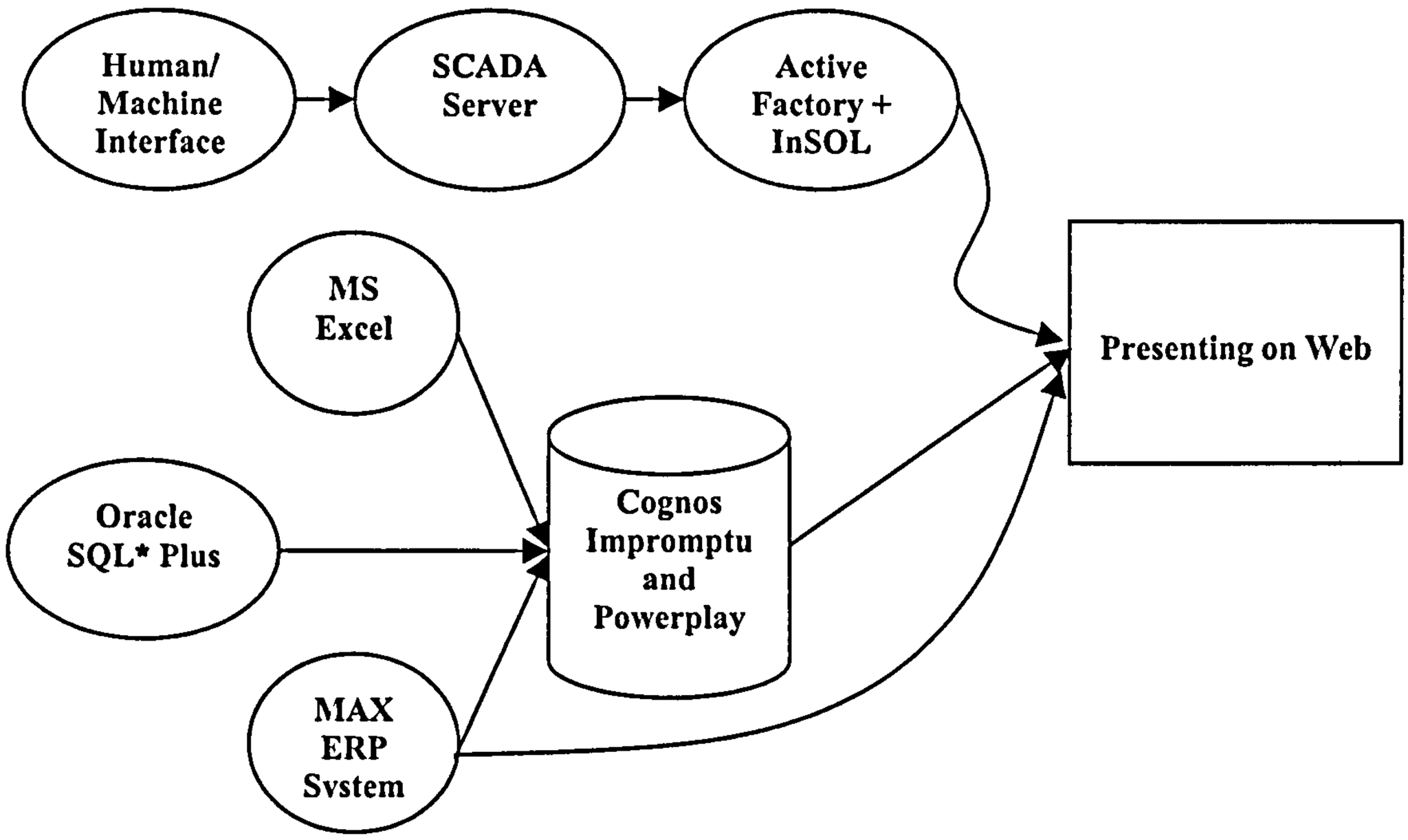


Figure 6.17: Architecture of the IT-PMS at HSL.

Tactical Phase: *Identify and specify all the projects required to implement each strategy, prioritise these projects. Develop a tactical plan for each project. Recommend monitoring and control process.*

The previous phase identified only one strategy i.e. only one project, planned for two years. Before implementing this project, a set of interviews were conducted with a cross section of employees to capture the initial situation of the Company (this was already done in during assessment phase). This project (IT-PMS implementation) was planned to be implemented in four months, immediately after which another set of interviews would be made. IPMS was decided to be the appropriate framework for deploying performance measures. Finally, the implemented system would be monitored for six months after which another set of interviews would be conducted to find the impact of IT-PMS on management and business.

6.4.2.3 Actual Implementation of IT-PMS

Deploying Performance Measures and Data Capturing

A fully customised web site was designed for HSL using Html, VB Script, CGI Script, Active Server Pages (ASP) and Internet Information Server (IIS). A sample web page is shown in Figure 6.18, where the users can filter data according to machine, operator, faults,

dates, etc. to see the down time. Similarly, there are other pages available for different measures. The users have to browse through these pages to go through different measures. The committee did not implement a single web page, which displays hierarchy of the business structure and the corresponding measures as implemented at other three companies. At HSL IPMS reference model was used as the performance measurement framework to identify the appropriate measures from their strategy.

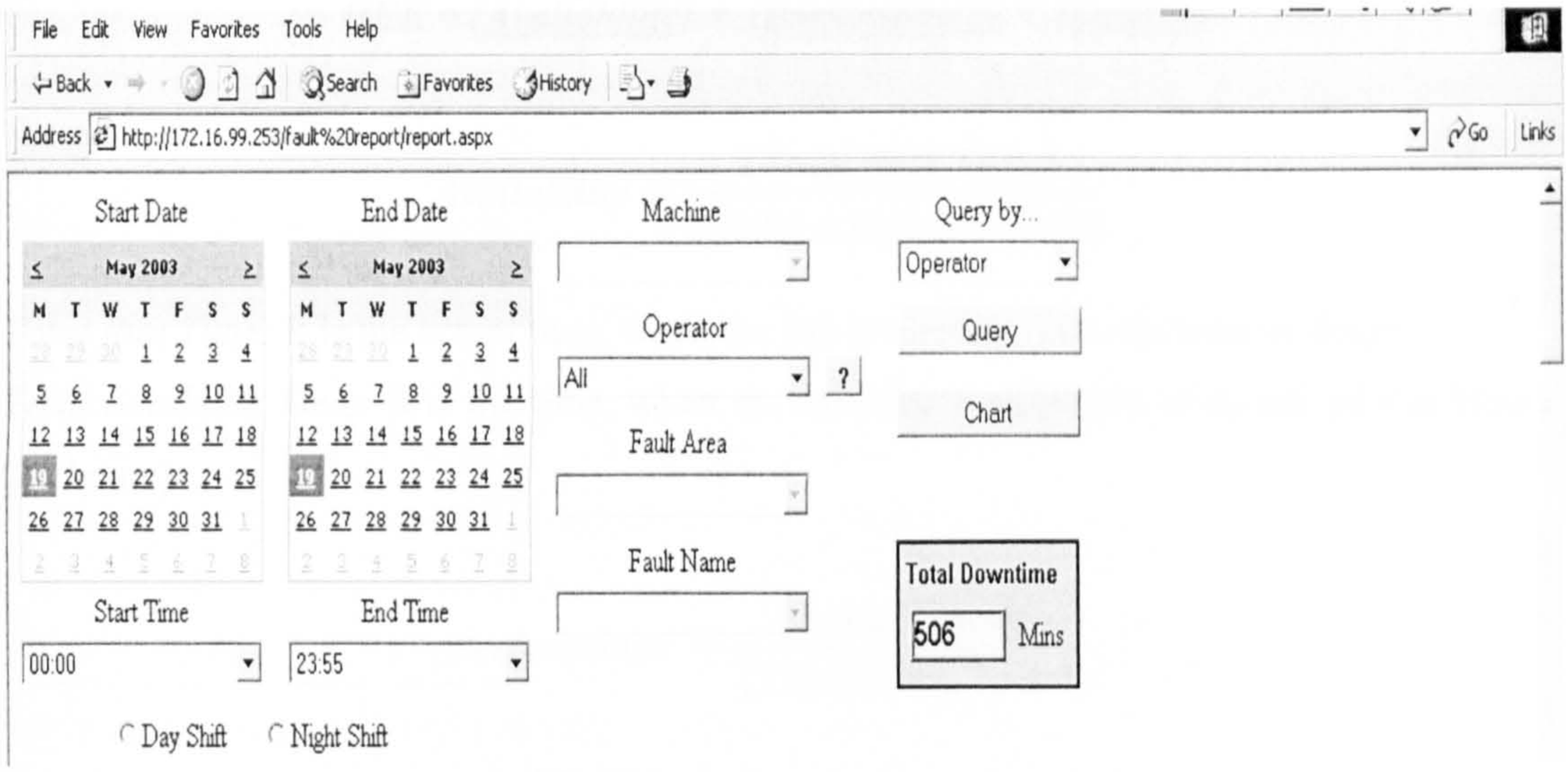


Figure 6.18: Sample web page displayed on the Intranet of HSL

From the objectives of the Company, the steering committee decided the performance measures as shown in Table 6.1 including their data sources. The measures were divided into four perspectives. And the data for these measures exist in different sources (databases), most of which has the capability of directly publishing information on the Intranet of the Company.

Table 6.1 Measures and their data sources at HSL

Dimension	Measure	Data source
(1) Effectiveness	(1) Overall Equipment Efficiency	SCADA system
	(2) First hour efficiency	SCADA system
	(3) Cost per case	ERP system
(2) Efficiency	(4) Cross-functional communication	Communication survey Observations
	(5) Effective feedback	Employee survey Observations
(3) Leaning and growth	(6) Skills shortage	Observations Performance appraisal Training records
	(7) Adoption of 'best practices'	Observations Benchmarking exercise

Data Analysis (Calculations)

All the calculations were done in the same database where the raw data was existing. OEE, Availability, Performance, Quality were calculated as follows:

$$OEE = (\underline{Availability}) * (\underline{Performance}) * (\underline{Quality})$$

$$Availability = \frac{(\text{Total Run Time})}{(\text{Total Available Time})}$$

Total Run Time: It is the actual time, when the job is running on a machine in Hours

Total Available Time: It is the time, when the machine is available to do the jobs in Hours (24 hours)

$$Performance = \frac{(\text{Actual Speed})}{(\text{Theoretical Speed})}$$

where, $\text{Actual Speed} = \frac{(\text{Total Input})}{(\text{Total Productive Hours})}$

Total Input: Total input going into the machines

Total Productive Hours: It is the actual time, when the job is running on a machine in Hours

Theoretical Speed: It is the maximum speed with which the machines are recommended to work

$$Quality = \frac{(\text{Total Good Output})}{(\text{Total Input})}$$

Total Good Output: Total productive output coming out from machine

Total Input: Total input going into the machines

$$First\ Hour\ Efficiency\ (\eta) = \frac{(\text{First Hour BPH})}{(\text{Theoretical BPH})}$$

First Hour BPH: Total number of bottles produced in the first hour

Theoretical BPH: The maximum number of bottles that can be theoretically produced in an hour

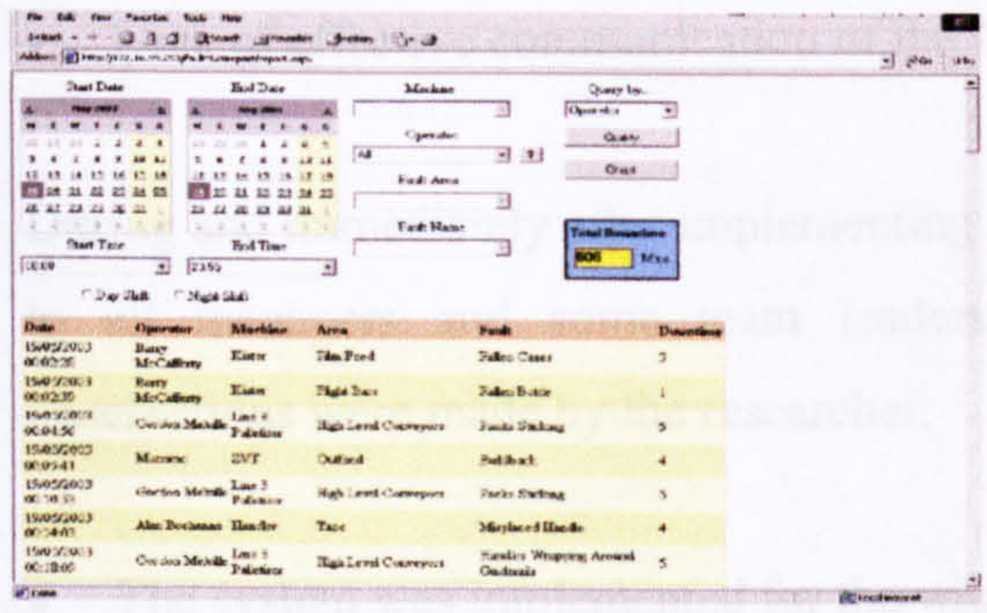
Cost/Case = (Material Cost/Case) + (Overheads/Case) + (Production Cost/Case)

All the rest of measures were either based on interviews, surveys, questionnaires and observation, as shown in Table 6.1

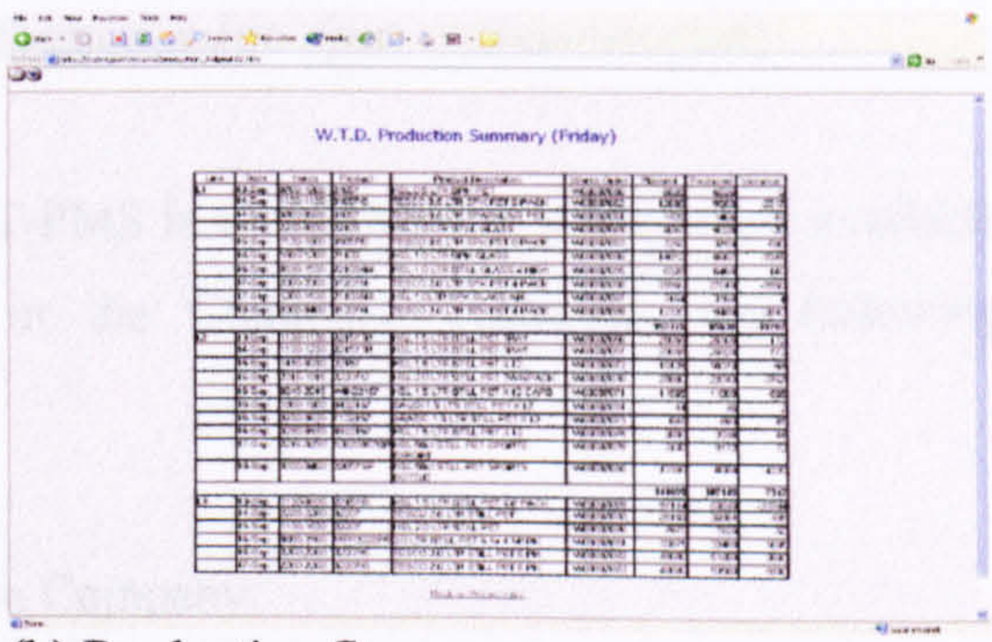
Reporting and Communication

As mentioned in the above sections, the same IT technologies (Html, VB Script, CGI Script, ASP, Cognos Impromptu and Powerplay, MAX ERP System, SCADA Server and Internet Information Server (IIS) were used in reporting and communicating information as Normal Charts, Statistical Charts and Summary Reports. These reports and charts (information) were communicated to different people through the Intranet within the Company.

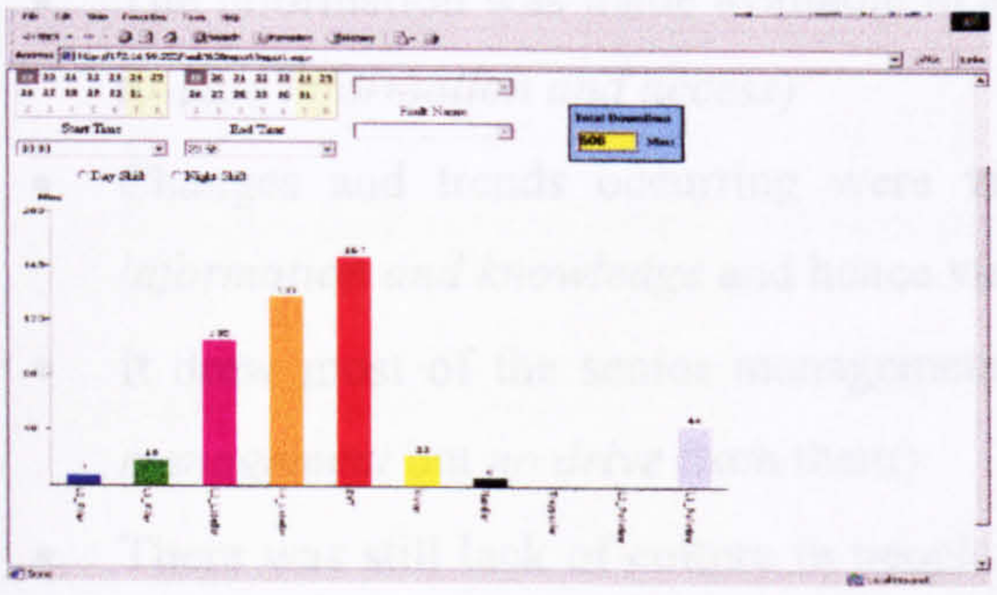
The information was dynamically available to the users. This was made possible with Cognos Impromptu and Powerplay, MAX ERP System, SCADA Server. Once the user selects an option and clicks a button on the web page as shown in Figure 6.19a the software platform automatically connects to the database and gets that information in the form of Pareto chart, statistical quality control charts as shown in Figures 6.19c and 6.19d as well as summary reports as shown in Figure 6.19b.



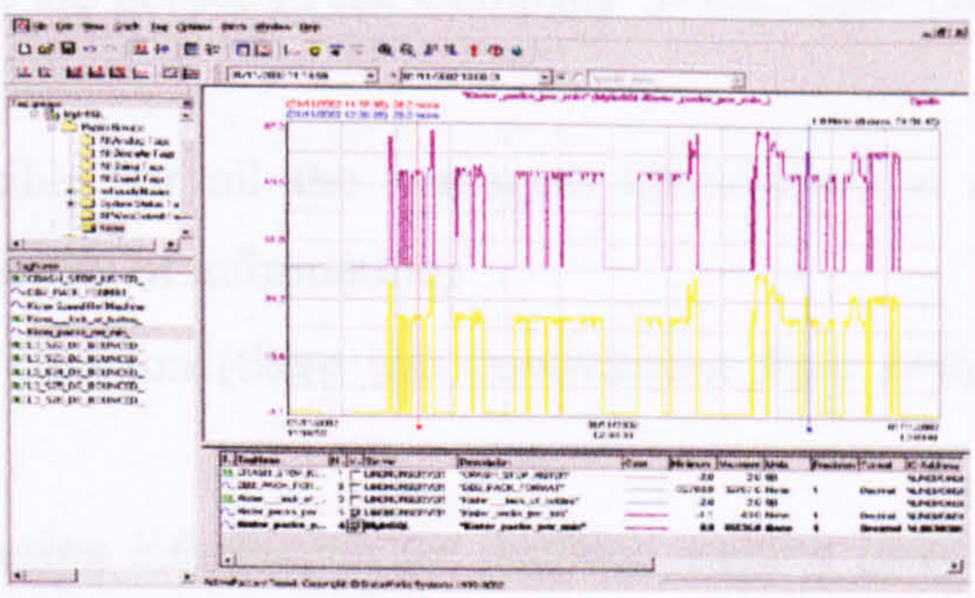
(a) Operator Fault Report



(b) Production Summary



(c) Pareto Analysis for Downtime



(d) Trend chart for number of bottles produced per minute

Figure 6.19: Sample pages available on the Intranet of HSL

6.4.2.4 Impact of IT-PMS on Management

6.4.2.4.1 Action Case Results

Summary of Personal Observation

Before IT-PMS was implemented at HSL:

- Some of the senior management were committed to the project, however none of them took the drive into their own hands (there was *senior management commitment but no drive*)
- Lack of balanced set of indicators (such as customer measures, operational measures, etc.)
- Information was hidden in paper sources (no *up-to-date information and access*)
- Difficulties associated with data collection on the shop floor (more *time and effort*)
- There was less scope for making people use the system for finding information (no *usability*)
- Lack of visibility over changes and trends (no *dissemination of information and knowledge*)
- Lack of effective communication of the information (no *open communication*)

During and immediately after implementing IT-PMS in the Company, it was made available to all managers and some team leaders in the Company. However, the following observations were made by the researcher:

- The system was implemented for the whole Company.
- The information was made available to all the people in the Company in real-time. (*up-to-date information and access*)
- Changes and trends occurring were visible for all the managers (*dissemination of information and knowledge* and hence visibility of information)
- It drew most of the senior management attention (there was *commitment from senior management* but *no drive* from them)
- There was still lack of culture in people using information for decision making (*people not using information in decision making*)

For the next six months, the managing director with the help of the TCS associates took the drive into his hands in using the information from IT-PMS and making the continuous improvement teams to use the information to improve the performance, especially in improving first hour efficiency, cost per case and reducing down times. However after six months of implementation:

- The performance results were communicated to everyone in the organisation, especially for all the team leaders and people on the shop floor (*open communication*)
- The performance information from IT-PMS was up-to-date (in real-time) and accurate (*up-to-date information and access*)
- The management team gained confidence in the performance information generated by the system because the data was accurate and timely (*Data accuracy and consistency* and *confidence in information*)
- Most of the senior management were committed to the system and driven its use (*senior management commitment and drive*)
- Senior management encouraged cross-functional, flexible, team-based working culture (*people acting as teams*)
- Less time was spent on data collection, analysis and communication (*reduction in time and effort*)
- People were using the information from IT-PMS for decision making (*people are using information in decision-making*)
- People were using the information from IT-PMS for identifying business trends and hence identifying root causes of problems (*people using continuous improvement techniques*)
- People were using IT-PMS as a routine part of business (*people using information as routine part of business*)
- IT-PMS made significant impact on transparency and visibility of information, identifying the weaknesses of the lines, continuous improvement of lines, pro-active decision-making and positive behaviour of people.

Summary of Interviews

The weightings obtained in the interviews are summarised into table as shown in the Appendix E. This data is classified as data on technical factors, people factors as well as management and business implications as shown in Figures 6.20, 6.21 and 6.22 respectively.

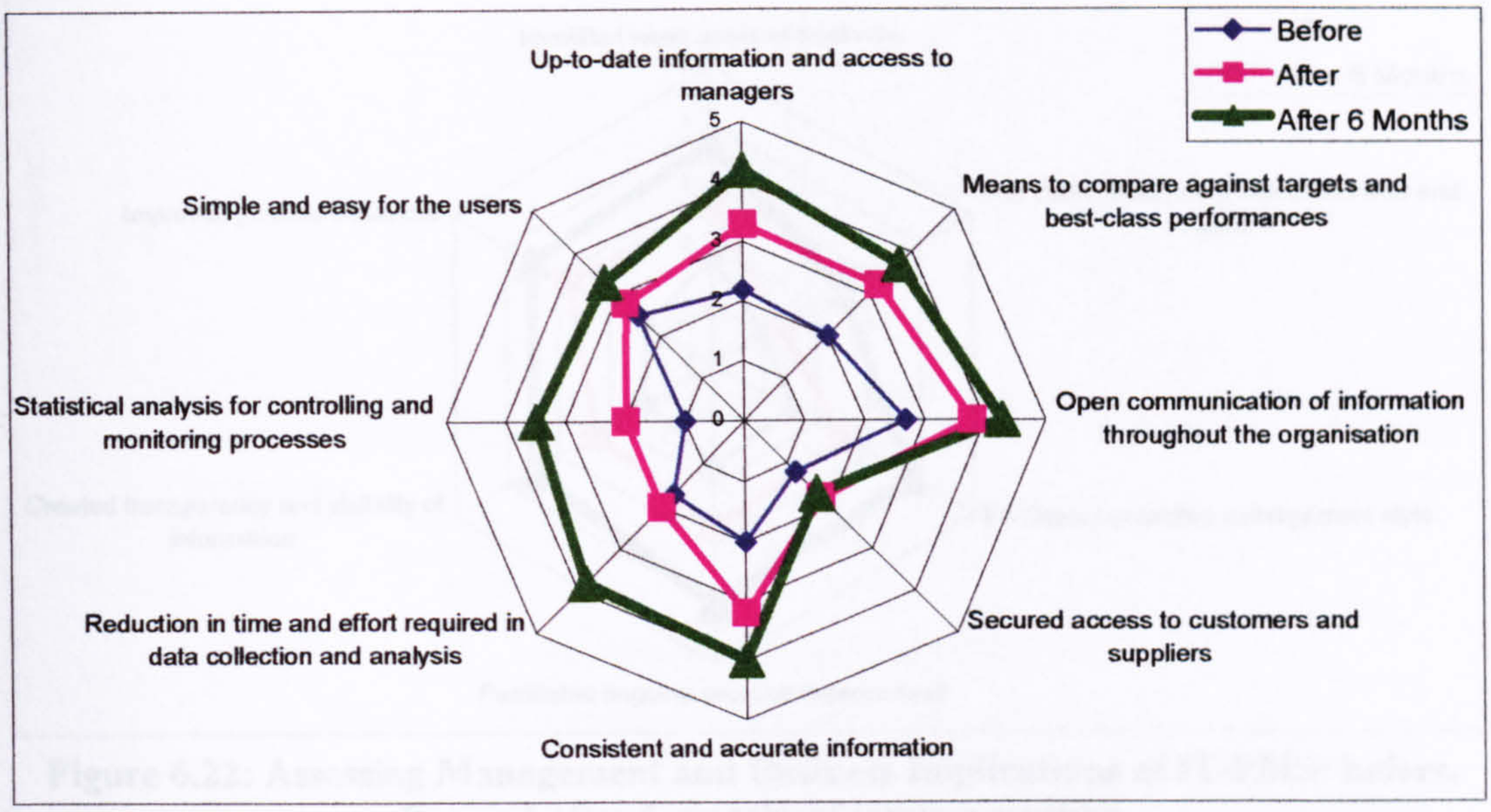


Figure 6.20: Assessing Technical Factors of IT-PMS: before, after and after 6 months of implementation

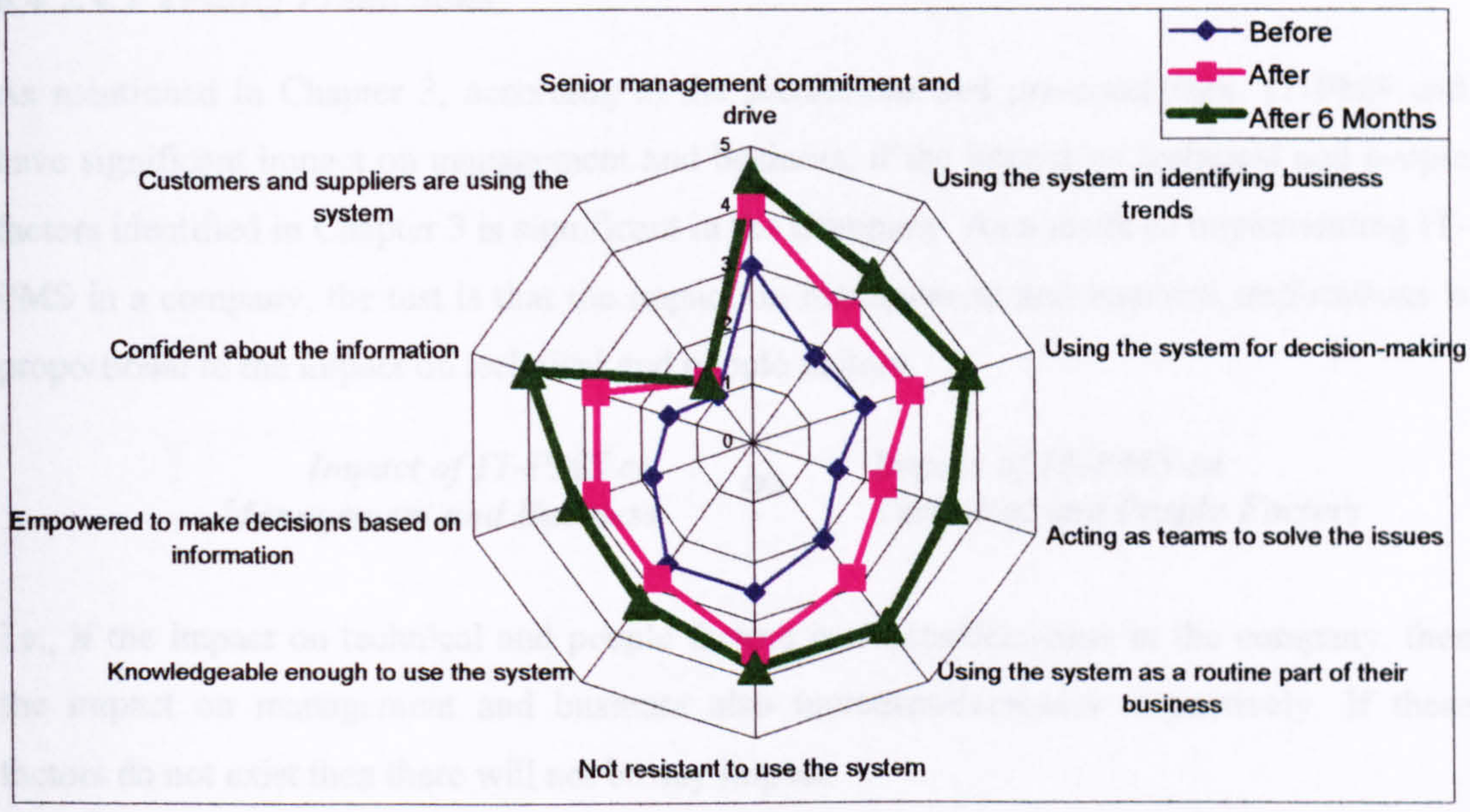


Figure 6.21: Assessing People Factors of IT-PMS: before, after and after 6 months of implementation

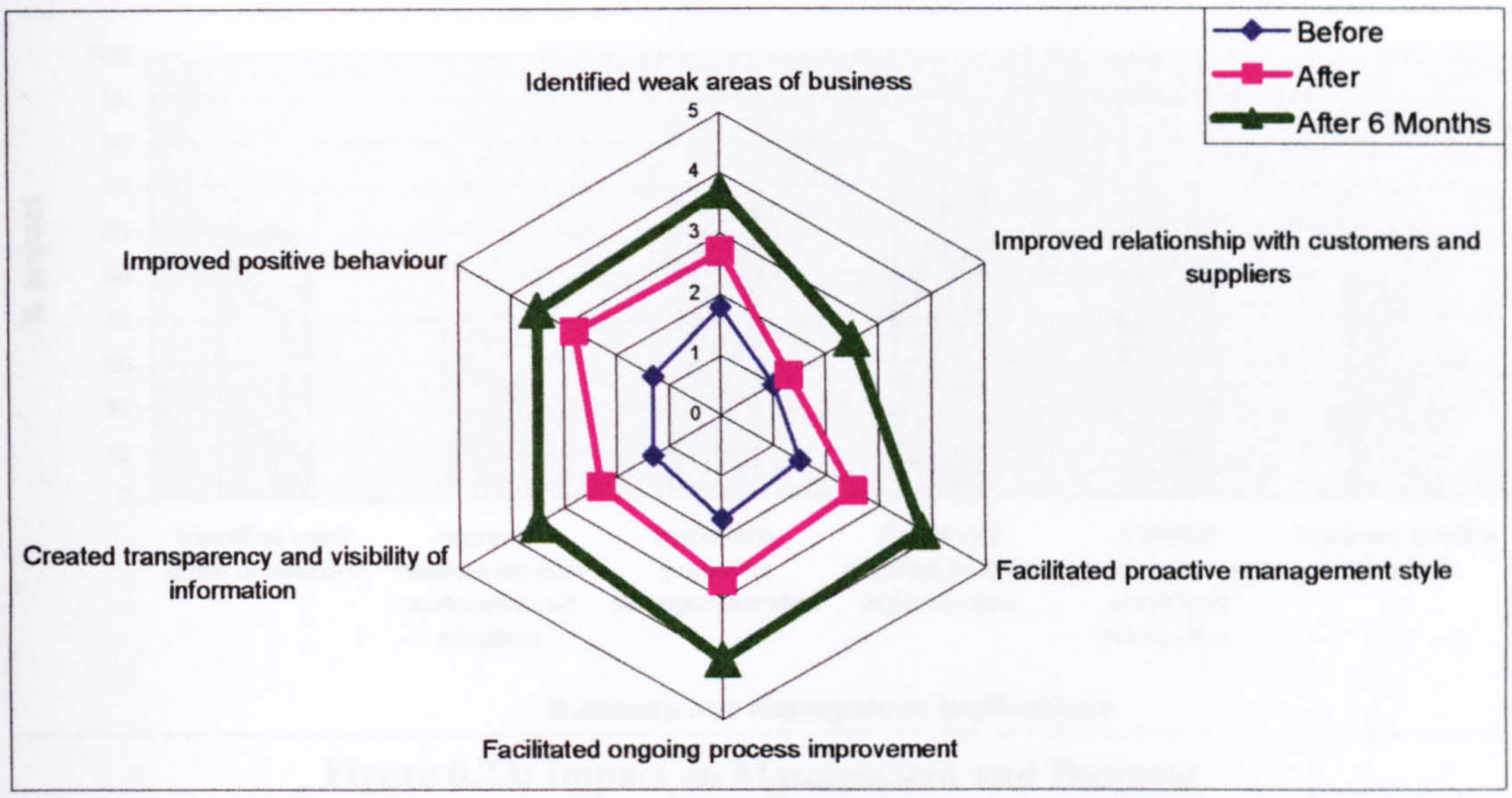


Figure 6.22: Assessing Management and Business Implications of IT-PMS: before, after and after 6 months of implementation

6.4.2.4.2 Testing Predictions

As mentioned in Chapter 3, according to the predictions and pre-conditions, IT-PMS will have significant impact on management and business, if the impact on technical and people factors identified in Chapter 3 is significant in the Company. As a result of implementing IT-PMS in a company, the test is that the impact on management and business implications is proportional to the impact on technical and people factors

$$\textit{Impact of IT-PMS on Management and Business} \propto \textit{Impact of IT-PMS on Technical and People Factors}$$

i.e., if the impact on technical and people factors increases/decreases in the company, then the impact on management and business also increases/decreases respectively. If these factors do not exist then there will not be any impact.

From the data collected and summarised from interviews at HSL, it is evident that there was moderate to significant impact of IT-PMS on management and business. Out of possible 100% impact, IT-PMS at HSL had 60% impact (on an average) as demonstrated in Figure 6.23. It is because out of 100% possible impact, the impact on technical and people factors was also 55% each as demonstrated in Figures 6.24 and 6.25. From Figures 6.23, 6.24 and 6.25 it is evident that the impact on management and business is proportional to the impact on technical and people factors.

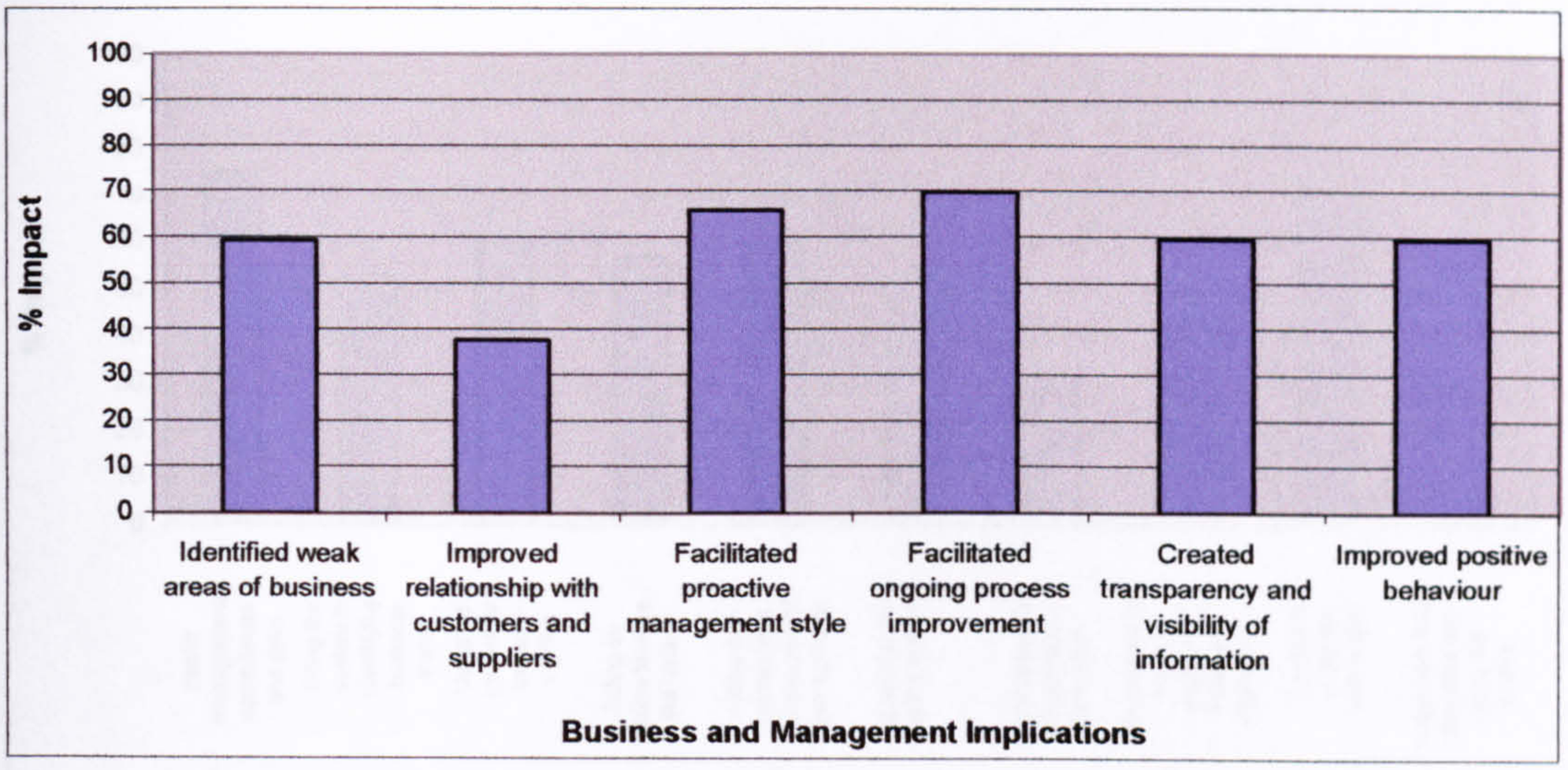


Figure 6.23: Impact on Management and Business

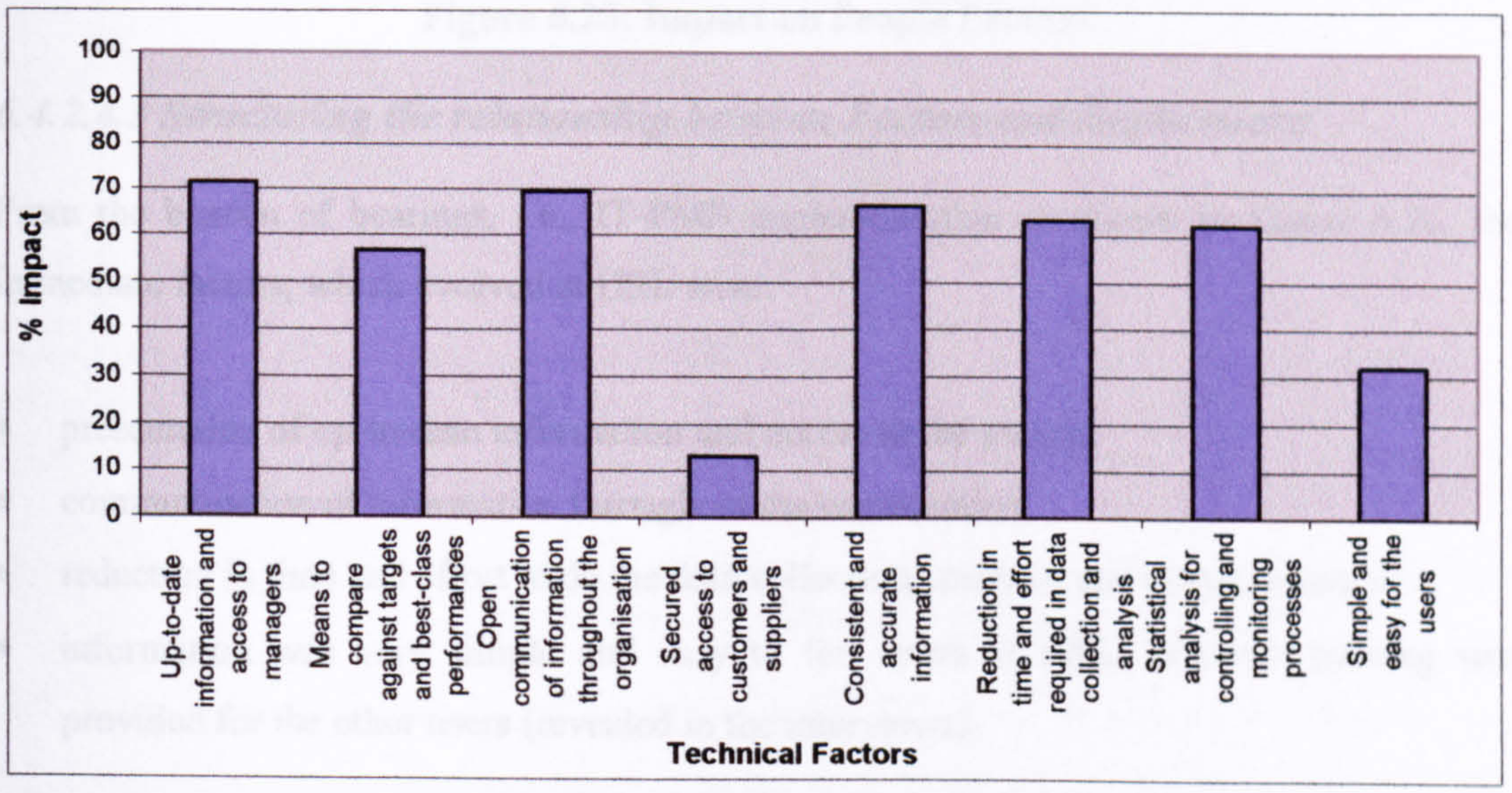


Figure 6.24: Impact on Technical Factors

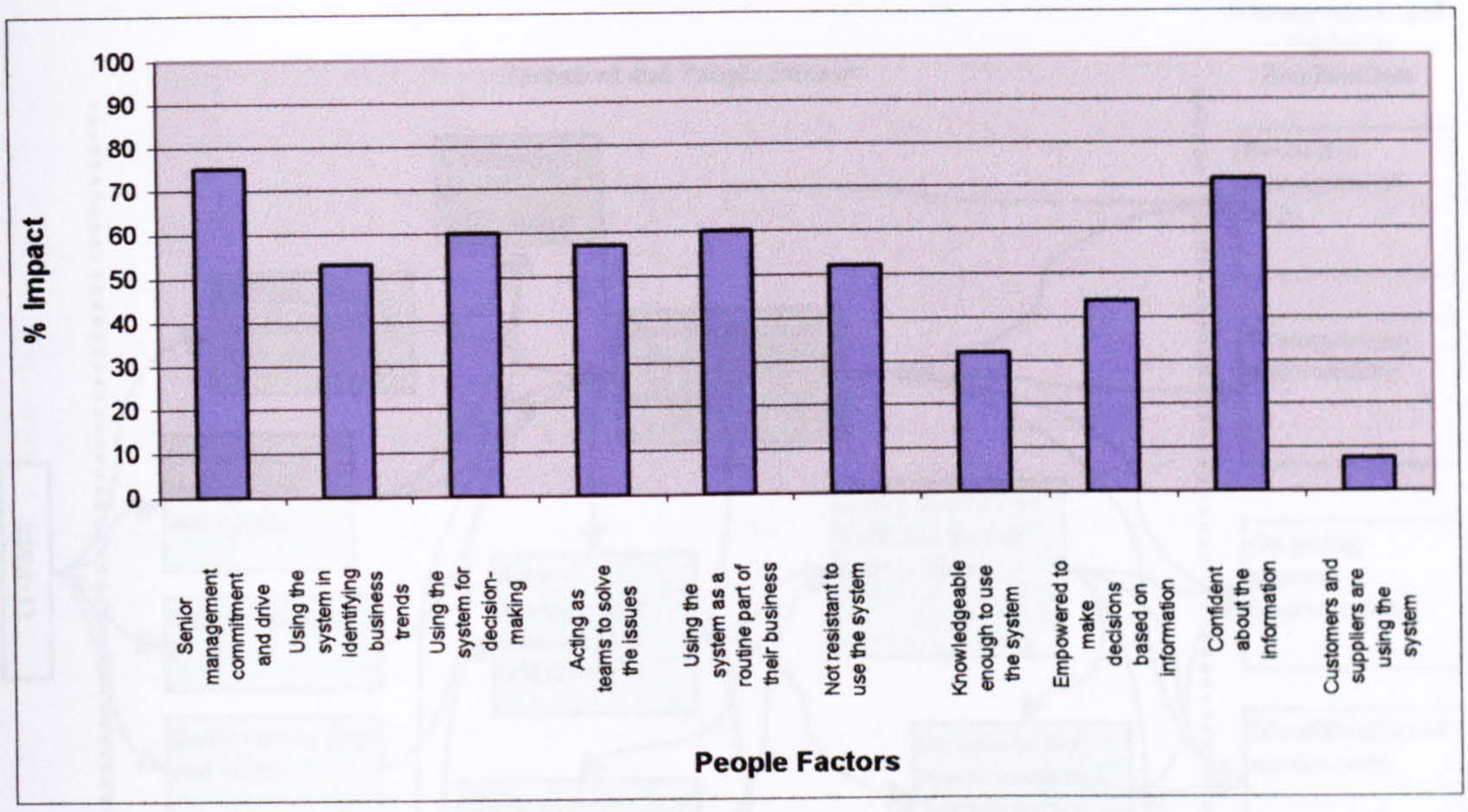


Figure 6.25: Impact on People Factors

6.4.2.4.3 Structuring the relationship between Factors and Implications

From the beacon of bearings, i.e., IT-PMS implementation as shown in Figure 6.26, the immediate factors, which evolved at HSL were:

- presentation of up-to-date information and access to the people
- communication of information throughout the organisation
- reduction in time and effort to do the data collection, analysis and communication
- information was very simple and easy to few users at HSL, however training was provided for the other users (revealed in the interviews)

Within few weeks, the implementation team ensured that the data coming out of IT-PMS was accurate and consistent. The data accuracy together with previous factors led to the gain in confidence in information from IT-PMS. Hence the senior management were very much committed and took the drive into their hands by:

- making people use the information from IT-PMS as their routine part of business
- encouraging the dissemination of information and knowledge throughout the organisation (which created complete transparency and visibility of information)
- initiating process based, cross-functional, flexible teams to use information in continuous improvement techniques such as six sigma, kaizen, etc.
- providing training on IT-PMS to the users who require it

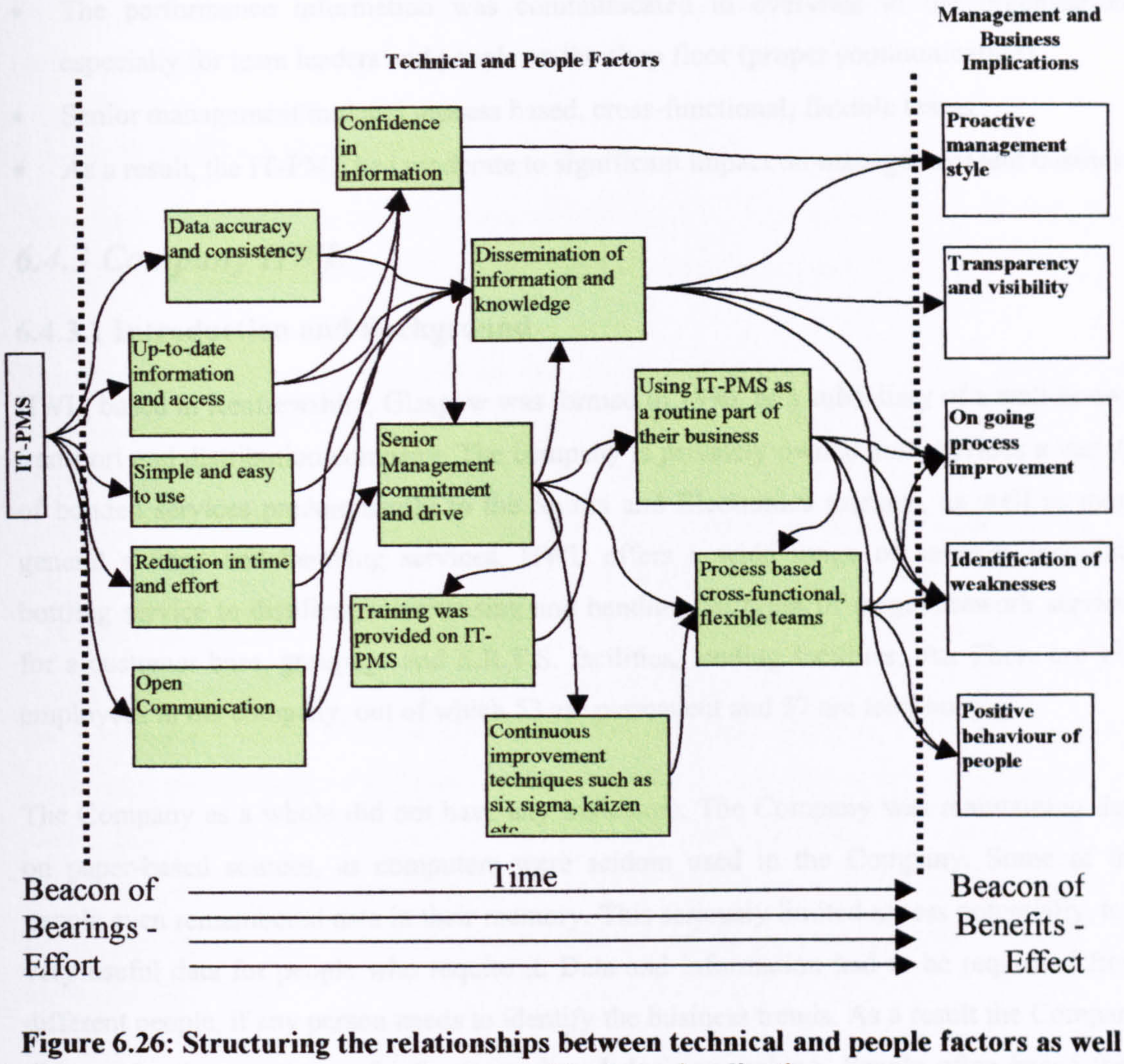


Figure 6.26: Structuring the relationships between technical and people factors as well as management and business implications

All these factors (technical and people factors) led towards beacon of benefits, i.e. implications on management and business as shown in Figure 6.26. Since most of the factors evolved have moderate to significant positive impact on one another, the final impact on the management and business (benefits) was also moderate to significant. After six months, this was reflected with moderate to significant impact on the five implications.

6.4.2.4.4 Conclusion

- The nature of HSL business was continuous manufacturing and hence OEE was the best measure for it (proper measures)
- IT-PMS system was implemented throughout the Company (holistic approach)
- Senior management could build confidence in the system (data accuracy)
- Senior management took the drive into their hands in making the people use IT-PMS throughout the organisation (drive and commitment from senior management)

- The performance information was communicated to everyone in the organisation, especially for team leaders and people on the shop floor (proper communication)
- Senior management initiated process based, cross-functional, flexible teams
- As a result, the IT-PMS had moderate to significant impact on management and business

6.4.3 Company HWL

6.4.3.1 Introduction and Background

HWL, based in Renfrewshire, Glasgow was formed in 1990, as a subsidiary of a well-known transport and distribution company. The company is privately owned and provides a variety of bonded services predominantly to the Spirits and Electronics markets, as well as more general storage and handling services. HWL offers a wide range of services including bottling service to distillers, warehousing and handling all types of cargos, rework services for a customer base, groupage and E.R.T.S. facilities, loading facilities, etc. There are 110 employees in the company, out of which 53 are permanent and 57 are temporary.

The Company as a whole did not have any indicators. The Company was maintaining data on paper-based sources, as computers were seldom used in the Company. Some of the people even remembered data in their memory. This seriously limited access potentially, to a very useful data for people who require it. Data and information had to be requested from different people, if any person needs to identify the business trends. As a result the Company did not develop a culture of information-based decision-making. People often based their decision on their experience alone. Some of the people were also resistant to use computers in their routine business.

The Company had brought in a network server and developed an intranet through third party IT services. However, initially it did not communicate any information. Since the Company was not collecting any data electronically, it did not include performance analysis, dynamic charts or reports. Raw data was available only in the paper sources. There was no standard tool and mechanism for the performance analysis. Generally, people spent lot of time and effort in doing performance analysis and reporting (when even required) by entering data into MS Excel.

The researcher presented his work with AFE, pilot case, SLC and HSL, action cases to the management team at HWL, who decided to adopt and implement IT-PMS using Sage Cost Accounting Software, SPC Software and MS Access for the whole Company. Since the

Company did not have any measures in place, the management team wanted to deploy both leading and leading indicators for the whole Company from their strategy.

6.4.3.2 Implementation Plan for IT-PMS

Orientation Phase: *Defining the scope of the business for implementing IT-PMS and methodologies used to find the impact of IT-PMS on management and business.*

The reason the Company decided to implement IT-PMS was to deploy performance measures from their strategy and hence promote continuous improvement as a part of TCS programme. There is evidence in literature and consultancy projects that performance measurement enhances continuous improvement. Performance measurement and continuous improvement are complementary projects to each other. Initially, a ***Steering Committee*** was established in the Company for planning IT-PMS in the Company. It consisted of Bill Dickie (Operations Manager), Michael Toal (Planning Manager), George Irvine (TCS Associate), Sai Nudurupati (Action Researcher), Umit Bititci (External Advisor). An ***Implementation Committee*** was established for implementing IT-PMS in the Company. It consisted of Sai Nudurupati (IT-PMS Provider) and George Irvine (IT-PMS Provider). As a part of the TCS programme, the Steering Committee identified to improve the effectiveness of their services in the factory and hence the committee decided the scope to implement IT-PMS was throughout the Company.

The committee decided to use personal observations and a set of interviews for assessing the impact of IT-PMS on management and business. The overall time for this project was decided to be one year.

Assessment Phase: *Establish business direction (operational site) and drivers and find its impact on IT-PMS. Establish a view of benefits of IT-PMS for the management and business. Outline the future requirements for the business (as a whole) in terms of IT-PMS. Establish a brief description of current IT resources used in the company. Finally establish a gap between what is desired and what is required by the company.*

The business direction for the Company was to promote continuous improvement in the factory and attract more customer base in Scotland. Ideally the Company was looking for sophisticated IT systems for planning and scheduling the customer orders and provide an online access to its customers, on the status of their orders. The anticipated list of benefits in

implementing IT-PMS was given in Chapter 3 (as predictions and pre-conditions). The list was developed from both pilot cases and literature review of action researcher. Most of the IT resources used by the Company were MS Access, MS Excel and Bond Master. Hence *gap* identified was that there were no performance indicators. Performance measurement related information was not at all available to the right people (at different levels of organisation) in right time (in near real-time) in right format (such trend charts, Pareto analysis, reports, etc.) in the Company to promote continuous improvement.

Strategic Phase: *Establish vision for the company in terms of IT-PMS. Conduct an optional analysis with different alternative solutions for the company. Finally develop a strategy by justifying it.*

The vision for the Company was to automate the IT systems from data capturing to the data reporting and communicating to different set of audience in different formats in (near) real time, that promotes continuous improvement. In order to achieve this vision, the steering committee used the software review done by Nudurupati et al (2000). All the software products and solutions included in the report were either very expensive or expensive for HWL. Hence the committee decided to implement a less expensive solution, which could be built using existing IT resources available within the Company (Sage Cost Accounting Software, Bond Master, MS Access and Network Server) as well as a simple charting and reporting tool available in the market. The different options available for charting and reporting include:

1. MS Access reporting tool (already available in the Company)
2. MS Excel (available in the Company, but has to be automated and customised to act as statistical tool)
3. NWA QAWS (statistical charting and dynamic reporting tool)

The steering committee decided to use MS Access for data analysis and NWA QAWS (temporarily obtained on a pilot basis for one year) for charting, reporting and communicating information. This temporary decision made would work in conjunction with the data capturing systems existing as shown in Figure 6.27

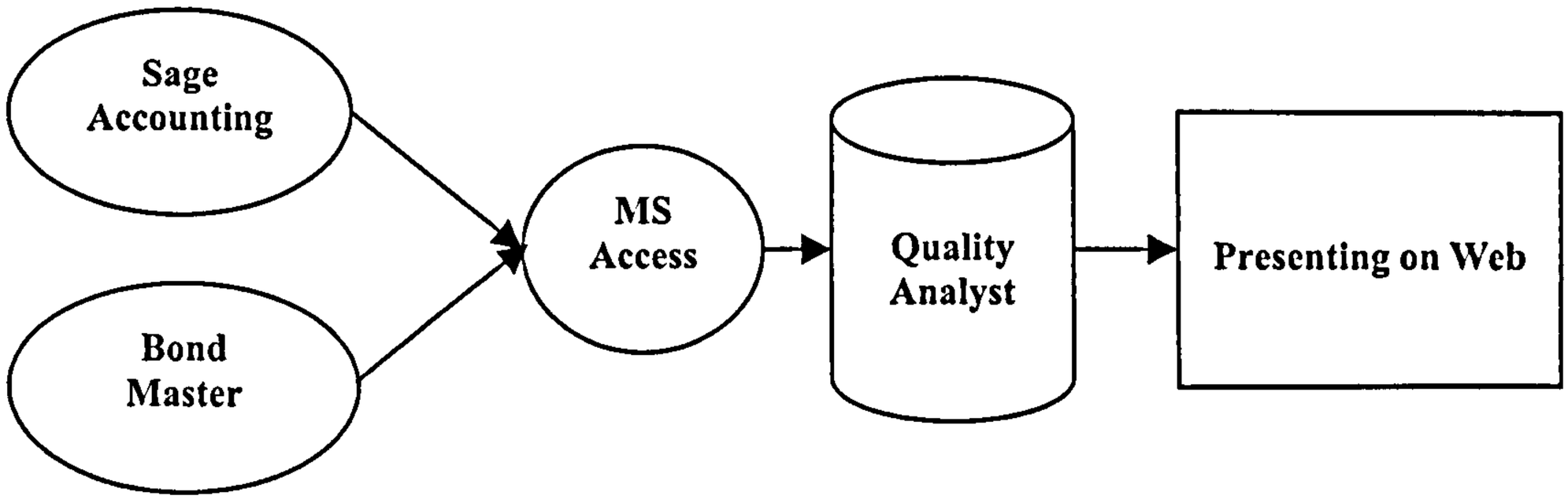


Figure 6.27. Architecture of the IT-PMS at HWL

Tactical Phase: *Identify and specify all the projects required to implement each strategy, prioritise these projects. Develop a tactical plan for each project. Recommend monitoring and control process.*

The previous phase identified only one strategy i.e. only one project, which was small (one year). Before implementing this project, a set of interviews were conducted with a cross section of employees to capture the initial situation of the Company (this was already done in during assessment phase). This project (IT-PMS implementation) was planned to be implemented in six months, immediately after which another set of interviews would be made. Balanced Scorecard was decided to be the appropriate framework for deploying performance measures. Finally, the implemented system would be monitored for six months after which another set of interviews would be conducted to find the impact of IT-PMS on management and business.

6.4.3.3 Actual Implementation of IT-PMS

Deploying Performance Measures and Data Capturing

A fully customised web site was designed for HWL using Html, Java Script, VB Script, CGI Script and Quality Analyst Web Server. As shown in Figure 6.28, the left pane includes a tree structure, which can be modelled to adapt any performance measurement framework. In this Company Balanced Scorecard was used as the performance measurement framework.

From the objectives of the operational site of the Company, the steering committee decided the performance measures (improvement measures) to be:

- *Financial perspective*: Margin, Cost of goods sold
- *Customer perspective*: Delivery performance to customer request, Fill rates
- *Internal perspective*: Order fulfilment lead-time, Down time, Inventory days of supply
- *Learning and Growth perspective*: None

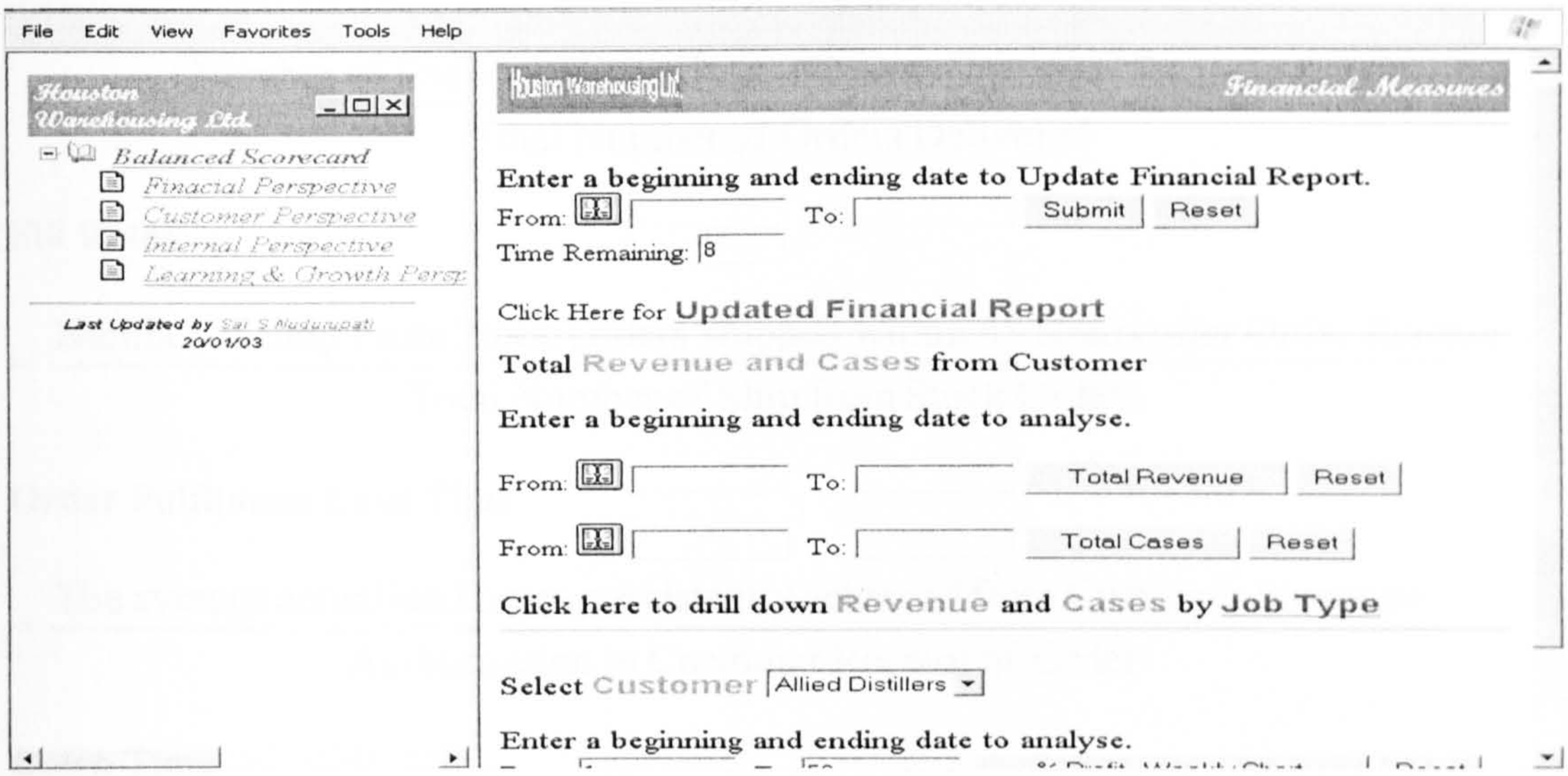


Figure 6.28 Web page displayed on the Intranet of HWL

All these measures mentioned are shown in the right pane in Figure 6.28. Depending on the perspective in the left pane, corresponding measures are shown in the right pane. It is almost simulating a windows explorer, which we generally use in windows operating system.

The data source for the above measures was Sage Cost Accounting System, MS Access, MS Excel, Bond Master. The raw data was available for every computer, which was connected to the Intranet existing within the Company. However, since the data existed in different sources, the steering committee had decided to transfer data into single source Microsoft Access database, from which different calculations and analysis were performed.

Data Analysis (Calculations)

All the calculations in this section were carried out in several queries facilitated by MS Access.

Margin

$$= \frac{\text{Total Costs}}{\text{Total Revenue}} \times 100$$

Cost of Goods Sold

$$= (\text{Direct Materials}) + (\text{Direct Labour}) + (\text{Allocated Overhead})$$

Delivery Performance to Customer Request

$$= \frac{(\text{Number of Orders Delivered On - Time to Customer Request Date})}{\text{Total Number of Orders Delivered}} \times 100$$

Fill Rates

$$= \frac{\text{Number of Ship From Stock Orders Shipped within 48 Hours after Order Release}}{\text{Total Number of Ship from Stock Orders}}$$

Order Fulfilment Lead Time

$$= \frac{\text{The average actual lead times consistently achieved from Customer Signature}}{\text{Authorisation to Customer Receipt of Order}}$$

Down Time

= The time for which the line is stopped

Inventory Days of Supply

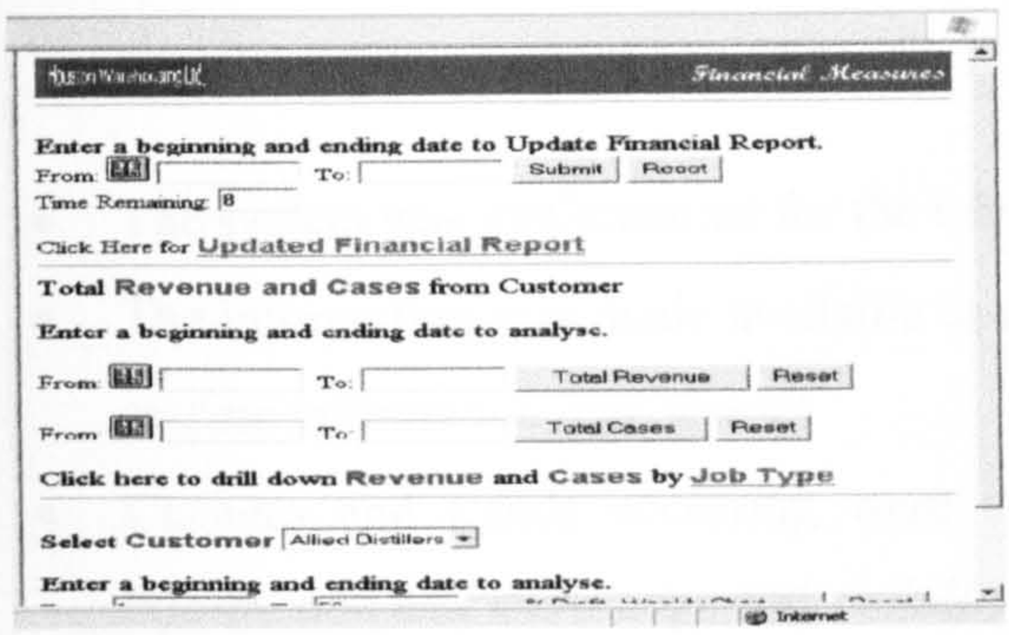
$$= \frac{\text{Total Five Point Annual Average Inventory}}{(\text{Cost of Goods Sold})/365}$$

Reporting and Communication

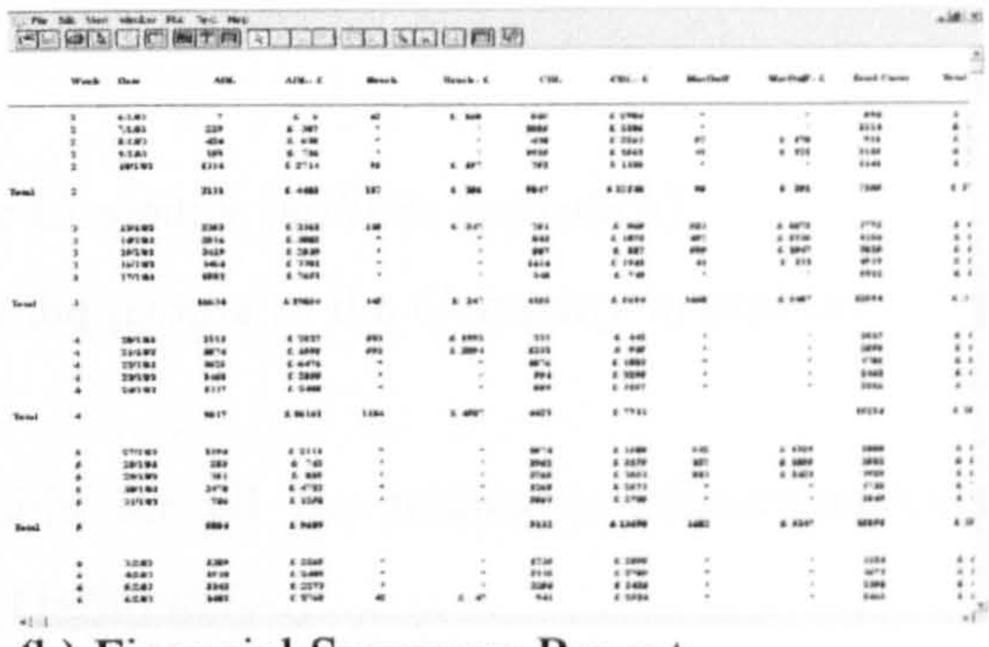
As mentioned in the above sections, the same IT technologies (Html, Java Script, VB Script, CGI Script, NWA Quality Analyst Web Server and MS Access) were used in reporting and communicating information as Normal Charts, Statistical Charts, Pareto Analysis and Summary Reports. These reports and charts (information) were communicated to different people through the Intranet within the Company.

The information was dynamically available to the users. This was made possible with NWA QAWS Run file technology and Intranet. Once the user selects an option and clicks a button on the web page as shown in Figure 6.29a the software platform automatically connects to the MS Access or Sage Accounting Software database and gets that information in the form of normal charts, statistical quality control charts, summary reports, etc. For instance, the financial report of HWL, including revenue generated from each customer was summarised

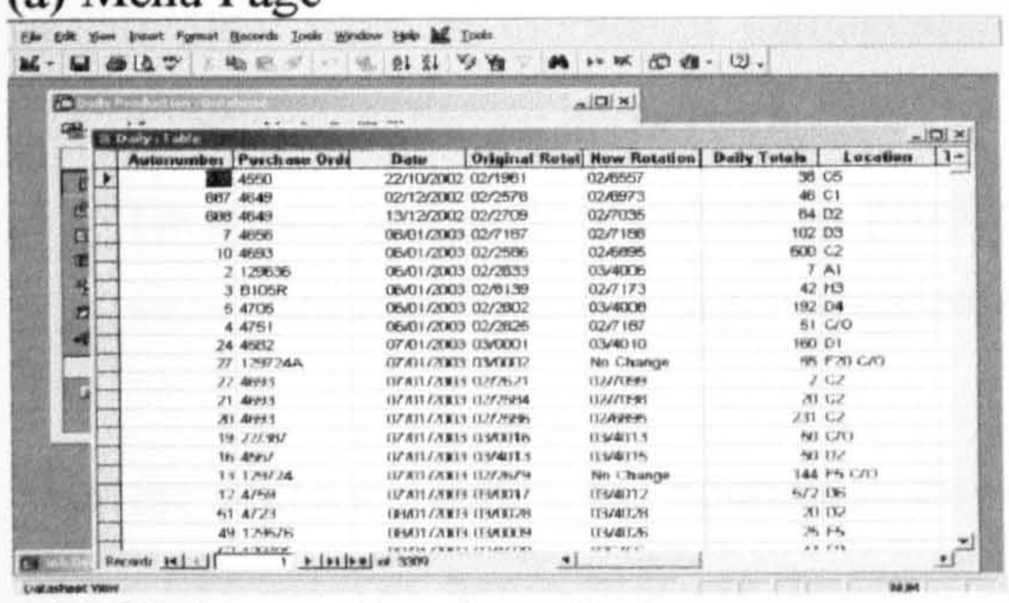
in Figure 6.29b. The purchase orders generated in MS Access is documented in Figure 6.29c. The number of cases re-worked in each week was compared against two consecutive years 2002 and 2003 as shown in Figure 6.29d.



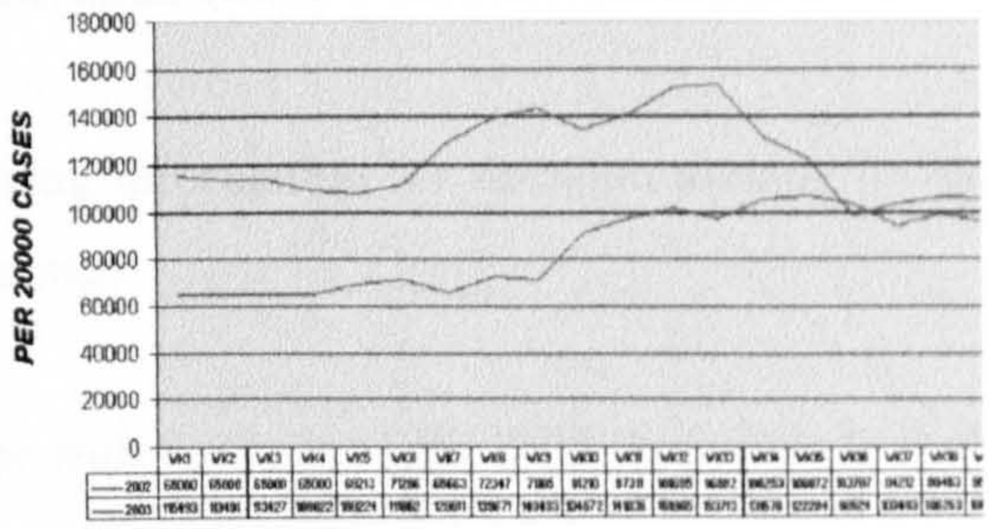
(a) Menu Page



(b) Financial Summary Report



(c) MS Access: Purchase Orders



(d) Cases Reworked: Year 2002 and 2003

Figure 6.29: Sample pages available on the Intranet of HWL

6.4.3.4 Impact of IT-PMS on Management

6.4.3.4.1 Action Case Results

Summary of Personal Observation

Before IT-PMS was implemented at HWL:

- Managing director, operations manager, planning manager were committed to the project (there was *senior management commitment* but *no drive*)
- Lack of performance indicators
- Information was hidden in paper sources (no *up-to-date information and access*)
- Difficulties associated with data collection on the shop floor (more *time and effort*)
- There was less scope for making people use the system for finding information (*people were not using information in decision-making*)
- Lack of visibility over changes and trends (no *dissemination of information and knowledge*)

- Lack of effective communication of the information (no *open communication*)

During and immediately after implementing IT-PMS in the Company, it was made available to all employees in the Company. However, the following observations were made by the researcher:

- The system was implemented for the whole Company (*holistic approach*).
- The information was made available to all the people in the Company in real-time. (*up-to-date information and access*)
- Changes and trends occurring were visible for all the managers (*dissemination of information and knowledge* and *visibility of information*)
- It drew most of the senior management attention (there was *commitment from senior management* but *no drive* from them)
- There was still lack of culture in people using information for decision making (*people were not using information for decision making*)

For the next six months, the operations director with the help of the TCS Associate took the drive into his own hands in using the information from IT-PMS and driving the people to use the information to improve the performance of the warehouse. However after six months of implementation:

- Too much change was implemented in the short period of time without any time to settle down (*too much change implemented*)
- Many projects were launched one after the other without any priorities between them (*no priority for different projects* including this project)
- Senior management took the drive into their hands in making people use the IT-PMS (*senior management commitment and drive*)
- Less time was spent on data collection, analysis and communication (*reduction in time and effort*)
- Most information (most performance measures) was deployed throughout the organisation. However there was no data existing for some information (few performance measures)
- Training was provided for people in using IT-PMS (*training*)
- People were using the information from IT-PMS for decision-making (*people were using information in decision making*)

- Using the information, people started acting as teams to improve the line performances (*people acting as teams*)
- IT-PMS made moderate impact on transparency and visibility of information, identifying the weak areas of the business, continuous improvement of business, pro-active decision-making and positive behaviour of people.

Summary of Interviews

The weightings obtained in the interviews are summarised into table as shown in the Appendix F. This data is classified as data on technical factors, people factors as well as management and business implications as shown in Figures 6.30, 6.31 and 6.32 respectively.

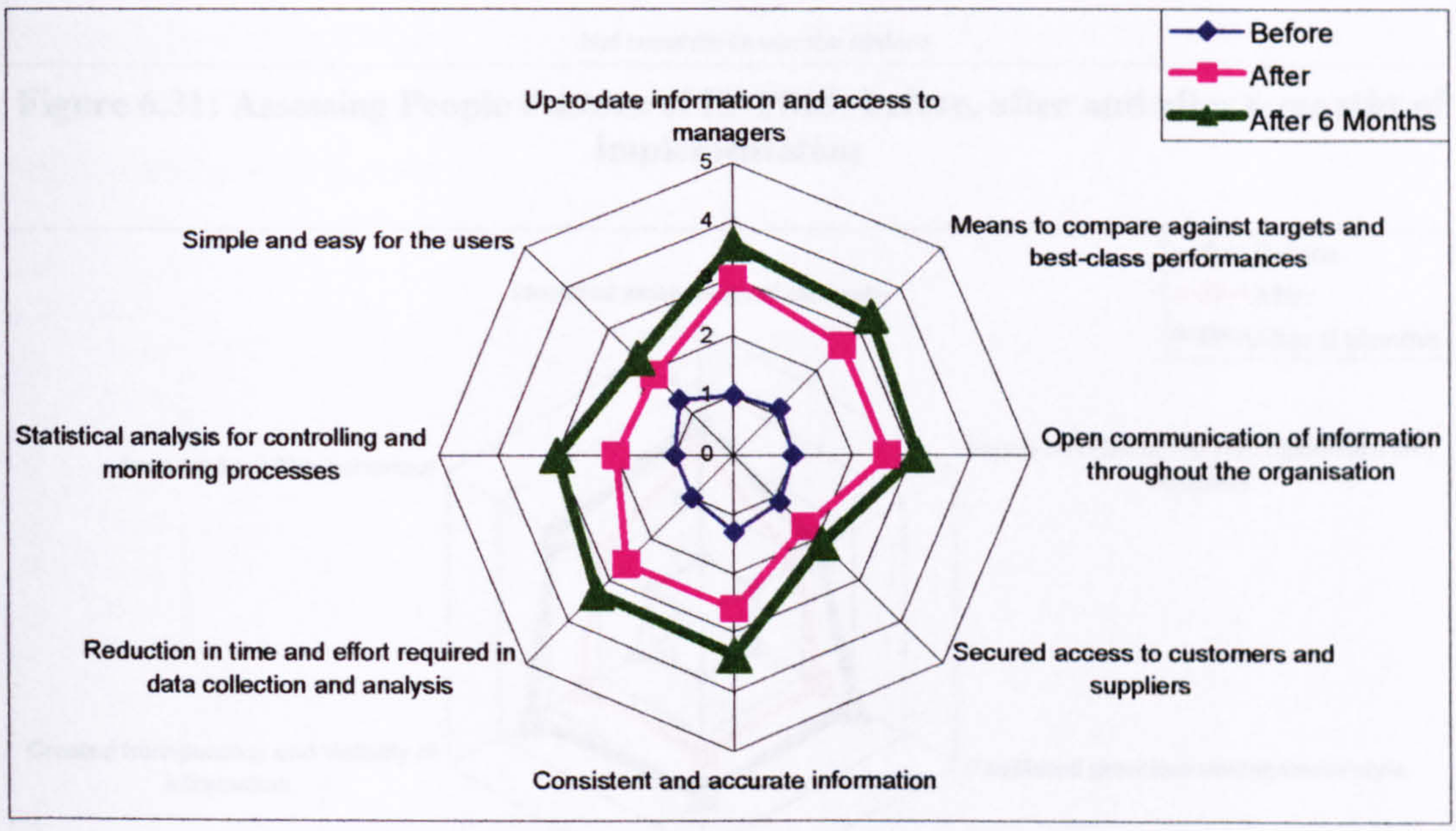


Figure 6.30: Assessing Technical Factors of IT-PMS: before, after and after 6 months of implementation

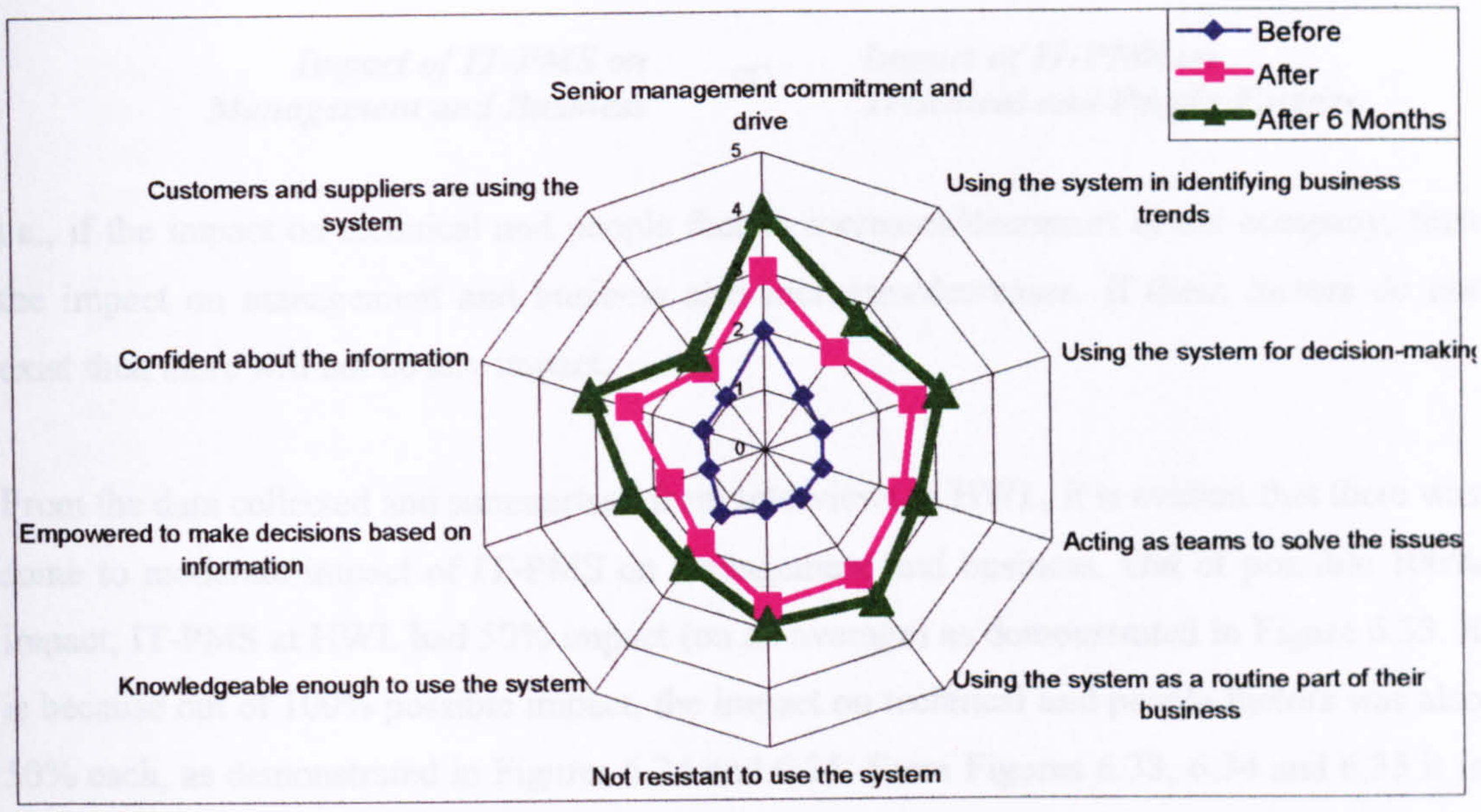


Figure 6.31: Assessing People Factors of IT-PMS: before, after and after 6 months of implementation

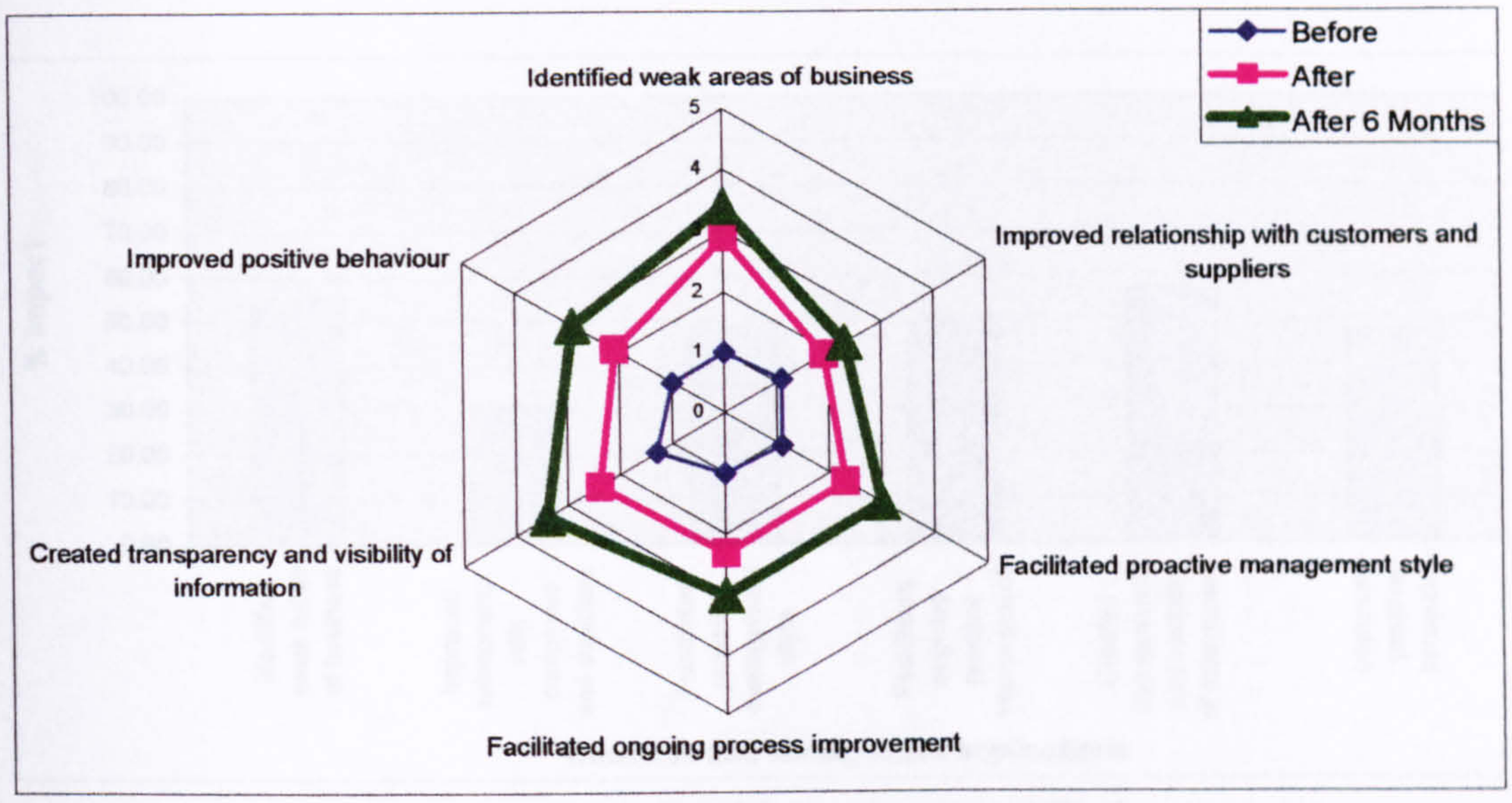


Figure 6.32: Assessing Management and Business Implications of IT-PMS: before, after and after 6 months of implementation

6.4.3.4.2 Testing Predictions

As mentioned in Chapter 3, according to the predictions and pre-conditions, IT-PMS will have significant impact on management and business, if the impact on technical and people factors identified in Chapter 3 is significant in the Company. As a result of implementing IT-PMS in a company, the test is that the impact on management and business implications is proportional to the impact on technical and people factors

$$\textit{Impact of IT-PMS on Management and Business} \propto \textit{Impact of IT-PMS on Technical and People Factors}$$

i.e., if the impact on technical and people factors increases/decreases in the company, then the impact on management and business also increases/decreases. If these factors do not exist then there will not be any impact.

From the data collected and summarised from interviews at HWL, it is evident that there was some to moderate impact of IT-PMS on management and business. Out of possible 100% impact, IT-PMS at HWL had 50% impact (on an average) as demonstrated in Figure 6.33. It is because out of 100% possible impact, the impact on technical and people factors was also 50% each, as demonstrated in Figures 6.34 and 6.35. From Figures 6.33, 6.34 and 6.35 it is evident that the impact on management and business is proportional to the impact on technical and people factors.

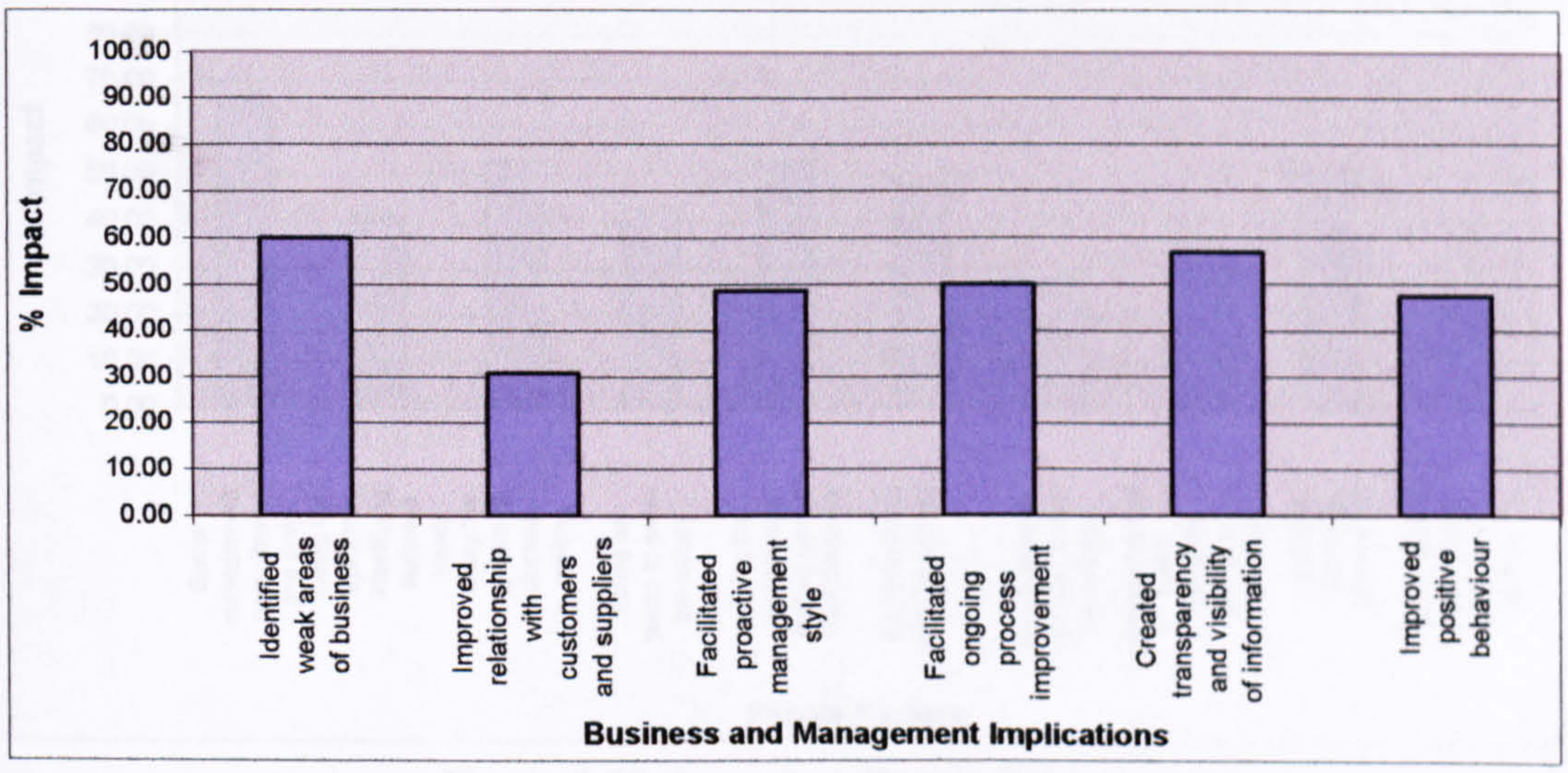


Figure 6.33: Impact on Management and Business

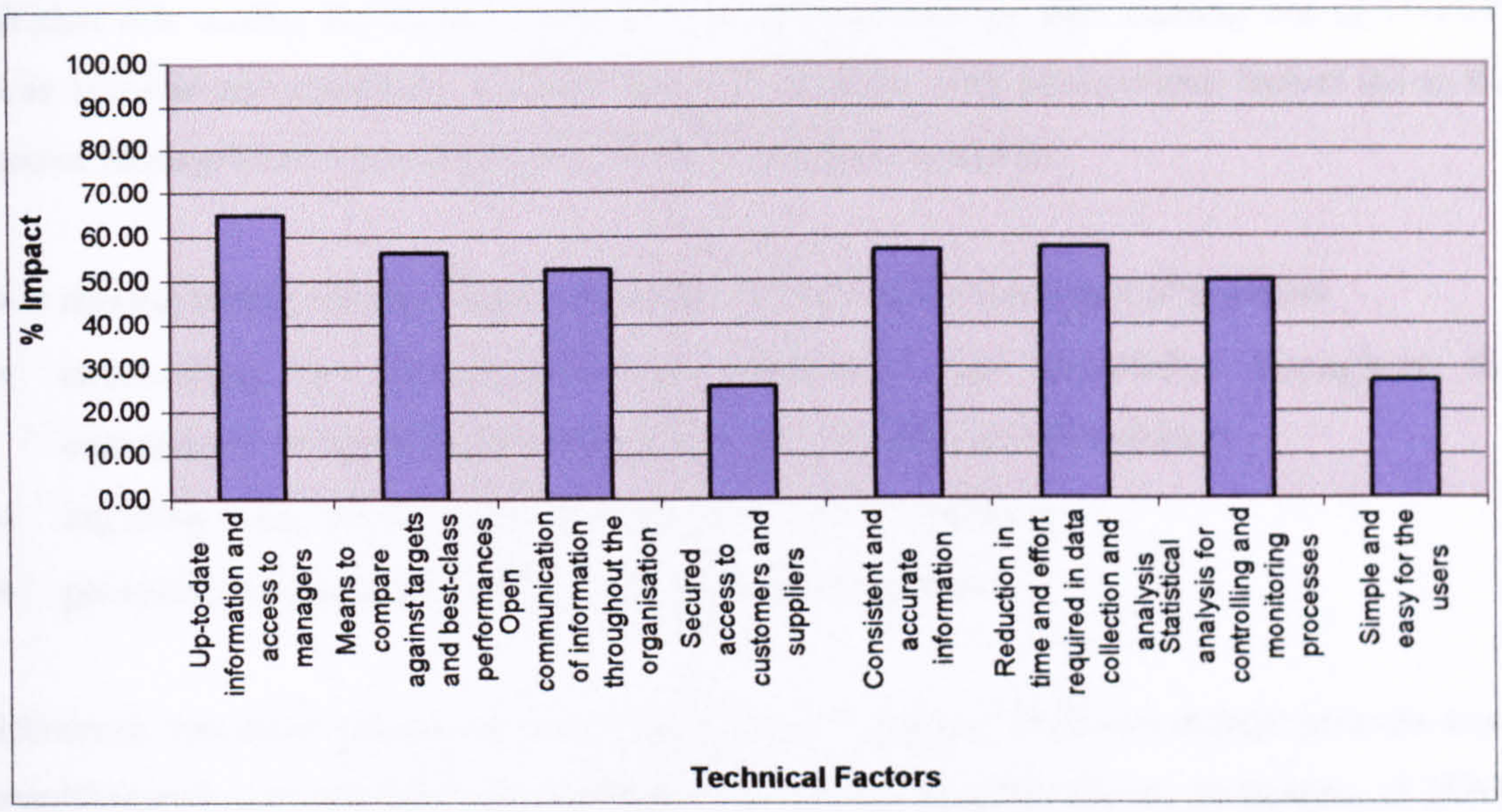


Figure 6.34: Impact on Technical Factors

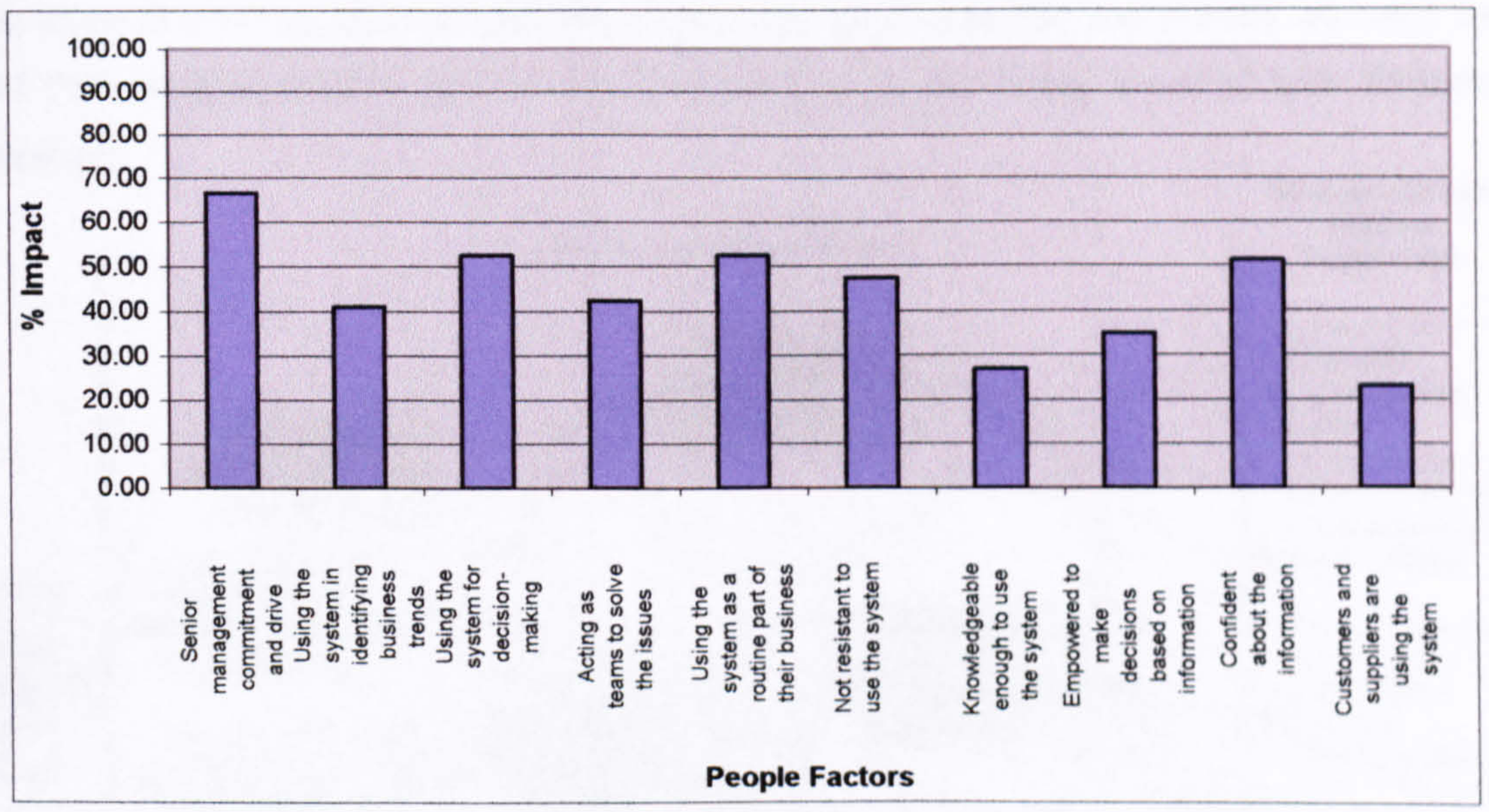


Figure 6.35: Impact on People Factors

6.4.3.4.3 Structuring the relationship between Factors and Implications

From the beacon of bearings, i.e., IT-PMS implementation as shown in Figure 6.36, the immediate factors, which evolved at HWL were:

- presentation of up-to-date information and access to the people
- communication of information throughout the organisation

Within few weeks, the implementation team ensured that the data coming out of IT-PMS was accurate and consistent. The data accuracy together with the previous factors led to the senior management committed and took drive into their hands by:

- making people use the information from IT-PMS as a routine part of business
- encouraging the dissemination of information and knowledge throughout the organisation (which created transparency and visibility of information)
- initiating team culture to use information in decision-making
- providing training on IT-PMS to the users who require it

However, too much change was introduced in the Company. Different change projects were implemented one after the other without any pauses to settle down. A manger at HWL commented it as "a *roller coaster on a mobius loop*". This created resistance in some people in using IT-PMS as their routine part of business. There was also less priority allocated for IT-PMS implementation project, which resulted in people being involved with different projects.

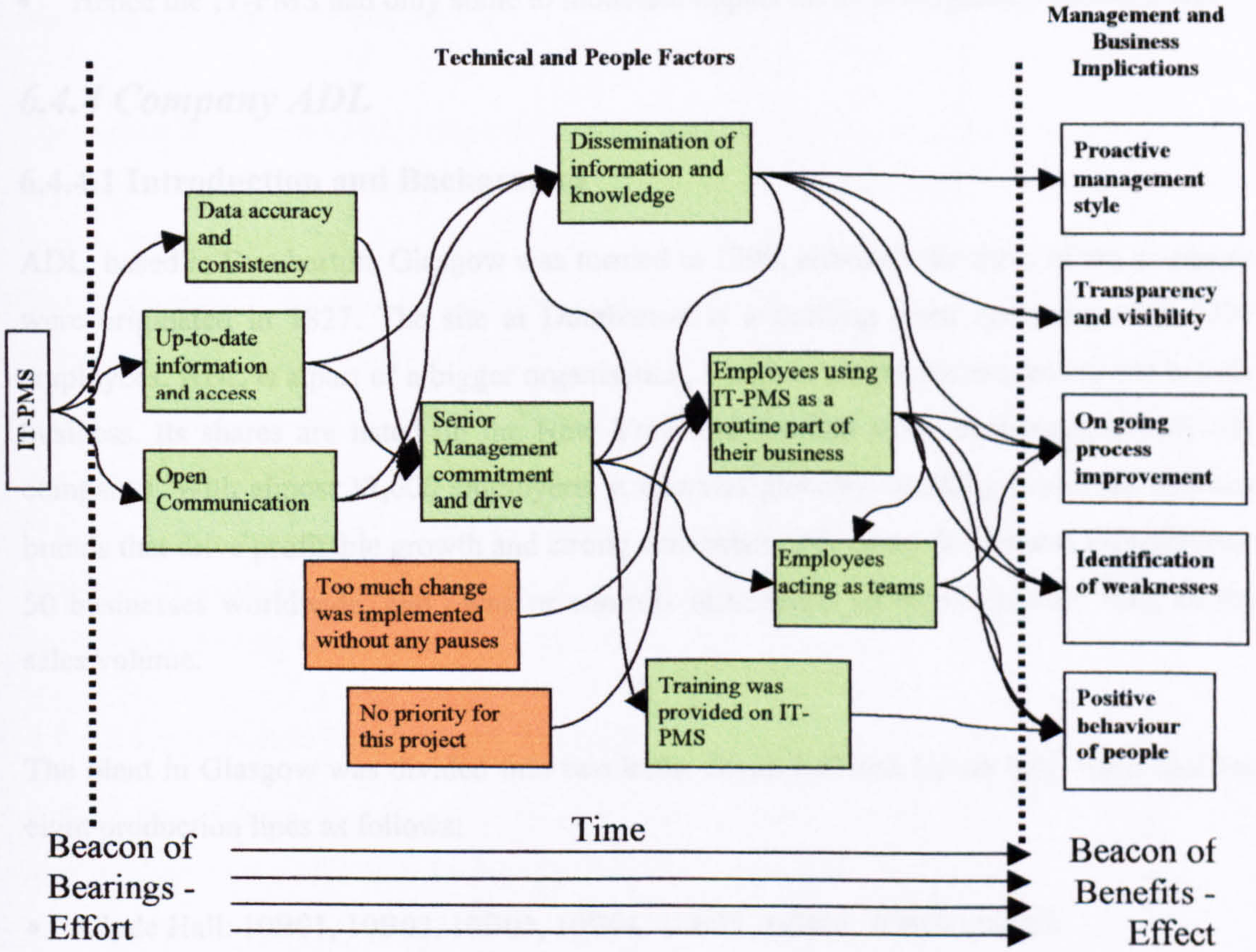


Figure 6.36: Structuring the relationships between technical and people factors as well as management and business implications

All these factors (technical and people factors) led towards beacon of benefits, i.e. implications on management and business as shown in Figure 6.36. Since most of the factors evolved have some to moderate positive impact (except two factors) on one another, there was also only some to moderate improvement on the implications (benefits). After six months, this was reflected with some to moderate impact on the five implications.

6.4.3.4.4 Conclusion

- The performance measures were deployed from their strategy (proper measures)
- IT-PMS system was implemented through the Company (holistic approach)
- The performance information was communicated to everyone in the organisation (proper communication)
- Senior management took the drive into their hands to use IT-PMS throughout the organisation (lack of drive and commitment from senior management)
- Too many projects were implemented in the Company, one after the other without any settling time.
- Hence the IT-PMS had only some to moderate impact on its management and business

6.4.4 Company ADL

6.4.4.1 Introduction and Background

ADL, based in Dumbarton, Glasgow was formed in 1990, although the roots of the company were originated in 1827. The site at Dumbarton is a bottling plant operating with 1200 employees. ADL is a part of a bigger organisation, which is a dynamic marketing-led brands business. Its shares are listed on the New York and London stock exchanges (FTSE-100 company). With almost 12,000 employees, it operates globally, building powerful, exciting brands that drive profitable growth and strong consistent cash flows. It operates through over 50 businesses worldwide, and owns or controls distribution of approximately 90% of the sales volume.

The plant in Glasgow was divided into two halls, Clyde hall and Leven hall. Each hall has eight production lines as follows:

- Clyde Hall: 10B01, 10B02, 10B03, 10B04, 10B05, 10B06, 10B07, 10B08
- Leven Hall: 50B11, 50B12, 50B13, 50B14, 50B15, 50B16, 50B17, 50B18

Before the IT-PMS was implemented at ADL, the Company as a whole had few lagging indicators. However the data on these indicators was stored at different sources such as Data3, Lotus Notes, Lotus Approach Database, AS 400, Cognos, MS Access, MS Excel, etc. There was no single source to collate the data from different sources, analyse it and communicate it. Hence it took lot of time and effort in gathering, analysing the information and communicating it. Often the information available for decision-making was out-of-date.

The business was functionally deployed and there was no communication of information between different departments (over the walls). The departments were completely isolated and the improvement projects launched by one department do not always tie in with the other departments, "*One person's music was sometimes noise to the other*". Most of the managers are bureaucratic and based their decisions on experience rather than on information. Some of the managers are unfocused and do not know their objectives. Hence there was lack of visibility of what's happening within the Company. Changes and trends occurring were not transparent to everyone. Most of the employees at ADL were afraid of changing their job roles for any new implementations or new projects and resisted the implementations or projects directly or indirectly.

The researcher presented his work with ***AFE, pilot case***, SLC and HSL, action cases to the management team at ADL, who decided to adopt and implement IT-PMS using NWA Quality Analyst Web Server (NWA QAWS) for their Operations and Quality Departments. The management decided to measure Line reliability, End of line Quality, Customer complaints, On Time In Full (OTIF) and Absenteeism. However since the IT department was involved with other higher priority projects, the IT department within the Company could not get involved in this project. To support implementing these measures, the Company brought in the researcher (from Strathclyde University) for implementing it as a research project. The researcher Sai Nudurupati, who played a lead role in implementing this project, as well as in finding the impact of IT-PMS.

6.4.4.2 Implementation Plan for IT-PMS

Orientation Phase: *Defining the scope of the business for implementing IT-PMS and methodologies used to find the impact of IT-PMS on management and business.*

The reason the Company decided to implement IT-PMS was to create complete visibility and transparency of key information and hence promote continuous improvement. There is

evidence in literature and the previous consultancy projects that, IT-PMS creates visibility as well as transparency and enhances continuous improvement. Initially, a ***Steering Committee*** was established in the Company for planning IT-PMS in the Company. It consisted of Rob Hinton (Operations Director), Andrew Pursey (Head of Operations), Alan Mitchell (Head of Quality), Robert Cowan (Line Reliability Manager), Sai Nudurupati (Action Researcher), and Trevor Turner (External Advisor). An ***Implementation Committee*** was established for implementing IT-PMS in the Company. It consisted of Sai Nudurupati (IT-PMS Provider), Robert Cowan (Line Reliability Manager). Since the Company was large scale, as a starting point, the Steering Committee decided the scope to implement IT-PMS was for the operational activities of the Company.

The committee decided to use personal observations and a set of interviews for assessing the impact of IT-PMS on management and business. The overall time for this project was decided to be one year.

Assessment Phase: *Establish business direction (operational site) and drivers and find its impact on IT-PMS. Establish a view of benefits of IT-PMS for the management and business. Outline the future requirements for the business (as a whole) in terms of IT-PMS. Establish a brief description of current IT resources used in the company. Finally establish a gap between what is desired and what is required by the company.*

The business direction for the Company was to promote continuous improvement in the operational site. As a part of it, to create complete visibility and transparency of information available within the Company. The anticipated list of benefits in implementing IT-PMS was given in Chapter 3 (as predictions and pre-conditions). The list was developed from both pilot cases and literature review of action researcher. The future direction of the business was to promote continuous improvement project in other parts of the business. Most of the IT resources used by the Company were described briefly in the Company background. Although raw data captured automatically on the shop floor was available on the Company intranet (protected), the analysed performance related information required to promote continuous improvement was not available. Hence *gap* identified was that performance measurement related information (such as information on line reliability, end of line quality, customer complaints, on time in full (OTIF), absenteeism, etc. on each line, each hall and the whole factory) was not available to the right people (at different levels of the organisation) in

the right time (in near real-time) in the right format (such trend charts, Pareto analysis, reports, etc.) in the Company to promote continuous improvement.

Strategic Phase: *Establish vision for the company in terms of IT-PMS. Conduct an optional analysis with different alternative solutions for the company. Finally develop a strategy by justifying it.*

The vision for the Company was to automate the IT systems from data capturing to data reporting and communication to a different set of audience in different formats in (near) real time, which promotes continuous improvement. The Company already had automated data capturing system to collect data on the shop floor. However, in order to achieve the vision, the Company requires single software, which have the capability of gathering that information from different sources, analysing it and communicating it. The Company would also like to link this software to their SAP implementation (Global decision), which is expected to start in 2004. For selecting this software, the steering committee used the software review done by Nudurupati et al (2000). All the software products and solutions included in the report were not flexible enough to fulfil all the requirements (statistical analysis) of ADL. Also taking into account the vision that the Company is going to have SAP implementation, the committee decided not to invest much in buying software. Hence the committee decided to implement a solution, which can be built using existing IT resources available within the Company (MS Access and Intranet) as well as a simple statistical charting and reporting tool available in the market. The different options available include:

1. MS Access reporting tool (already available in the Company)
2. Ms Excel (available in the Company, but has to be automated and customised to act as statistical tool)
3. NWA QAWS (statistical charting and dynamic reporting tool)

The steering committee decided to use MS Access for data analysis and NWA QAWS for charting, reporting and communicating information. This temporary decision made would work in conjunction with the old data capturing system existing in the Company, as shown in Figure 6.37

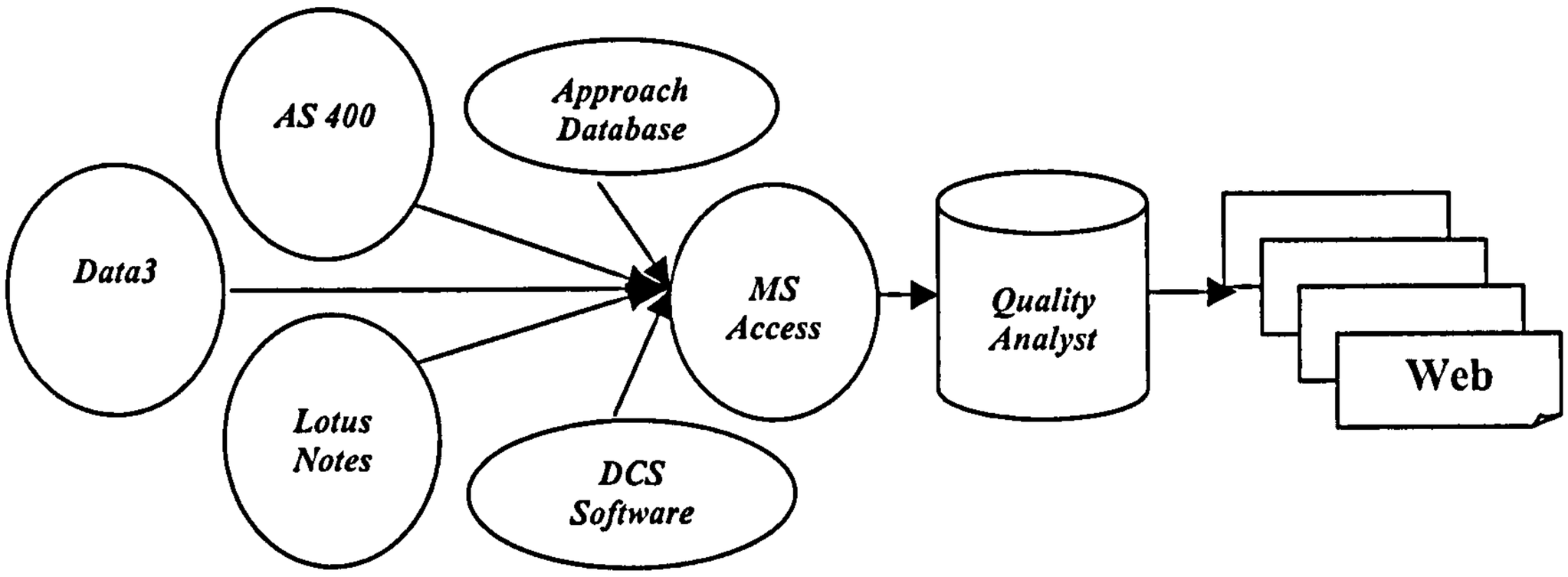


Figure 6.37: Architecture of the IT-PMS at ADL

Tactical Phase: *Identify and specify all the projects required to implement each strategy, prioritise these projects. Develop a tactical plan for each project. Recommend monitoring and control process.*

The previous phase identified only one strategy i.e. only one project, which was small (one year). Before implementing this project, a set of interviews was done with a cross section of employees to capture the initial situation of the Company (this was already done during the assessment phase). This project (IT-PMS implementation) was planned to be implemented in four months, immediately after which another set of interviews would be made. IPMS was decided to be the appropriate framework for deploying performance measures. The implemented system would be monitored for six months after which another set of interviews would be conducted to find the impact of IT-PMS on business (operational site) and management.

6.4.4.3 Actual Implementation of IT-PMS

Deploying Performance Measures and Data Capturing

A fully customised web site was designed for the operational site (ADL) using Html, Java Script, VB Script, CGI Script, NWA Quality Analyst Web Server. As shown in Figure 6.36, the left pane includes a tree structure, which can be modelled to adopt any performance measurement framework. In this Company IPMS was used as the performance measurement framework.

From the objectives of the operational site of the Company, the steering committee decided the performance measures (improvement measures) to be *Line Reliability, End of Line Quality, Customer Complaints, OTIF and Absenteeism* for each line in Clyde Hall and Leven

Hall and for the whole factory on daily basis, weekly basis and monthly basis where applicable. All the measures mentioned are shown in the right pane in Figure 6.38. Depending on the hierarchical level in left pane, corresponding measures are shown in right pane. It is almost simulating a windows explorer, which we generally use in windows operating system. The data source for the above measures were:

- Line Reliability → Data was automatically captured to the central database (Data 3) maintained at Bristol
- End of line Quality → Data was captured onto SASE sheets manually after the end of line checks. This information is manually logged into database (Lotus Approach) located on a stand alone PC
- Customer Complaints → Data was collected from all over the world through their private network to a central database (Lotus Notes) maintained in Bristol
- On Time In Full (OTIF) → Data was collected to the central database (Data 3)
- Absenteeism → Data was collected to database (DCS Software)

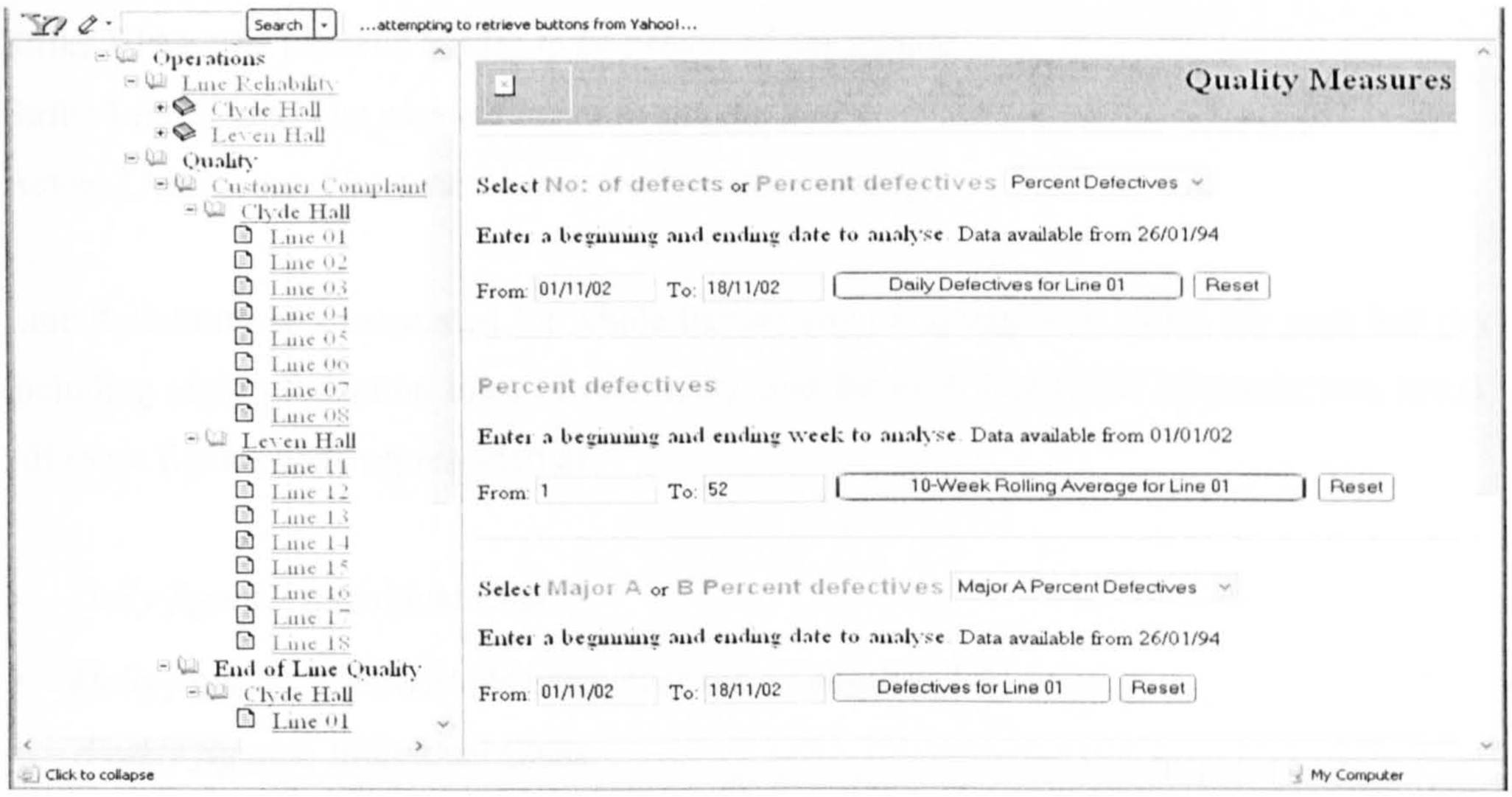


Figure 6.38 Web page displayed on the Intranet of ADL

Most of the raw data was protected and restricted access was given to the people who required it through their private network (Global Intranet). However, due to the limitations of analytical and charting capabilities, the steering committee had decided to gather all the scattered data into a single source (Microsoft Access database), from which different calculations and analysis were performed.

Data Analysis (Calculations)

All the calculations in this section were carried out in several queries facilitated by MS Access.

Line Reliability

$$\text{Line Reliability} = \frac{(\text{Actual BPM})}{(\text{Strike BPM})} \text{// used for calculating daily figures}$$

$$= \frac{(\text{Actual Dozens} * 12)/\text{Run Minutes}}{(\text{Strike BPM})}$$

$$= \left(\frac{\text{Actual Dozens} * 12}{\text{Strike BPM} * 60}\right) * \left(\frac{60}{\text{Run Minutes}}\right)$$

$$= \frac{(\text{Strike Line Hours})}{(\text{Actual Line Hours})} \text{// used for calculating weekly figures}$$

Actual BPM: *The actual bottles produced per minute*

Strike BPM: *The planned bottles to be produced per minute*

Strike Line Hours: *The planned hours to run the line*

Actual Line Hours: *The actual hours the line was running*

Line Reliability was calculated for whole factory (by including both halls), for each hall (by including eight production lines in each hall), and for each line (total 18 production lines). All these figures were represented as:

- *Daily figures:* Individual Chart
- *Daily figures:* $\overline{X}$ - Chart *(Moving Average – Length = 10)*
- *Weekly figures:* Individual Chart
- *Weekly figures:* $\overline{X}$ - Chart *(Moving Average – Length = 10) (See Figure 4d)*

End of Line Quality

$$\%\,\text{Defectives} = \frac{(\text{Number of Defectives in each Sample})}{(\text{Number Sampled})}$$

$$= \frac{(\text{Critical A} + \text{Critical B} + \text{Major A} + \text{Major B})\ \text{Defects}}{(\text{Number Sampled})}$$

Critical A, Critical B, Major A and Major B defects were further classified as shown in Appendix G.

Number of Defectives as well as % Defectives were calculated for whole factory (by including both halls), for each hall (by including eight production lines in each hall), and for each line (total 18 production lines). All these defects are represented as:

- Daily – Total defects, Total % defects, Critical A defects, Critical %A defects, Critical B defects, Critical %B defects, Major A defects, Major %A defects, Major B defects, Major %B defects: Individual Chart
- Weekly – Total defects, Total % defects, Critical A defects, Critical %A defects, Critical B defects, Critical %B defects, Major A defects, Major %A defects, Major B defects, Major %B defects: $\overline{X}$ - Chart (Moving Average – Length = 10) (See Figure 4e)
- Classification of all defects using Pareto Analysis between selected dates for any particular Production Line (can be a day, a week, a month, an year, etc.) (See Figure 4c)
- Classification of all defects using Pareto Analysis between selected dates for any particular Product (can be a day, a week, a month, an year, etc.)
- Summary Report on Critical A, Critical B, major A, Major B and Total defects (See Figure 4b)

Customer Complaints

Number of customer complaints was calculated for the whole factory and for each production line (total 18 production lines). All these complaints were presented as:

- Daily figures: Individual Chart
- Daily figures: $\overline{X}$ - Chart (Moving Average – Length = 5)
- Weekly figures: Individual Chart
- Weekly figures: $\overline{X}$ - Chart (Moving Average – Length = 5) (See Figure 4a)

On Time In Full (OTIF)

$$\%\,\text{Orders OTIF} = \frac{(\text{Number of Orders Delivers to Customers in time})}{(\text{Total Number of Orders Processed})}$$

% Orders OTIF was calculated for whole factory (by including both halls), for each hall (by including eight production lines in each hall), and for each line (total 18 production lines). All these defects were presented on monthly basis.

Absenteeism

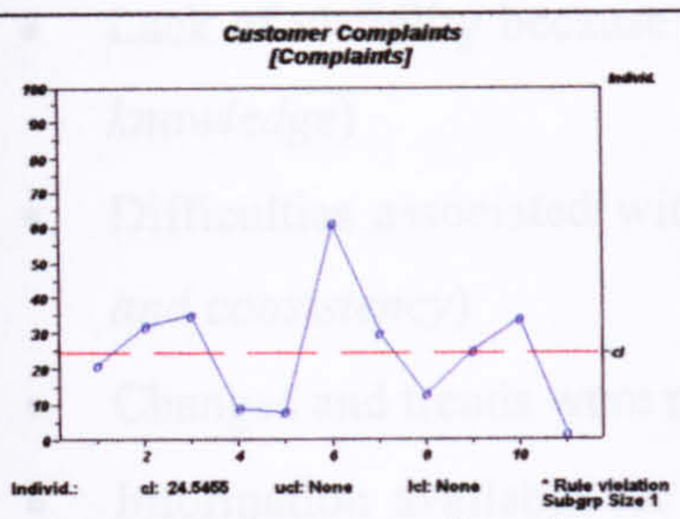
$$\%\,\text{Absenteeism} = \frac{(\text{Number of People Absent})}{(\text{Total Number of People Employed})}$$

% Absenteeism was calculated for Engineers and Operators for each hall as well as whole factory (including both halls) on monthly basis.

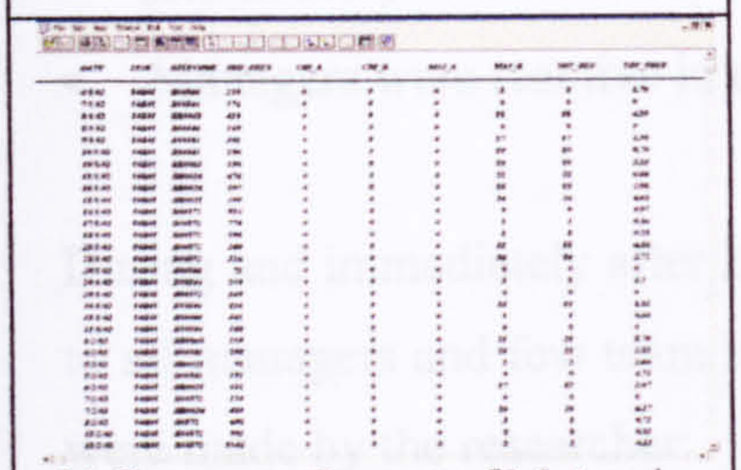
Reporting and Communication

As mentioned in the above sections, the same IT technologies (Html, Java Script, VB Script, CGI Script, NWA Quality Analyst Web Server) were used in reporting and communicating information as Normal Charts, Statistical Charts, Pareto Analysis and Summary Reports. These reports and charts (information) were communicated to different people through the Intranet within the Company.

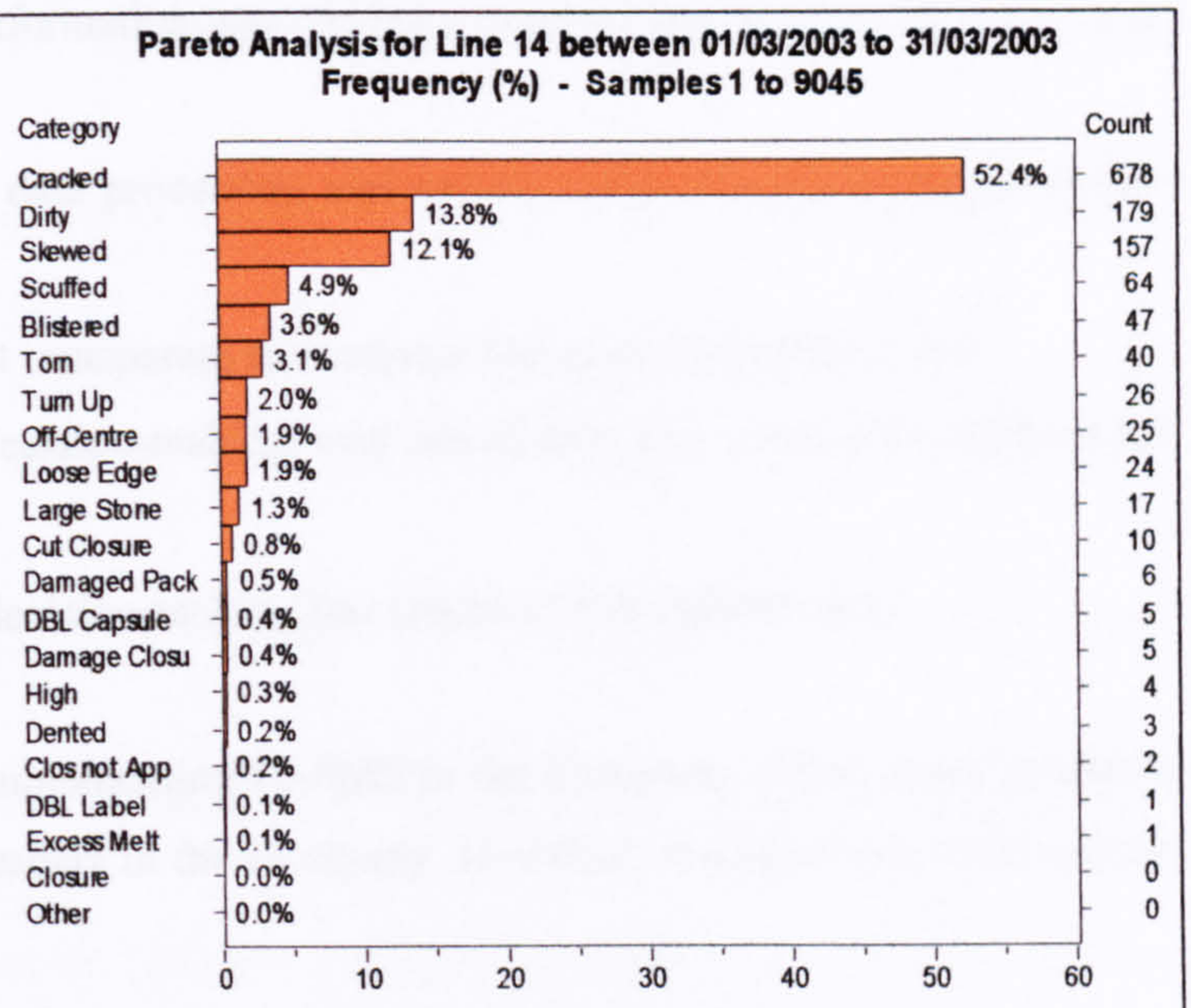
The information was dynamically available to the users. This was made possible with NWA QAWS Run file technology. Once the user selects an option and clicks a button on the web page as shown in Figure 6.39 the software platform automatically connects to the MS Access database and gets that information in the form of normal charts, statistical quality control charts as shown in Figures 6.39a, 6.39d, 6.39e and 6.39f, Pareto analysis as shown in Figure 6.39c as well as summary report as shown in Figure 6.39b.



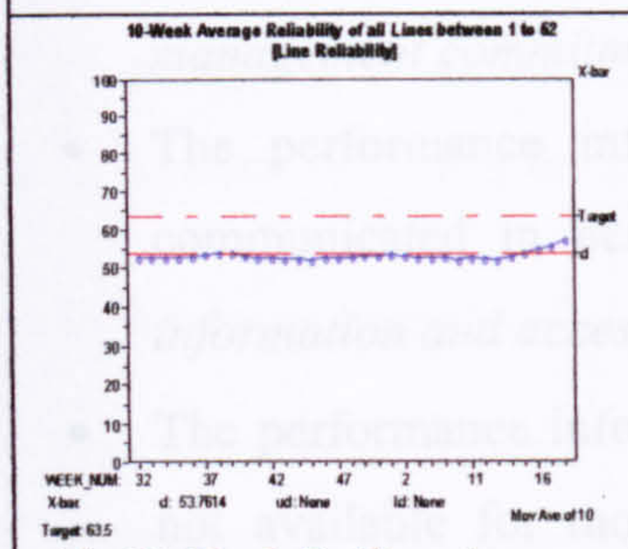
(a) Weekly Customer Complaints



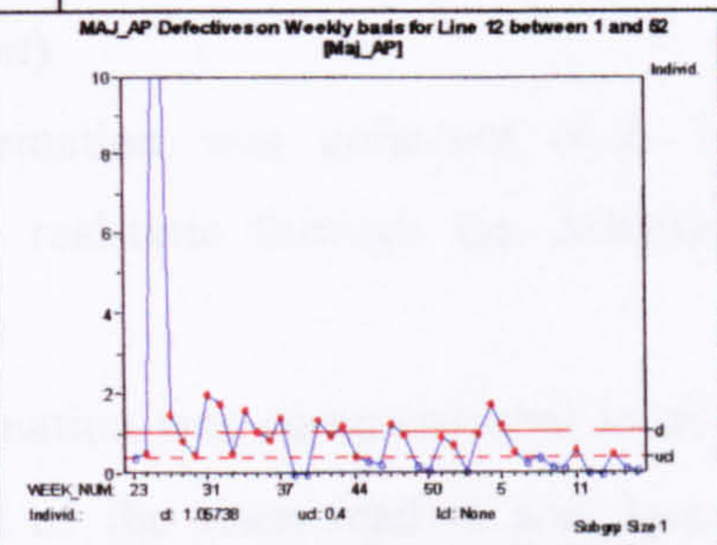
(b) Summary Report of Major A and B, Critical A and B Defects on Line 01



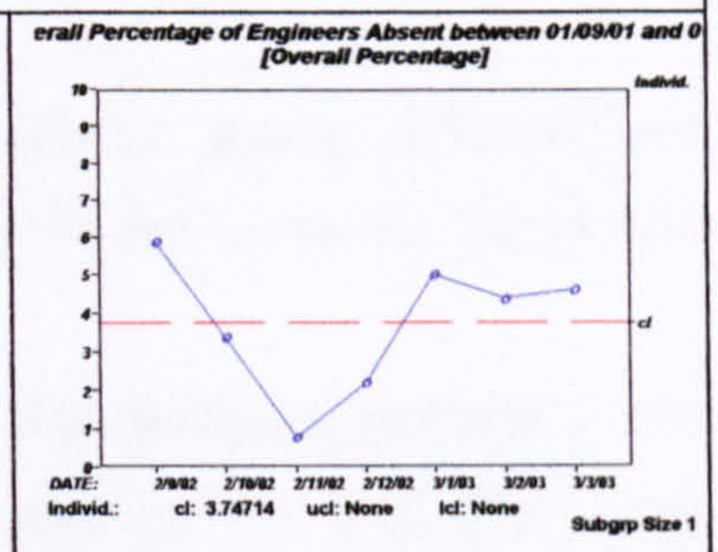
(c) Pareto Analysis of Defect Classification on Line 14



(d) 10-Week Rolling Average: Line Reliability of all Lines with a Target = 63.5



(e) Percentage of Major A Defects on Line 12 including an Upper Control Limit =0.4%



(f) Overall Percentage of Engineers absenteeism between 01/09/02 to 01/04/03

Figure 6.39: Sample pages available on the Intranet of ADL

6.4.4.4 Impact of IT-PMS on Management

6.4.4.4.1 Action Case Results

Summary of Personal Observation

Before IT-PMS was implemented at ADL:

- Operations director, head of operations, head of quality were committed to the project (there was *senior management commitment* but *no drive*)
- Performance information was not available at single source (no *up-date information and access*)
- Having few lagging indicators and not having any leading indicators

- Lack of visibility because information was hidden (no *dissemination of information and knowledge*)
- Difficulties associated with data processing and sorting information (*no data accuracy and consistency*)
- Changes and trends were not transparent to everyone (no *open communication*)
- Information available for decision-making was out-of-date (no *up-to-date information and access*)
- Managers were reactive in decision-making (no *confidence in information*)

During and immediately after implementing IT-PMS in the Company, it was made available to all managers and few team leaders in the Company. However, the following observations were made by the researcher:

- The senior management were still committed with the implementation and its use (*senior management commitment*)
- The performance information was collected from different source, analysed and communicated in near real-time through the Intranet of the Company (*up-to-date information and access*)
- The performance information was communicated to all the managers. However it was not available for most of the team leaders and operators on the shop floor (*open communication* to some extent)
- Changes and trends were transparent, however some of the managers were not using the system (*dissemination of information and knowledge* and *visibility*)
- The senior management did not gain confidence in the information generated by the IT-PMS (no *confidence in information*)
- The senior management did not take drive into their hands in making people use the IT-PMS (*no drive* from senior management)
- Managers were still reactive in decision-making (no *confidence in information*)

For the next six months, the reliability manager with the help of the researcher took the drive into his hands in making people use the information from IT-PMS and driven the continuous improvement teams to use the information in improving the performance on lines. However after six months of implementation:

- The senior management gained confidence in the information generated by the IT-PMS (*confidence in information*)
- The senior management were more committed with the implementation and its use (*senior management commitment*)
- The head of operations and head of quality took the drive into their hands in making people use the information generated through the system (*drive from senior management*)
- IT-PMS was rolled out to lower levels (team leaders and operators on the shop floor) (*open communication*)
- People started using the system as their routine part of the business (*people are using information in routine business*)
- IT-PMS made some impact on transparency and visibility of information, identifying the weak areas of the operational processes, continuous improvement of operational processes, pro-active decision-making and positive behaviour of people.
- However, at the end of the project the senior management were worried in finding a champion to keep the IT-PMS alive (*no champion to update IT-PMS*)

Summary of Interviews

The weightings obtained in the interviews are summarised into table as shown in the Appendix H. This data is classified as data on technical factors, people factors as well as management and business implications as shown in Figures 6.40, 6.41 and 6.42 respectively.

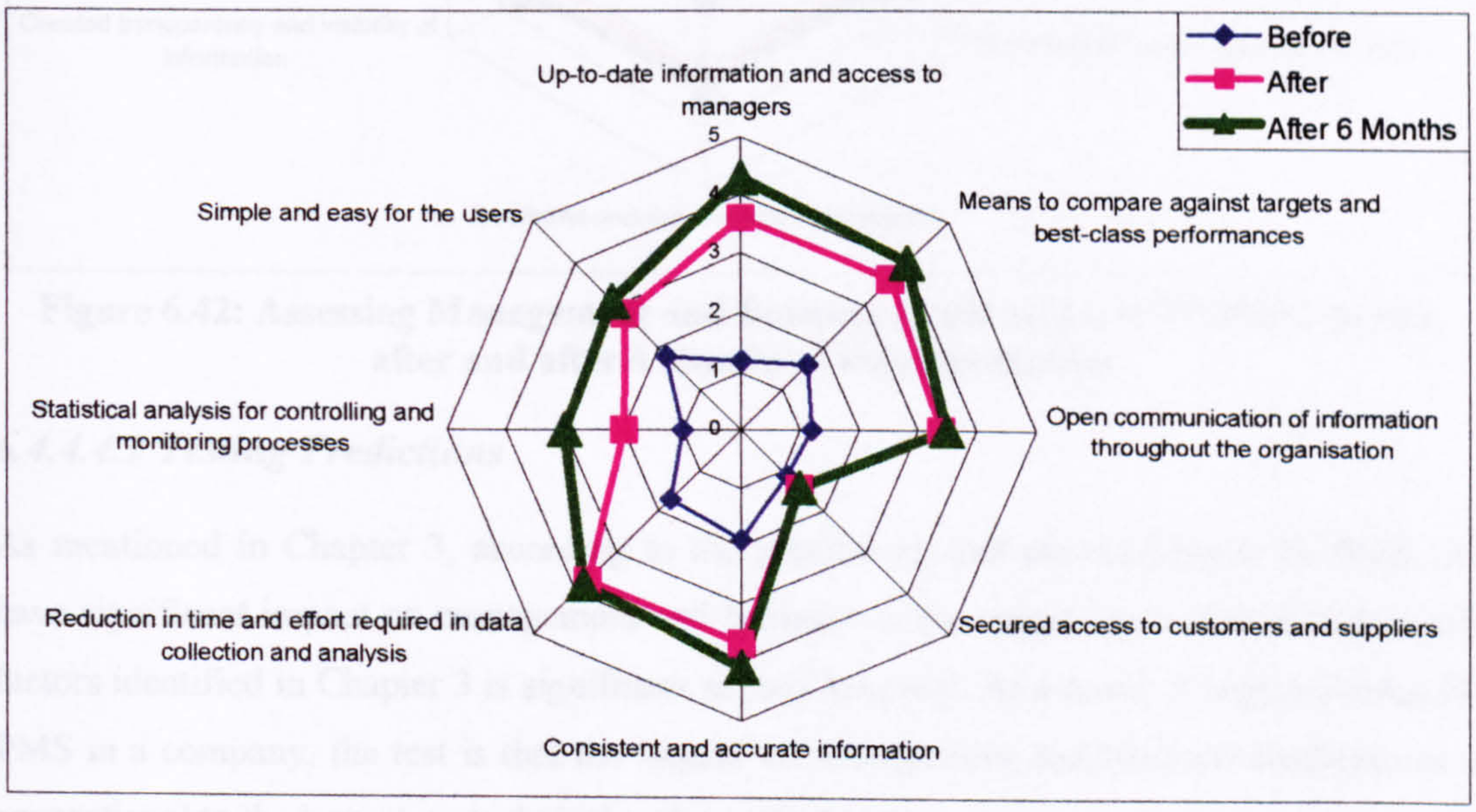


Figure 6.40: Assessing Technical Factors of IT-PMS: before, after and after 6 months of implementation

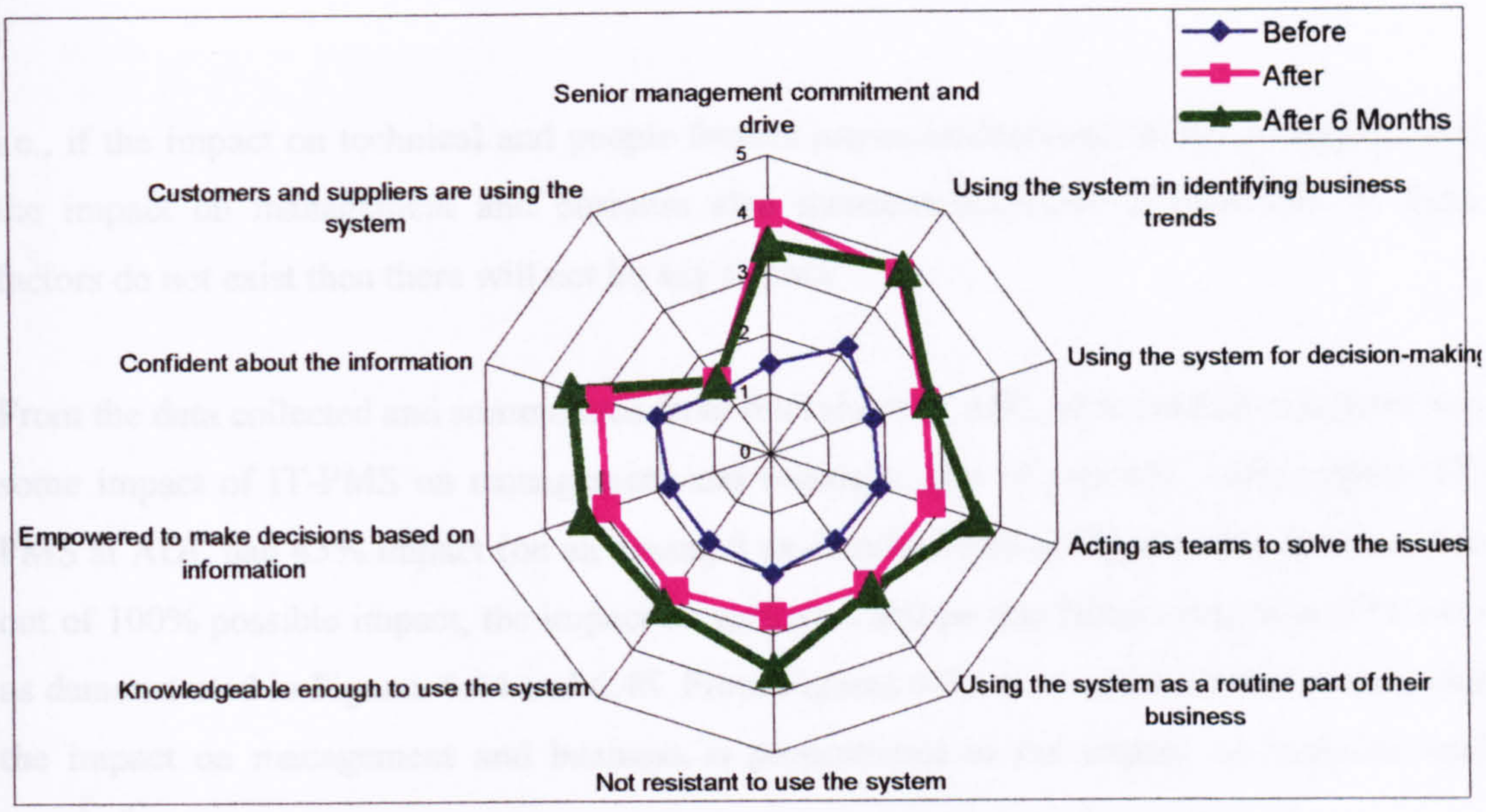


Figure 6.41: Assessing People Factors of IT-PMS: before, after and after 6 months of implementation

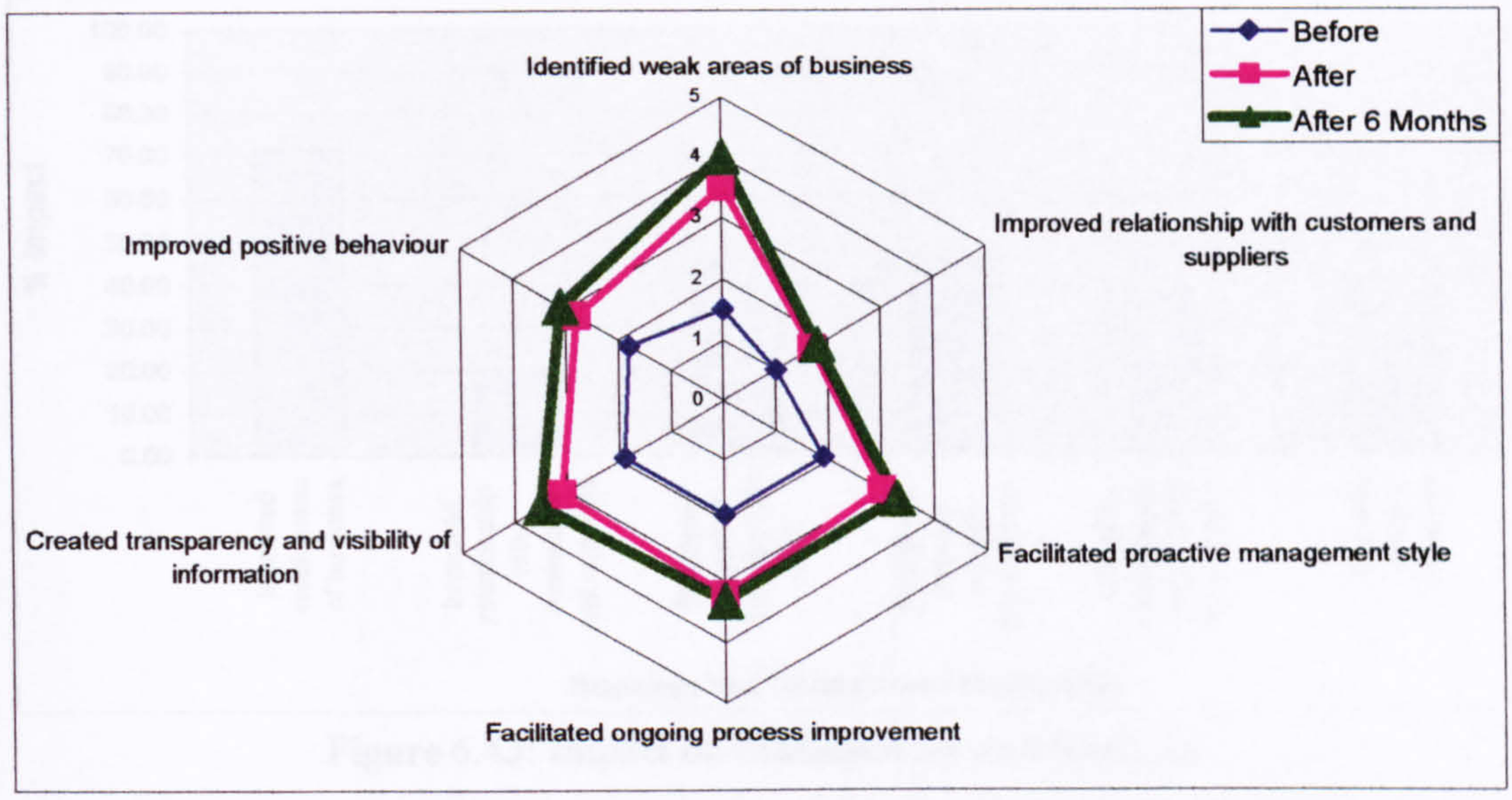


Figure 6.42: Assessing Management and Business Implications of IT-PMS: before, after and after 6 months of implementation

6.4.4.4.2 Testing Predictions

As mentioned in Chapter 3, according to the predictions and pre-conditions, IT-PMS will have significant impact on management and business, if the impact on technical and people factors identified in Chapter 3 is significant in the Company. As a result of implementing IT-PMS in a company, the test is that the impact on management and business implications is proportional to the impact on technical and people factors

$$\textit{Impact of IT-PMS on Management and Business} \propto \textit{Impact of IT-PMS on Technical and People Factors}$$

i.e., if the impact on technical and people factors increases/decreases in the company, then the impact on management and business also increases/decreases respectively. If these factors do not exist then there will not be any impact.

From the data collected and summarised from interviews at ADL, it is evident that there was some impact of IT-PMS on management and business. Out of possible 100% impact, IT-PMS at ADL had 45% impact (on an average) as demonstrated in Figure 6.43. It is because out of 100% possible impact, the impact on technical and people factors was also 50% each as demonstrated in Figures 6.44 and 6.45. From Figures 6.43, 6.44 and 6.45 it is evident that the impact on management and business is proportional to the impact on technical and people factors.

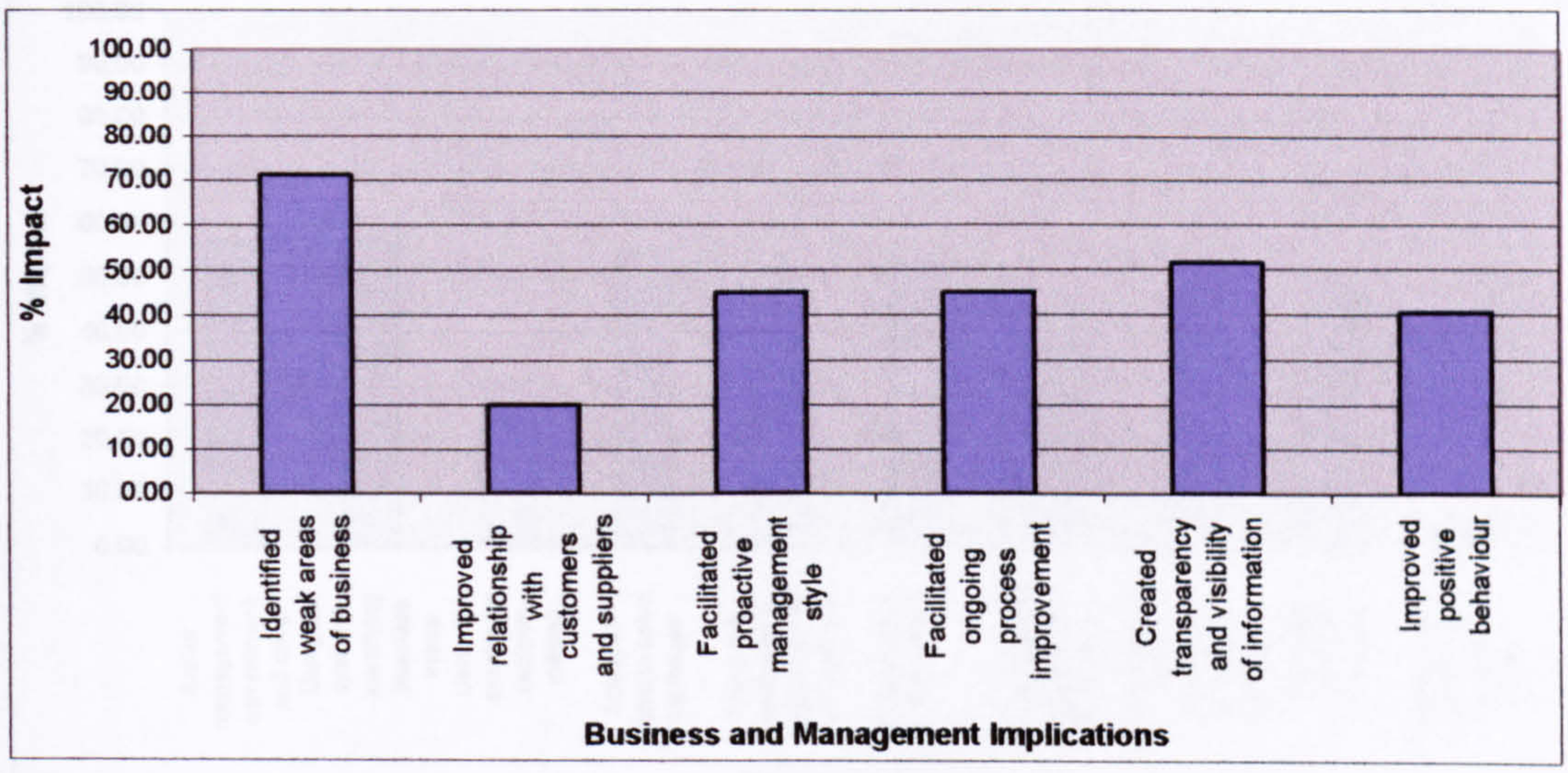


Figure 6.43: Impact on Management and Business

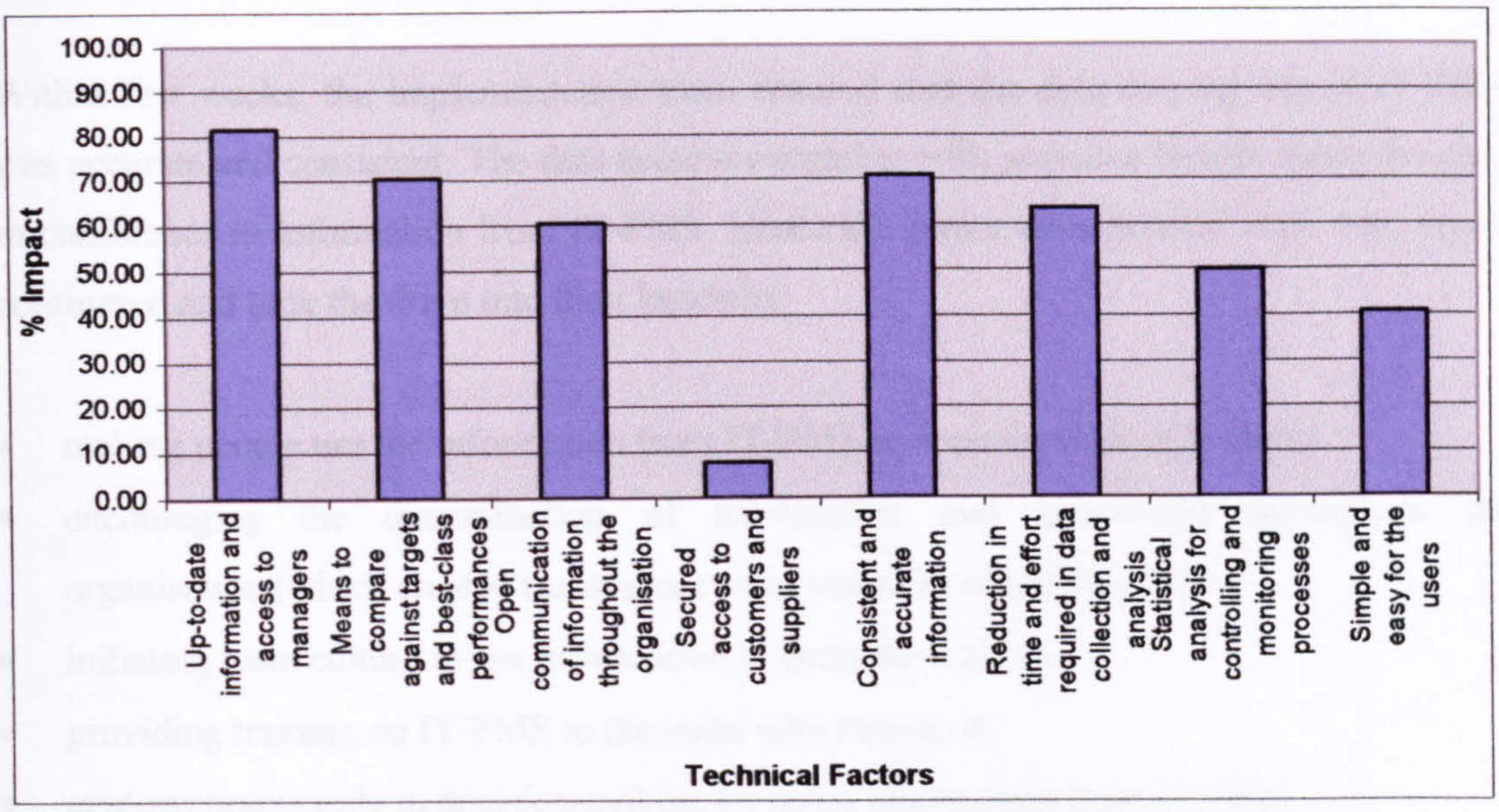


Figure 6.44: Impact on Technical Factors

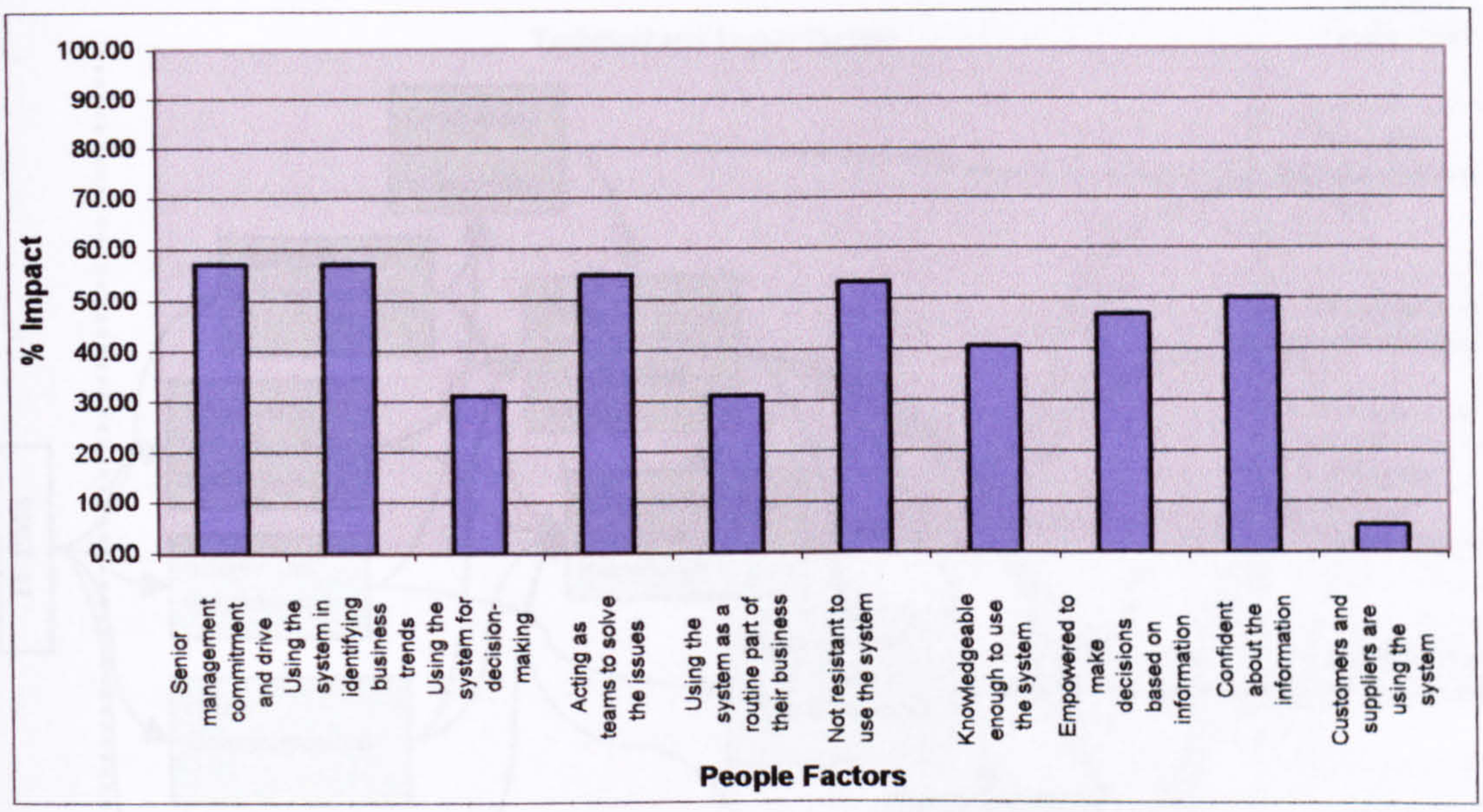


Figure 6.45: Impact on People Factors

6.4.4.4.3 Structuring the relationship between Factors and Implications

From the beacon of bearings, i.e., IT-PMS implementation as shown in Figure 6.46, the immediate factors, which evolved at ADL were:

- presentation of up-to-date information and access to the people
- communication of information throughout the organisation
- reduction in time and effort to do the data collection, analysis and communication
- information was very simple and easy to the users at HSL (revealed in the interviews)

Within few weeks, the implementation team ensured that the data coming out of IT-PMS was accurate and consistent. The data accuracy together with previous factors led to the gain in confidence in information from IT-PMS. Hence the senior management were very much committed and took the drive into their hands by:

- making people use the information from IT-PMS as a routine part of business
- encouraging the dissemination of information and knowledge throughout the organisation (which created transparency and visibility of information)
- initiating team culture to use information in decision-making
- providing training on IT-PMS to the users who require it
- empowering people in decision-making by using information from IT-PMS

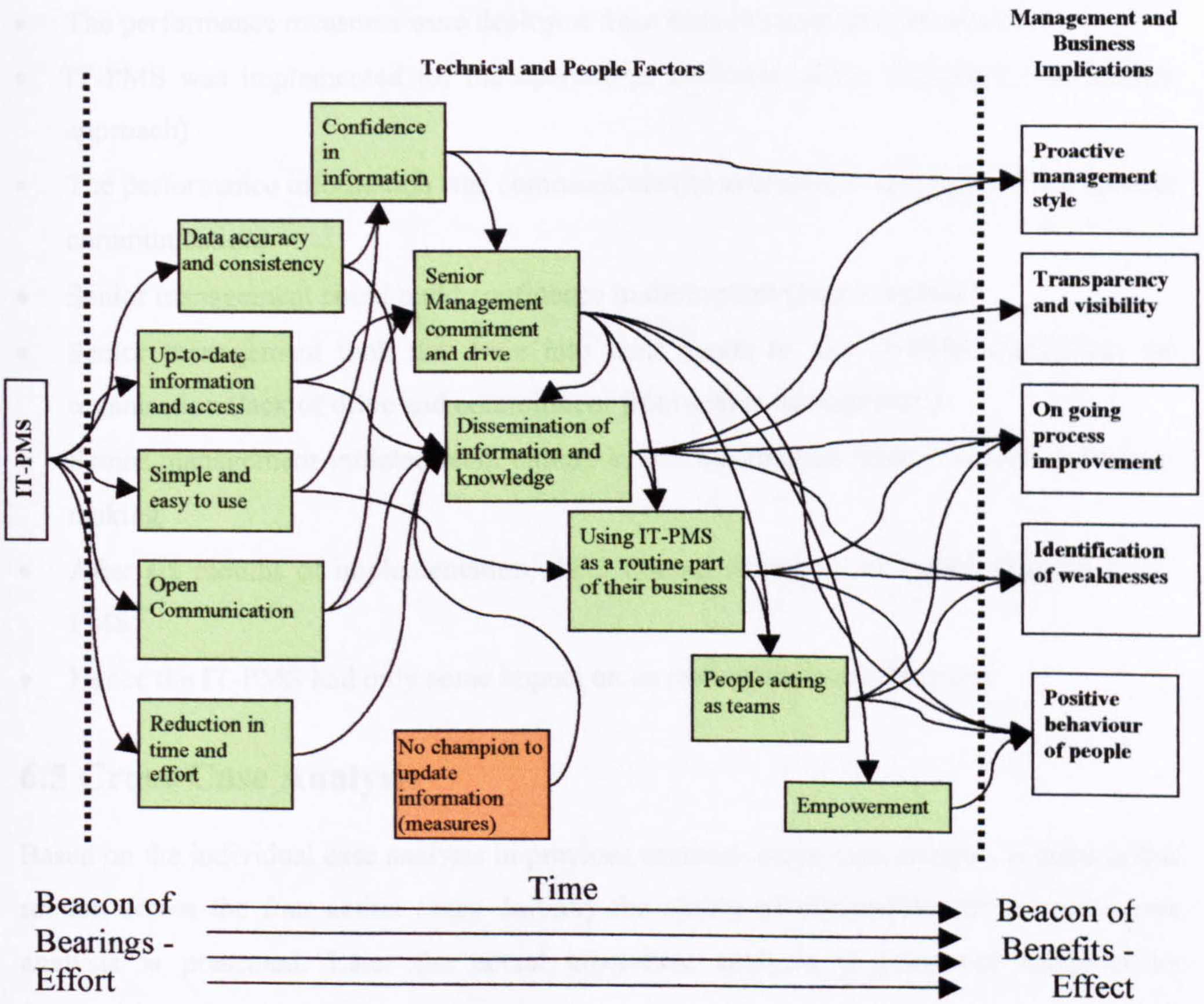


Figure 6.46: Structuring the relationships between technical and people factors as well as management and business implications

Since the performance measures change quite often based on business priorities at ADL, someone in the Company should be able to update these changes in the software. However the Company does not have a champion (in future) to update information in IT-PMS. This will affect the dissemination of information and knowledge, which in turn will affect other factors.

All these factors (technical and people factors) led towards beacon of benefits, i.e. implications on management and business as shown in Figure 6.44. Since most of the factors evolved have some positive impact on one another there was also only some improvement on the implications (benefits). After six months, this was reflected with some impact on the five implications.

6.4.4.4.4 Conclusion

- The performance measures were deployed from their strategy (proper measures)
- IT-PMS was implemented for the operational activities of the Company (not holistic approach)
- The performance information was communicated to everyone in the organisation (proper communication)
- Senior management could build confidence in the system (data accuracy)
- Senior management took the drive into their hands to use IT-PMS throughout the organisation (lack of drive and commitment from senior management)
- Senior management initiated team culture to use information from IT-PMS in decision making
- After six months of implementation, there was no champion to update changes in IT-PMS
- Hence the IT-PMS had only some impact on its management and business

6.5 Cross-Case Analysis

Based on the individual case analysis in previous sections, cross-case analysis is done in this section across the four action cases. Initially the choice of dimensions for the cross-case analysis is presented. Later the actual cross-case analysis is presented followed by conclusion.

6.5.1 Choice of dimensions

According to Lillrank et al (2001), the basic dimensions of the EEM diagram, which are used in finding the impact of an IT-PMS are:

- Beacon of bearings: The resources already existing in the Company and new resources obtained from external sources for implementing the system
- Terrain and a compass: The control processes involved to use the effort to realise the effects
- Beacon of benefits: The value generated by the system, i.e. business benefits such as pro-active management style, improved behaviour of people, continuous improvement, improved relationships on supply chain, etc.

According to Pettigrew (1990), the study of his contextualist approach includes three dimensions:

- Content of the change project: It refers to the particular areas of transformation under examination such as technology, manpower, products, geographical positioning, corporate culture, etc.
- Process of change project: It refers to the actions, reactions, and interactions from the various people (involved in the change process) as they seek to move the firm from its present to its future state
- Context in which changes occur: Outer context refers to the social, economic, political, and competitive environment in which the firm operates. Inner context refers to the structure, corporate culture and political context within the firm through which ideas for change have to proceed

From the pilot case and individual action cases the different dimensions identified are:

- Resources allocated for this project: Such as the databases existing in the Company, the software used for IT-PMS, people involved in the project, etc.
- Senior management commitment and drive: In addition to the actual commitment of senior management the dirve or initiative taken by them to make employees use IT-PMS in decision-making

- Project management: Overall attendance and contribution to the meetings throughout the project
- Initial impact on technical factors: Such as data collection, analysis, dissemination, accuracy, etc.
- Initial impact on people factors: Such as using data in decision-making, resistance, empowerment etc.
- Final impact on management and business: Such as identifying weak areas of business, continuous improvement, relationship with customers and suppliers, management style etc.

To summarise, the dimensions from the above perspectives are classified into three main categories, which are used to do cross-case analysis for this research, which are:

❖ Initial State
  - Scope of business
  - IT resources allocated
  - Steering committee allocated
  - Implementation committee allocated
  - Senior management commitment

❖ Implementation State
  - Project management
  - Support/involvement of IT department
  - Major issues of implementation
  - Senior management commitment

❖ Post-implementations State
  - Drive form senior management
  - Impact on technical factors
  - Impact on people factors
  - Impact on management and business

6.5.2 Cross-Case Analysis

As seen in Table 6.2, IT-PMS was implemented throughout the business at HSL and HWL. However it was implemented for only operational activities at SLC and ADL. IT resources used in all four companies are almost the same with a database, SPC/Chart tool and Intranet.

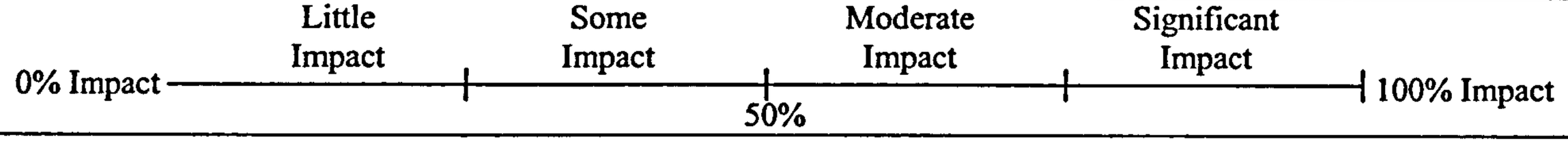
Steering Committees and Implementation Committees were established at all four companies involving the people from the company as well as external advisors from the University. Although the senior management was high at HSL, it was only moderate at SLC, HWL and ADL. The project management was almost similar in all four companies with four meetings, however the attendance at these meetings was full at HSL and only partial at SLC, HWL and ADL (proportional to the senior management commitment).

At SLC, all measures derived could not be implemented. This was due to the incapability of data capturing system existing in the Company. The data required for measuring these indicators could not be captured. Hence IT-PMS was implemented with only few measures, which resulted with incomplete information. This did not build confidence in management to use the IT-PMS in decision-making. Hence during and after the implementation, the senior management lost the commitment and did not take the drive in making people use the system. This was reflected with less impact on technical and people factors as well as management and business implications as demonstrated in Figures 6.47 to 6.49.

Table 6.2 Cross-Case Analysis

Dimension for Cross-Case Analysis		SLC	HSL	HWL	ADL
Initial State	Scope of business	Operational activities	Whole business	Whole business	Operational activities
	IT resources allocated	MS Access, NWA Quality Analyst Web Server, Intranet	Cognos Impromptu and Powerplay, Intranet	Sage Accounting Software, MS Access, NWA Quality Analyst Web Server, Intranet	Lotus Approach, MS Access, NWA Quality Analyst Web Server, Intranet
	Steering committee	Managing Director, Operations Manager, IT Manager, TCA, EA1, EA2, Researcher	Operations Director, Projects Manager, IT Development Manager, TCA1, TCA2, EA1, EA2, Researcher	Operations Manager, Planning Manager, TCA, EA1, Researcher	Operations Director, Head of Operations, Head of Quality, Line Reliability Manager, EA3, Researcher
	Implementation committee	Action Researcher, TCA and Network Administrator	TCA1, TCA2, IT Developer	Action Researcher, TCA	Action Researcher, Line Reliability Manager
	Senior management commitment	Only some of the managers were enthusiastic	Most of the managers were enthusiastic	Most of the managers were enthusiastic	Most of the managers were enthusiastic
Note: Action Researcher – Sai Nudurupati, EA1 (External Advisor) – Umit Bititci, EA2 (External Advisor) – Peter Ball, EA3 (External Advisor) – Trevor Turner					
Implementation State	Project management	Four meetings, partial attendance	Four meetings, full attendance	Three meetings (one cancelled), partial attendance	Four meetings, partial attendance
	Support/involvement of IT department	Partial support	Full support	No support	No support
	Major issues of implementation	Automated data capturing system in the company was incapable to collect data required for few measures. It was not solved. Due to this some of the measures were not implemented. Employees were not knowledgeable enough to use the IT-PMS implemented	Initially there was no automated data collection system, however during the post implementation they got SCADA system for automated data capturing. All the measures were implemented. Training was provided for the users to use IT-PMS	The data required for measuring some of the performance indicators did not exist. Due to this some of the measures were not implemented. Training was provided for the users to use IT-PMS	Even though the raw data was available, the access to some of the databases was restricted by parent company. The data from these databases has to be downloaded (duplicated) for further analysis. Hence the information generated from these databases was not real-time. All the measures were implemented. Employees were knowledgeable enough to use IT-PMS
	Senior management commitment	Only few managers were enthusiastic	Most of the managers were enthusiastic	Most of the managers were enthusiastic	Most of the managers were enthusiastic

Dimension for Cross-Case Analysis			SLC	HSL	HWL	ADL
Post-implementations State	Drive from Senior Management in making the employees use the system		No body took the drive	Managing Director took the drive	Operations Director took the drive	Operations Director took the drive
	Impact on technical factors	Up-to-date information and access to managers	Little	Moderate	Moderate	Significant
		Means to compare against targets and best-class performances	Little	Moderate	Moderate	Moderate
		Open communication of information throughout the organisation	Some	Moderate	Moderate	Moderate
		Secured access to customers and suppliers	Little	Little	Some	Little
		Consistent and accurate information	Little	Moderate	Moderate	Moderate
		Reduction in time and effort required in data collection and analysis	Some	Moderate	Moderate	Moderate
		Statistical analysis for controlling and monitoring processes	Some	Moderate	Moderate	Moderate
		Simple and easy for the users	No	Some	Some	Some
	Impact on people factors	Senior management commitment and drive	No	Significant	Moderate	Moderate
		Using the system in identifying business trends	Little	Moderate	Some	Moderate
		Using the system for decision-making	Little	Moderate	Moderate	Some
		Acting as teams to solve the issues	Some	Moderate	Some	Moderate
		Using the system as a routine part of their business	Little	Moderate	Moderate	Some
		Not resistant to use the system	Some	Moderate	Some	Moderate
		Knowledgeable enough to use the system	No	Some	Some	Some
		Empowered to make decisions based on information	Little	Some	Some	Some
		Confident about the information	Little	Moderate	Moderate	Moderate
		Customers and suppliers are using the system	Little	Little	Little	Little
	Impact on implications	Identified weak areas of business	Little	Moderate	Moderate	Moderate
		Improved relationship with customers and suppliers	Little	Some	Some	Little
		Facilitated proactive management style	Some	Moderate	Some	Some
		Facilitated ongoing process improvement	Little	Moderate	Moderate	Some
		Created transparency and visibility of information	Little	Moderate	Moderate	Moderate
		Improved positive behaviour	Little	Moderate	Some	Some



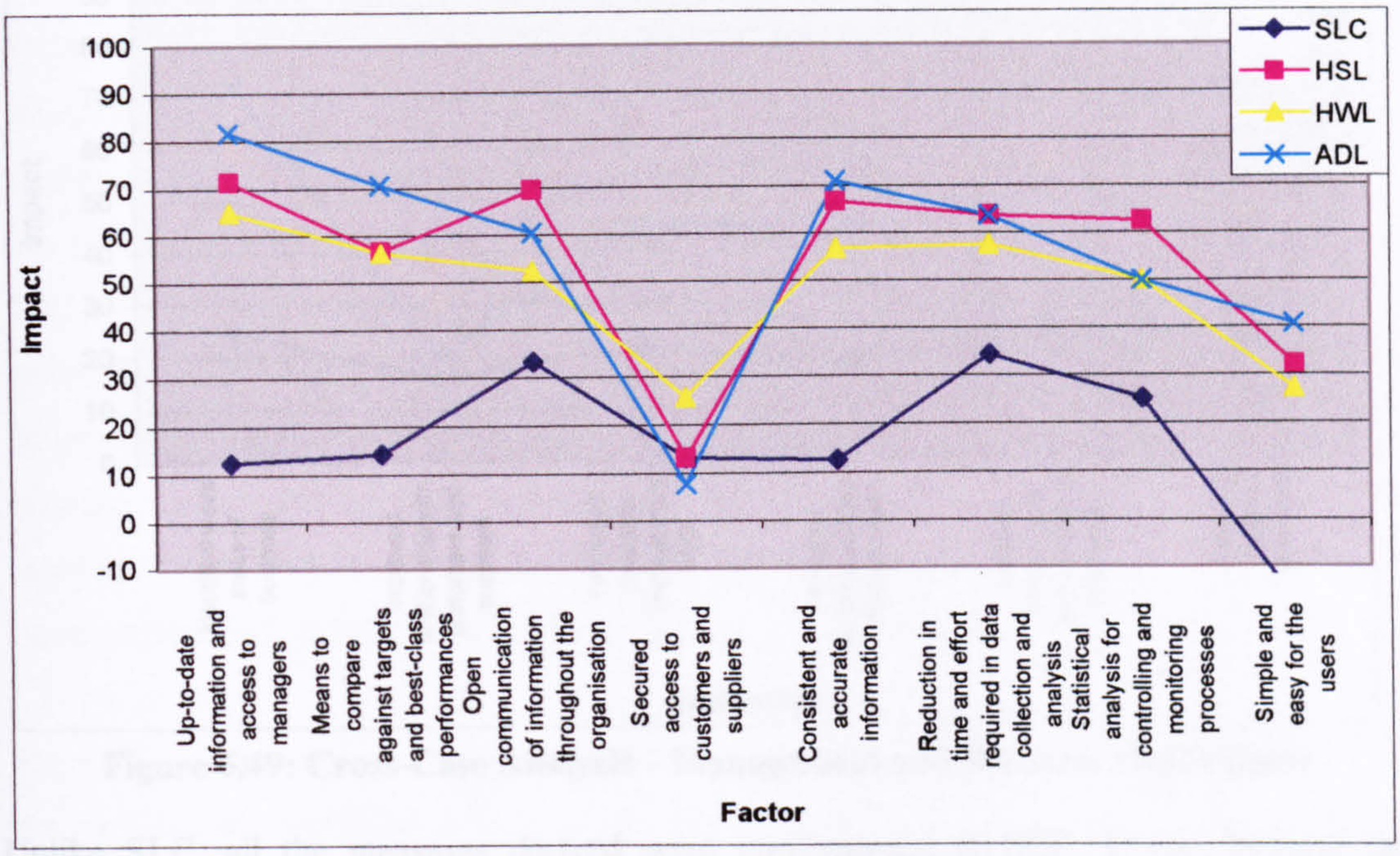


Figure 6.47: Cross-Case Analysis – Technical Factors

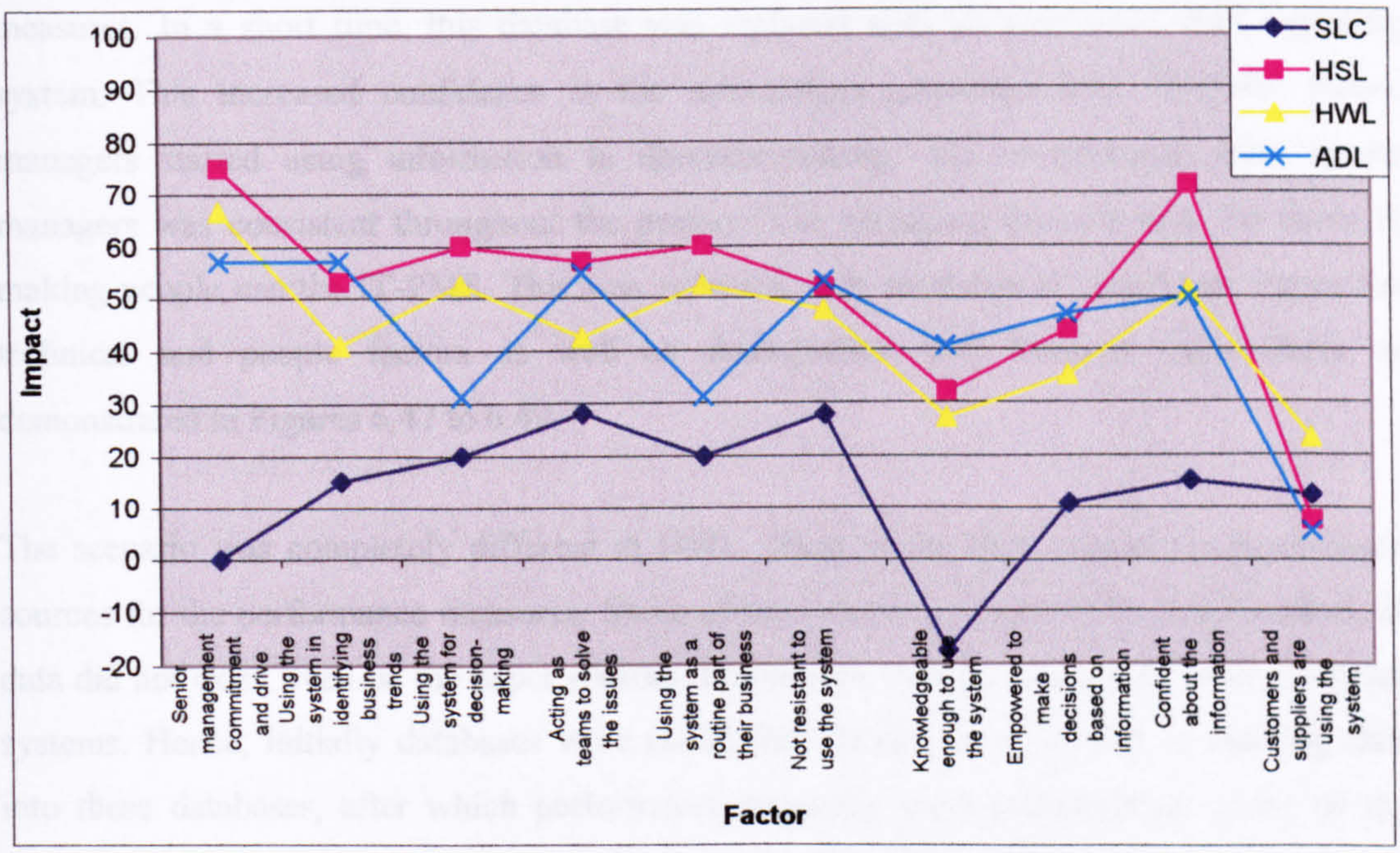
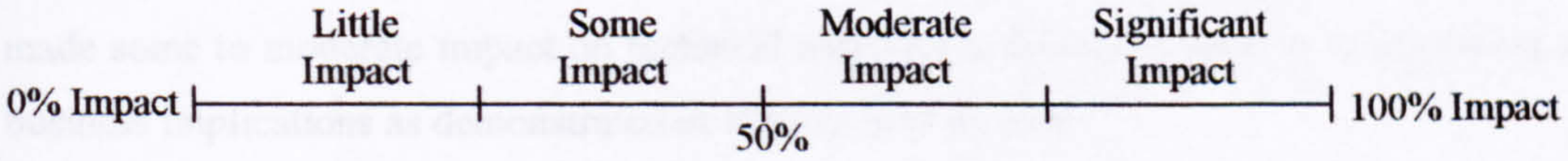


Figure 6.48: Cross-Case Analysis – People Factors



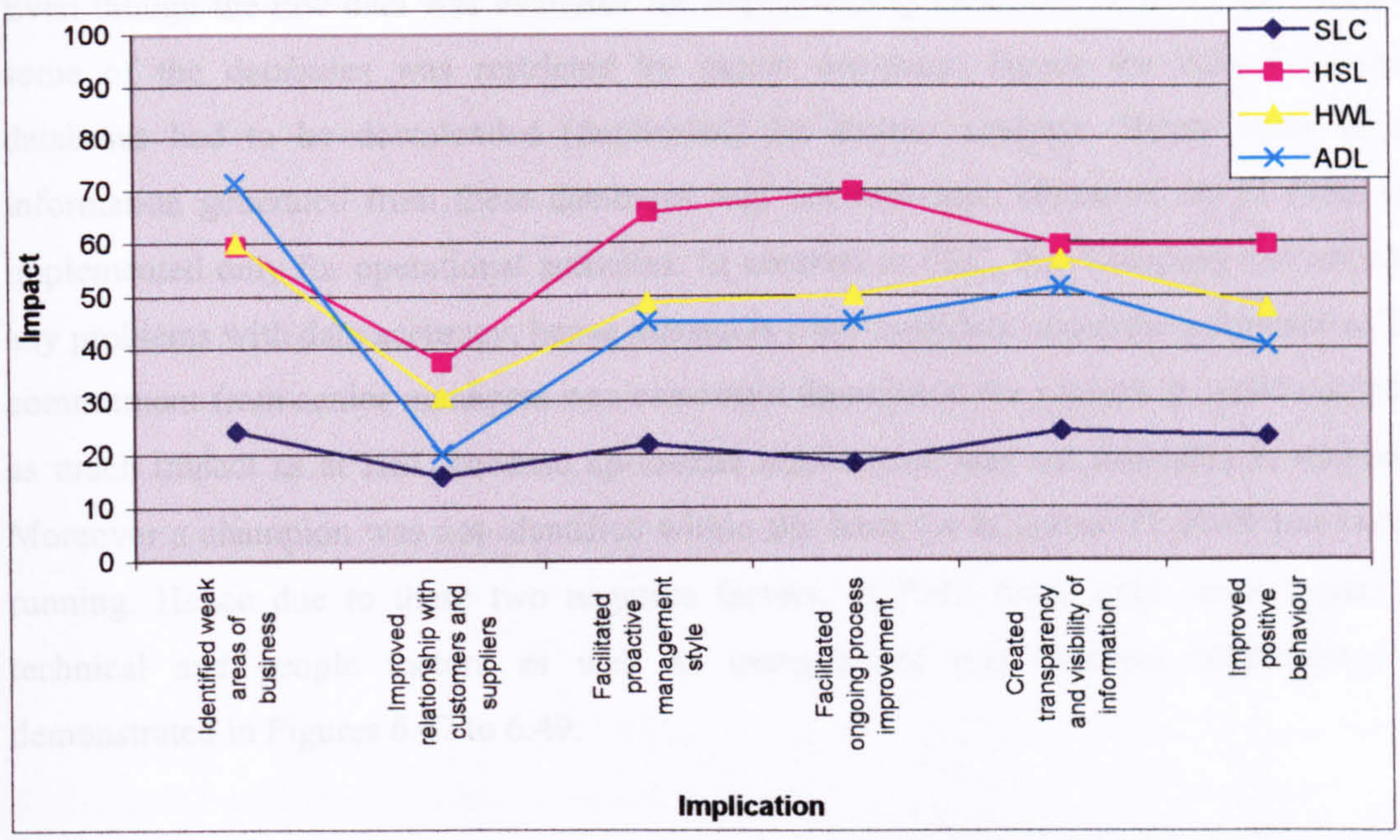


Figure 6.49: Cross-Case Analysis – Management and Business Implications

Unlike SLC, all the measures *derived* were *implemented* at HSL. It was because the Company established a database to capture all the required data to implement *all the* measures. In a short time, this database was replaced with an automated data capturing system. This increased confidence in the information generated from IT-PMS. Hence managers started using information in decision-making. The commitment from senior managers was consistent throughout the project. The managing director took the drive in making people use the IT-PMS. This was reflected with moderate to significant impact on technical and people factors as well as management and business implications as demonstrated in Figures 6.47 to 6.49.

The scenario was completely different at HWL. Most of the data existed on paper-based sources for the performance measures. Some of the measures could not be implemented, as data did not exist, even on the paper sources. Employees were not very good with computer systems. Hence, initially databases were established, people were trained in entering data into these databases, after which performance measures were implemented. Some of the managers felt that too much change was implemented at HWL without any pauses to settle down. Hence IT-PMS could not make moderate to significant impact as at HSL. However it made some to moderate impact on technical and people factors as well as management and business implications as demonstrated in Figures 6.47 to 6.49.

Even though the raw data was available for implementing measures at ADL, the access to some of the databases was restricted by parent company. Hence the data from these databases had to be downloaded (duplicated) for further analysis. Hence some of the information generated from these databases was not real-time. However the IT-PMS was implemented only for operational activities. In contrast to SLC, this Company did not have any problems with data accuracy, hence managers were confident about the information. The commitment from senior managers was consistent throughout the project. It could not make as much impact as at HSL because up-to-date information was not available in real-time. Moreover a champion was not identified within the business to update IT-PMS and keep it running. Hence due to these two negative factors, IT-PMS made only some impact on technical and people factors as well as management and business implications as demonstrated in Figures 6.47 to 6.49.

From the cross-case analysis between the four action cases the following common propositions are identified:

- As seen from the four action cases it is evident that the IT-PMS implemented as a holistic approach throughout the organisation (HSL and HWL) would have a higher impact than the IT-PMS implemented for a part of business (SLC and ADL)
- The IT support should be appropriate for the project from the following perspectives:
  - Presenting up-to-date information and access available for the users (failure to which has demonstrated lesser impact at ADL)
  - Ensuring data accuracy (failure to which has demonstrated chaos at SLC)
  - Communicating information throughout the organisation (failure to which has demonstrated lesser impact at SLC)
  - Dissemination of information and knowledge throughout the organisation (As demonstrated at HSL, HWL and ADL)
- Senior management commitment and drive should be there throughout the project to maximise the impact of IT-PMS (as demonstrated in HSL, HWL, ADL). They should make employees use IT-PMS in their routine part of business by:
  - Communicating the perceived benefits of IT-PMS to the employees (as demonstrated in HSL, ADL, and HWL)
  - Training the people on IT-PMS (as demonstrated in HSL and HWL)
  - Overcoming resistance (as demonstrated in HWL and ADL)

    - Prioritising the IT-PMS project (failure to do so has demonstrated lower impact at HWL)
    - Initiating team culture in using IT-PMS (as demonstrated in HSL and ADL)
- In case of bringing external skills for implementing IT-PMS, the business should make sure to involve people from IT department, so that a champion can be identified for updating IT-PMS to keep it live and running after the project (ADL and HWL had this problem of identifying a champion as IT department did not get involved in this project)
- If IT-PMS is implemented along with other projects, the company should make sure to prioritise the projects and include settling period for the employees, between projects (as demonstrated in HWL)

The technical and people factors identified from the individual cases and cross-case analysis would act as enablers between the beacon of bearings, i.e., IT-PMS implementation and the beacon of benefits, i.e. management and business implications as demonstrated in Figure 6.50. These management and business implications, which demonstrated the benefits of IT-PMS, in turn make the business to potentially invest more in IT-PMS, in terms of redesigning performance measures (or often called updating), IT resources (more), senior management commitment, extend the project to other parts of the business (if it is implemented to a part of business), supply chain, as demonstrated in Figure 6.50 (with dotted lines). This will result in more benefits of IT-PMS in the next cycle of implementation and so on.

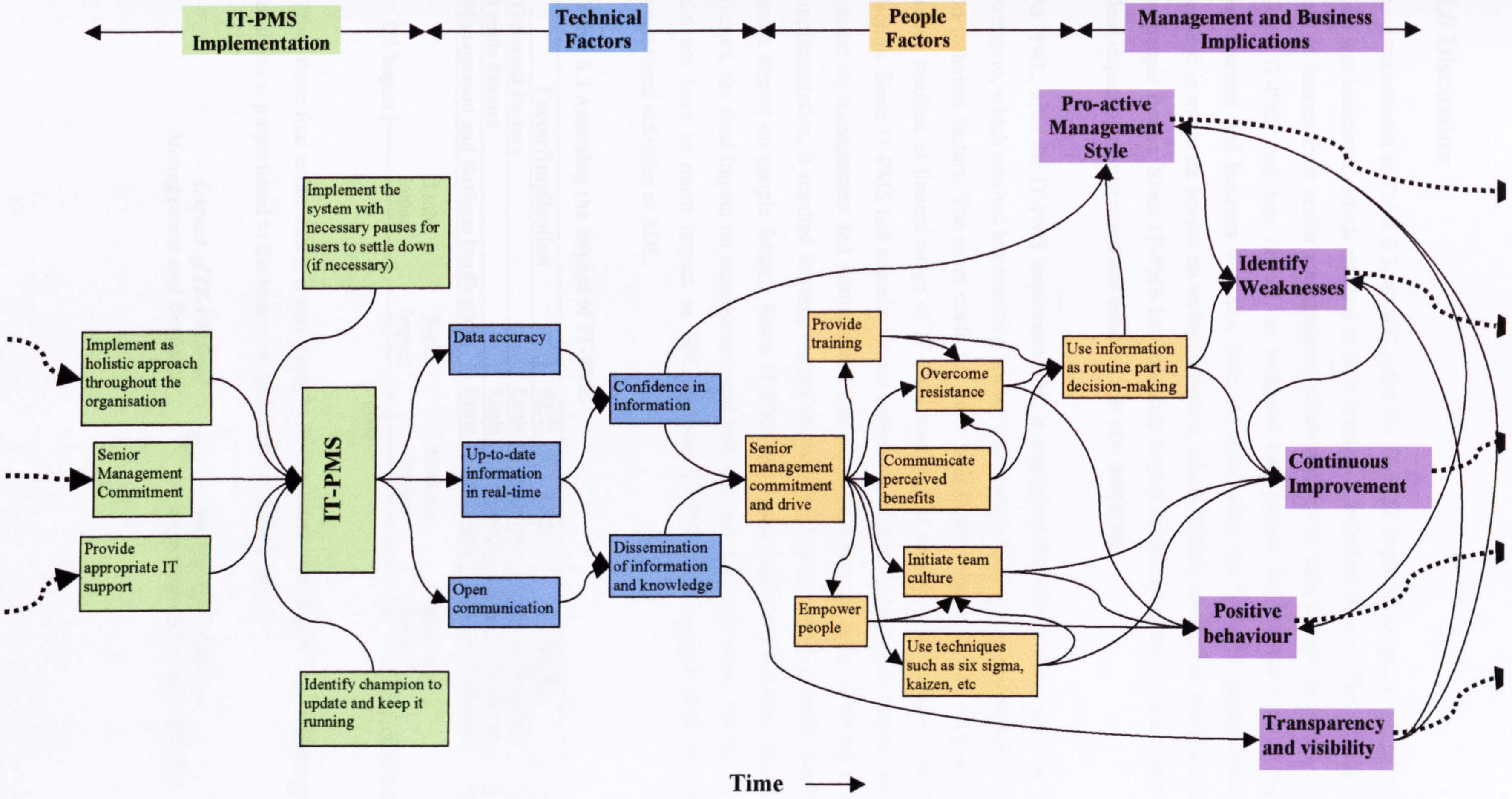


Figure: 6.50 Assessing the Impact of IT-PMS Implementation on Management and Business

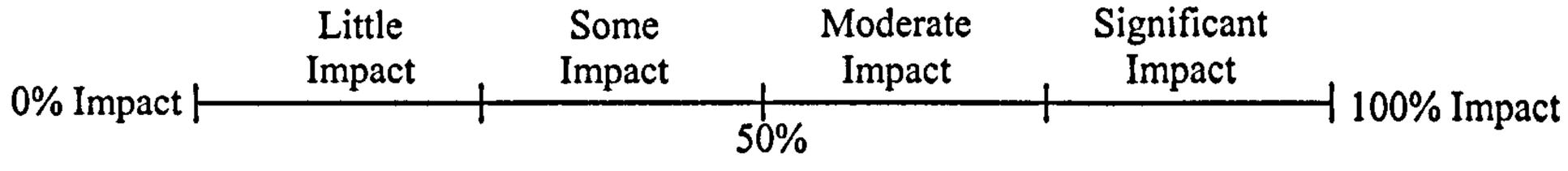
6.6 Discussion

As demonstrated in Table 6.3, at SLC, after the IT-PMS implementation, it was found that data was inaccurate, which resulted in little impact on technical factors. This directly led to loss of interest from senior management, which resulted in little impact on people factors. Since IT-PMS had less impact on technical and people factors, the final impact on management and business was also little. At HSL, after the IT-PMS implementation, it resulted in moderate impact on technical factors, which directly resulted in moderate impact on people factors. Since IT-PMS had moderate impact on technical and people factors, the final impact on management and business was also moderate.

At HWL, after the IT-PMS implementation, it was found that data did not exist for a few measures, which resulted in presenting limited information leading to some/moderate impact on technical factors. The users could not cope with different projects one after the other, which resulted in limited usage of IT-PMS resulting in some/moderate impact on people factors. Since IT-PMS had some/moderate impact on technical and people factors, the final impact on management and business was also some/moderate. At ADL, after the IT-PMS implementation, it resulted in some impact on technical factors, which directly resulted in some impact on people factors. Since IT-PMS had some impact on technical and people factors, the final impact on management and business was also only some. However, ADL did not have as much impact as HSL, because IT-PMS was implemented only in the operational activities at ADL.

Table 6.3 Assessing the impact of IT-PMS

Factor/Implication	SLC	HSL	HWL	ADL
Technical Factors	Little	Moderate	Some to Moderate	Some
People Factors	Little	Moderate	Some to Moderate	Some
Management and Business Implications	Little	Moderate	Some to Moderate	Some



From these four action cases, it was strongly demonstrated that impact on management and business is proportional to the impact on technical and people factors

$$\textit{Impact of IT-PMS on Management and Business} \propto \textit{Impact of IT-PMS on Technical and People Factors}$$

Understanding the relationship between beacon of bearings (IT-PMS implementation) and beacon of benefits (impact on management and business) was demonstrated for each action case in Figures 6.16, 6.26, 6.36 and 6.46. However from the common propositions identified from the cross-case analysis, the relationship between beacon of bearings and beacon of benefits are understood as shown in Figure 6.50. These relationships are realised in the following order:

- IT-PMS implementation
- Technical factors
- People factors
- Management and business implications

By implementing IT-PMS to part of a business, creates only partial transparency and visibility of information. There is also a good chance of losing priority to other projects in the business. Hence, it should be implemented as a holistic approach to maximize the positive impact. Appropriate IT support should be given to automate data collection, data analysis and data communication and to reduce time and effort. Ensure that a champion is identified to update IT-PMS after the project completion to keep it running. The failure to do so will result in difficulties for updating the system and keeping it running, it may lead to the termination of the use of IT-PMS in the company. If IT-PMS is implemented along with other projects, ensure sufficient time is provided for the users to settle down with the new software, procedures, etc. Failure to do so will end up with the users concentrating on different projects ultimately resulting in low usage of IT-PMS as a routine part of business. After IT-PMS implementation, ensure that the positive impact on the following technical factors are realized:

- Up-to-date information in real-time is presented
- Data accuracy is ensured
- Information is communicated

If the information is available up-to-date in real-time and is ensured for accuracy, it would create confidence in people. Similarly if information is available, up-to-date and is communicated to different users, it would create *transparency and visibility* in the business. All these factors lead to senior management commitment, and hence they would take the drive into their hands and ensure the following people factors are in place:

- Provide necessary training for people to overcome resistance and make them use IT-PMS
- Communicate perceived benefits to make people realize the importance of IT-PMS
- Overcome resistance from people
- Initiate team culture
- Empower people in making decisions based on the information available from IT-PMS

All these factors lead people to use IT-PMS as a routine part of the business in decision-making. These people factors would result in management and business implications. As the management is confident about the information and use it as a routine part of business, it would lead to a *proactive management style,* which would also lead them in *identifying weak areas of the business.* This together with team culture would result in *continuous improvement.* As the business experiences most of these people factors it would build *positive behaviour* of the people.

Chapter 7: Discussion and Conclusions

7.1 Introduction

In Chapter 2, the literature review was presented covering the life-cycle of performance measurement in general. In Chapters 3 and 4, the pilot case studies and specific literature review respectively, provided some insights into identifying the predictions and research objectives. Chapter 5 explained different models, techniques, and tools available in general and justified an overall methodology, to test these predictions and achieve the research objectives. Chapter 6 explained the implementations of IT-PMS, tested the predictions and built the relationship between technical and people factors as well as management and business implications at each company. Chapter 6 also included cross-case analysis between different action cases in testing the predictions and achieving the research objectives from the common propositions identified.

The structure of this chapter is presented in the following order:

- This chapter starts with a brief summary of previous chapters presented before in the form of a small discussion
- It presents a detailed discussion regarding the research problem, how it was identified from previous research (point of departure). It also includes discussion on the definition of initial research questions and a summary of initial investigation
- It also presents a brief summary of how these objectives were achieved with the research findings. This includes choice of methodology, main investigation of the research and the knowledge created by this research
- A discussion on the contribution made by the research, including both practical and theoretical contribution is presented.
- It also includes a discussion on assessing the quality of research using the metrics validity and reliability of the research

7.2 Summary of this research

The main flow of the previous chapters is shown in Figure 7.1 with the small window "chapter road map" in the extreme southeast corner acting as the guideline.

Chapter 1 started off with the background to performance measurement. It moved onto the current research explaining briefly the gap identified for this research "there was very little solid research evidence that illustrates the impact of performance measurement systems". The rest of this chapter explained the structure of this thesis.

Note: A more detailed discussion on research problems is provided in Section 7.3

Chapter 2 initially sets boundaries for the general literature review. It followed with a review on each of the following:

- Evolution of Performance Measurement: It reported the origins of performance measurement staring from 1940s to latest developments in performance measurement
- Designing performance measurement: It reviewed and explained most of the frameworks and models available for designing performance measures.
- Implementing performance measures: It reviewed and summarised the various issues in implementing performance measures, such as data collection, data analysis and data communication, etc. It also reviewed various drivers and barriers of performance measurement implementation.
- Using and updating performance measures: It reviewed and summarised the various issues in using performance measures.
- Impact of performance measurement: It reviewed for any models or frameworks existing in literature to study the impact of performance measurement.

This chapter demonstrated *that without the IT support*, coping with performance measures and indicators becomes very difficult, complex, frustrating, abused, misused and short-lived. However, this chapter also demonstrated that there was not much information on impact of performance measurement.

Since there was not much literature existing in the field "impact of performance measurement", the researcher decided to induce knowledge from companies. Chapter 3 reported evidence from four companies that performance measurement when implemented with appropriate IT support had positive impact on the management and business. This followed with a structured pilot case study with AFE (one amongst four cases of evidences) in studying the impact of IT-PMS and documented the results in later part of this chapter. Based on these findings and literature review reported in Chapter 2, the researcher generated

predictions (management and business implications), which were reported in last part of this chapter. Finally the research objectives identified were:

- To test the predictions (impact of IT-PMS on management and business as well as technical and people factors)
- Understand and build the relationship between technical factors, people factors and impact

In order to provide appropriate IT support for performance measurement, the researcher reviewed literature covering issues of both IT and performance measurement, which was documented in Chapter 4. The first section reviewed literature on general IT for data collection, analysis and communication, which was then subdivided into performance information practices and performance information behaviour. The second section covered the management information systems existing in the companies and their difficulties in supporting performance measurement. The third section reported a review of performance management information systems available in the market to support performance measurement. The fourth section reported the EEM model in literature, a guideline for identifying the impact of technology on business. Finally, in the fifth section, it described different change management models such as orthodoxy, contingent, contextualist approaches and Soft System Methodology. It also included a discussion on technology based change management models, for implementing IT-PMS in companies and studying the change.

Chapter 5 included a review on research methodology including the research paradigms, philosophies, strategies, domains, tools and techniques (for data collection and analysis), etc. Finally, this chapter identified the methodology for this research with proper justification. It also presented the suitability of the selected methodology for the current research. Towards the end of this chapter it defined a set of quality criteria to assess the quality of this research in terms of both design process of the research as well as its outcome.

Note: A more detailed discussion on research methodology is provided in Section 7.4.1

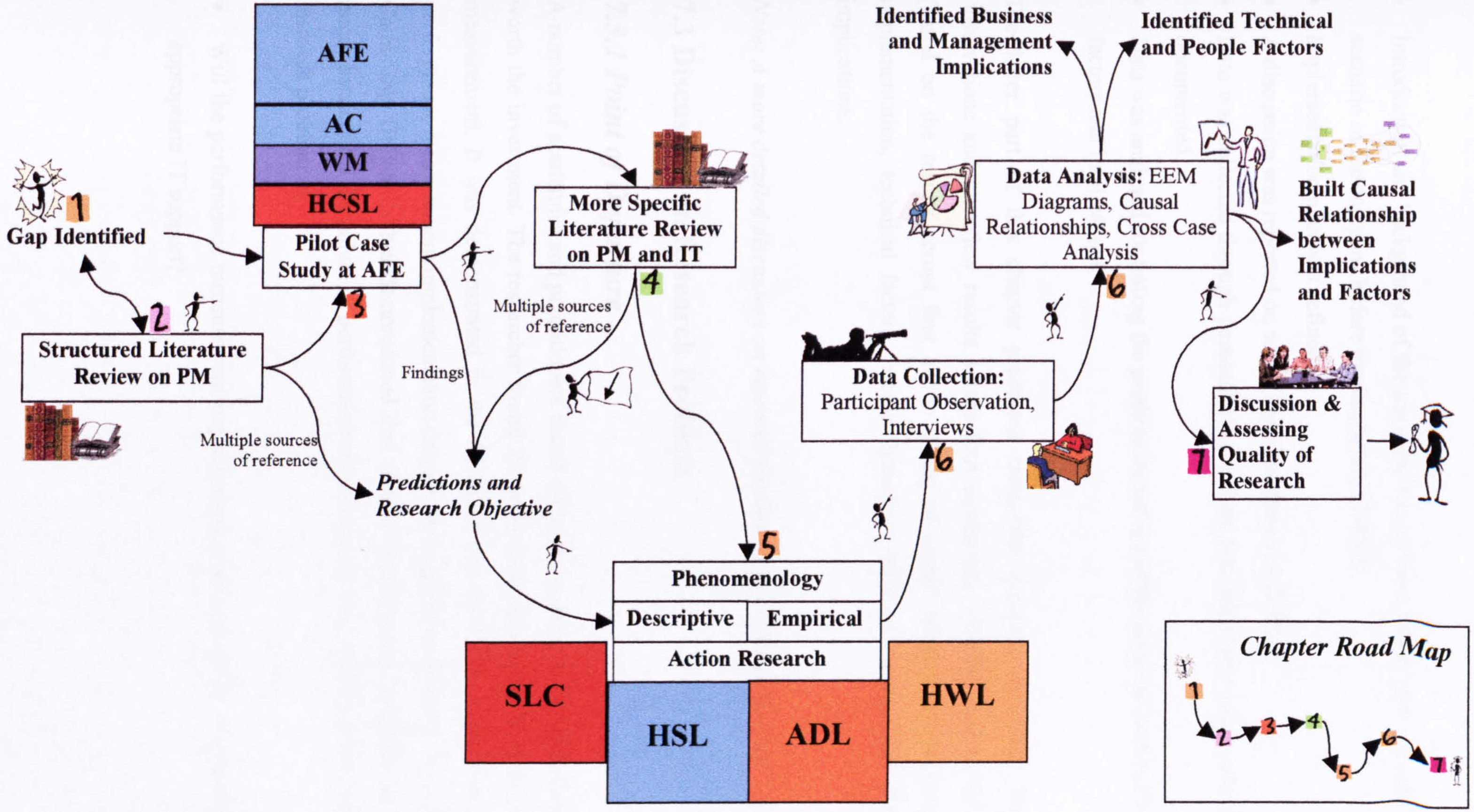


Figure 7.1 Summary of this research

The action research done at all the four companies were reported in Chapter 6. For each action case the following information was documented:

- Introduction and background of the company was written, which also included the initial scenario of the company before implementing IT-PMS
- Implementation plan was defined
- A discussion was reported on actual implementation of IT-PMS
- Data was collected through personal observations and interviews were summarised and documented
- Data was analysed for testing the predictions and understanding the relationship between factors and implications

The latter part of this chapter presented cross-case analysis, analysing the personal observations and interview results across four companies. Finally, built a richer picture (based on the results across four action cases) of causal relationship between IT-PMS implementation, technical factors, people factors as well as management and business implications.

Note: A more detailed discussion on research findings is provided in Section 7.4

7.3 Discussion on Research Problem

7.3.1 Point of Departure

A number of academics and practitioners found difficulty in proving IT implementations are worth the investment. The researcher found the same difficulty in the field of performance measurement. It was demonstrated in the literature that there are number of failures of performance measurement implementation despite the huge effort invested. A recent study at Cambridge University has demonstrated that lack of appropriate IT support, as one of the major barriers for the failure of performance measurement. This raised the first insight to the research problem as:

- Will the performance measurement implementation be successful, if supported through appropriate IT support?

7.3.2 Initial Research Questions

At this time the author experienced anecdotal evidence from a number of companies in Scotland that performance measurement with appropriate IT support had made positive impact on management and business. There is an old proverb in Indian mythology

> *"The reward is always in proportion to the effort involved, the greater the effort, the larger the reward. Humans are moved by hope. It is the hope, which sustains life and aids human effort. The hope usually comes in the form of reward."*
>
> *– Ananthanarayanan*

This strongly influenced the researcher to think about the effort and reward of IT-PMS. This formed a strong basis for defining the initial research questions as:

- What is the impact (benefit/reward) of IT-PMS on management and business?
- What are the critical success factors of IT-PMS design and implementation, which leads to the impact identified in previous question? (Where do we need to focus the effort?)

As seen in Chapters 1 and 2, little (almost none) research was focused on identifying the impact of performance measurement. Although few researchers have focused on identifying the critical success factors, the researchers failed to develop a clear understanding of the relationship between critical success factors as well as management and business implications.

7.3.3 Initial Investigation

As demonstrated in Chapter 2, there was not much literature existing in this field to answer the initial research questions identified. Hence pilot case studies were conducted with an exploratory research approach to get an idea on the impact (reward) of IT-PMS. Since the selected research strategy was exploratory there was no structured research design to do these pilot case studies (Kinnear et al 1979). The researcher visited these companies and got involved in informal discussions with the people in these companies. From these informal discussions, the researcher got strong evidence on the role of IT in implementing performance measures, which together with the performance measures was key reason for their success. These findings formed the basis for doing semi-structured interviews at one of the four pilot case studies, in studying the impact. The findings from the structured case

study presented in Chapter 3 demonstrated the following impact of IT-PMS on management and business:

What is the impact of IT-PMS on management and business? (What is the reward?)

- *Business benefits such as in identifying the weaknesses, leading to continuous improvement, improving transparency and visibility and improving relationship with customers and suppliers*
- *Management benefits such as building confidence in information, proactive decision-making and team behaviour*

However, the interviews with the managers at AFE were also focused on identifying the success factors behind the impact of IT-PMS on management and business. These success factors were classified as technical and people factors.

What are the critical success factors of IT-PMS design and implementation, which causes the impact identified earlier? (Where is the effort?)	
Technical Factors	***People Factors***
up-to-date information and access in (near) real time	*senior management commitment and drive*
means to compare against targets and best-class performances	*using the system in identifying business trends*
open communication of information throughout the organisation	*using the system for decision-making*
secured access to customers and suppliers and facilitates communication with them	*acting as teams to solve the issues*
consistent and accurate information	*using the system as a routine part of their business*
reduced time and effort required to gather data, analyse it and communicate it throughout the organisation	*not resistant to use the system or statistical analysis*
statistical analysis for controlling and monitoring key variables on the process	*knowledgeable enough to use the system*
simple and easy to the users	*empowered to make decision based on information available*
	confident about the information
	customers and suppliers are using the system

These implications and factors were identified as a result of an exploratory research approach and will serve as the starting point of this research. Hence at this stage, the findings obtained were tentative and not yet validated.

7.3.4 Final Research Objectives

As demonstrated in the previous section, the answers to the initial research questions were obtained from an exploratory research approach. Hence they were not sufficient to generate theory (cannot fulfil quality criteria: external validity and reliability). These answers are used in formulating predictions as presented in Chapter 3. From the findings and interviews conducted at pilot case studies, the researcher also got an evidence that there was also a strong relationship existing between IT-PMS implementation, its impact on technical and people factors (effort) as well as it impact on management and business. However the pilot case studies are not sufficient to find these relationships because:

- The IT-PMS implementations were already implemented and impacted the management and business before the researcher got involved with the companies

This potentially limited the researcher from not having:

- The degree of control over some of the technical and people factors
- Personal observation of these factors and implications in real-time
- Interviews with people in real-time (as things are happening) to get a richer picture

Hence the researcher set the objectives of this research as:

- To test the predictions and pre-conditions (management and business implications as well as technical and people factors), and hence prove

$$\textit{Impact of IT-PMS on Management and Business} \propto \textit{Impact of IT-PMS on Technical and People Factors}$$

(Impact on management and business is proportional to impact on technical and people factors. i.e. if the impact of IT-PMS on technical factors increases/decreases, the impact on management and business also increases/decreases respectively)

- Understand and build the relationship between technical factors, people factors as well as impact

7.4 Discussion on Research Findings

7.4.1 Choice of Methodology

The research paradigm, mode, strategy became obvious in this research as presented in Chapter 5. However, selecting the domain for this research became critical, as the quality of research findings were based on it. Hence choice of research domain is argued here.

In this research there are dependent variables such as management and business implications (uncontrollable), semi-dependent variables such as people factors (partially controllable) and technical factors (controllable) as well as independent variables such as IT-PMS implementation (controllable). In order to study and vary the dependent, semi-dependent, independent and extraneous variables as well as understand and build their complex relationship, a true experiment with the researcher as facilitator / personal observer (of the experiment) was essential. It was also essential to have the degree of control for the researcher to vary these independent variables and study their impact on semi-dependent and dependent variables.

However, since this research was phenomenological research, the experiment should be carried out in a real-world setting (companies). This strongly urged the researcher to chose action research as the main research domain, by implementing IT-PMS at four different companies and study their impact. The same quality research findings wouldn't have been possible with any other research domain. However the detailed methodology from the philosophical, social and technical sense was documented in Table 5.7 and explained in Section 5.3.

7.4.2 Main Investigation

Since the domain selected for doing this research was action research, the researcher used the quality criteria (defined by Eden et al, 1996 for action research) as guideline in doing the action case studies. The implementations at all four companies were followed with a high degree of method and orderliness with proper plan and project management. Triangulation was exploited in conducting these studies. The researcher used different research methods (interviews, personal observations, informal discussion with other participants) to collect data. Data source was triangulated from different sources (literature, pilot cases and action cases). Case investigations were triangulated through different investigators (facilitator of IT-PMS, internal participants and external observers or consultants). The study was also

examined and triangulated by people from different theoretical backgrounds (research student, industrialists and consultants from academic background). The findings obtained from one action case were triangulated against the findings from other action cases.

The impact on technical factors and people factors as well as impact on management and business was identified through interviews with managers as well as personal observations at each company as demonstrated in Chapter 6. Finally from the cross-case analysis, the main research objectives were achieved as follows:

To test the predictions and pre-conditions (management and business implications as well as technical and people factors), and hence prove

Impact of IT-PMS on Management and Business ∞ ***Impact of IT-PMS on Technical and People Factors***

The evidence was shown in three action cases (out of four action cases) presented in Chapter 6, there was some or moderate impact of IT-PMS on management and business in:

- *Creating transparency and visibility of information (by disseminates of information and knowledge)*
- *Identifying weak areas of the business*
- *Enhancing continuous improvement*
- *Leading to more confident and pro-active management style*
- *Provoking positive behaviour of people*

However the above impact was demonstrated because there was also some to moderate impact of IT-PMS on technical and people factors:

Technical Factors	*People Factors*
up-to-date information and access in (near) real time	senior management commitment and drive
open communication of information throughout the organisation	employees using the system in identifying business trends
consistent and accurate information	employees using the system for decision-making in routine part of business
reduced time and effort required to gather data, analyse it and communicate it throughout the organisation	employees acting as teams to solve the issues (internal teams as well as external teams including suppliers and customers)
statistical analysis for controlling and monitoring key variables on the process	employees are not resistant to use the system or statistical analysis
simple and easy to the users	employees are empowered to make decision based on information available
	employees are confident about the information

At SLC, as demonstrated in Section 6.4.1 it was identified that there was little impact of IT-PMS on management and business because there was only little existence of technical and people factors

At HSL, as demonstrated in Section 6.4.2 it was identified that there was moderate impact of IT-PMS on management and business because there was moderate existence of technical and people factors

At HWL, as demonstrated in Section 6.4.3 it was identified that there was some to moderate impact of IT-PMS on business and management because there was some to moderate existence of technical and people factors

At ADL, as demonstrated in Section 6.4.4 it was identified that there was some impact of IT-PMS on business and management because there was some existence of technical and people factors

Therefore, from these four action cases, it was proved that

$$\textit{Impact of IT-PMS on Management and Business} \propto \textit{Impact of IT-PMS on Technical and People Factors}$$

However one business implication for improving the relationship with customers and suppliers was not proved. Since access to information generated from IT-PMS was restricted to customers and suppliers in all the four companies, the suppliers and customers could not use the information. Hence IT-PMS as a whole did not have any impact on it, few managers said that IT-PMS should be very well matured in the company before sharing it with customers and suppliers. According to their perception it could take up to two years (after the implementation) to see the impact on the supply chain.

Note: The idea of using "proportional" is to prove that impact on management and business implications increase if impact on technical and people factors increase and vice versa. The researcher neither means to prove something in absolute values nor was he in search of finding a constant value between them.

Understand and build the relationship between technical factors, people factors as well as impact

At each company as demonstrated in 6.4.1 to 6.4.4, the relationship between the variables was understood using Enabler-Effect Mapping (EEM) diagram. As it was demonstrated from Chapter 2 that there was very little research focused in the field of finding impact of performance measurement. EEM diagram was adapted from the field of finding impact of IT as demonstrated in Chapter 4. From the understanding of individual action cases, the relationship between technical factors, people factors as well as management and business implications was built as shown in Figure 6.50 in Chapter 6.

7.4.3 Knowledge Created from this Research

Appropriately designed performance measurement systems, if supported through appropriate IT platforms and senior management commitment, appropriately implemented and used will result in positive management and business implications as shown in Figure 7.2

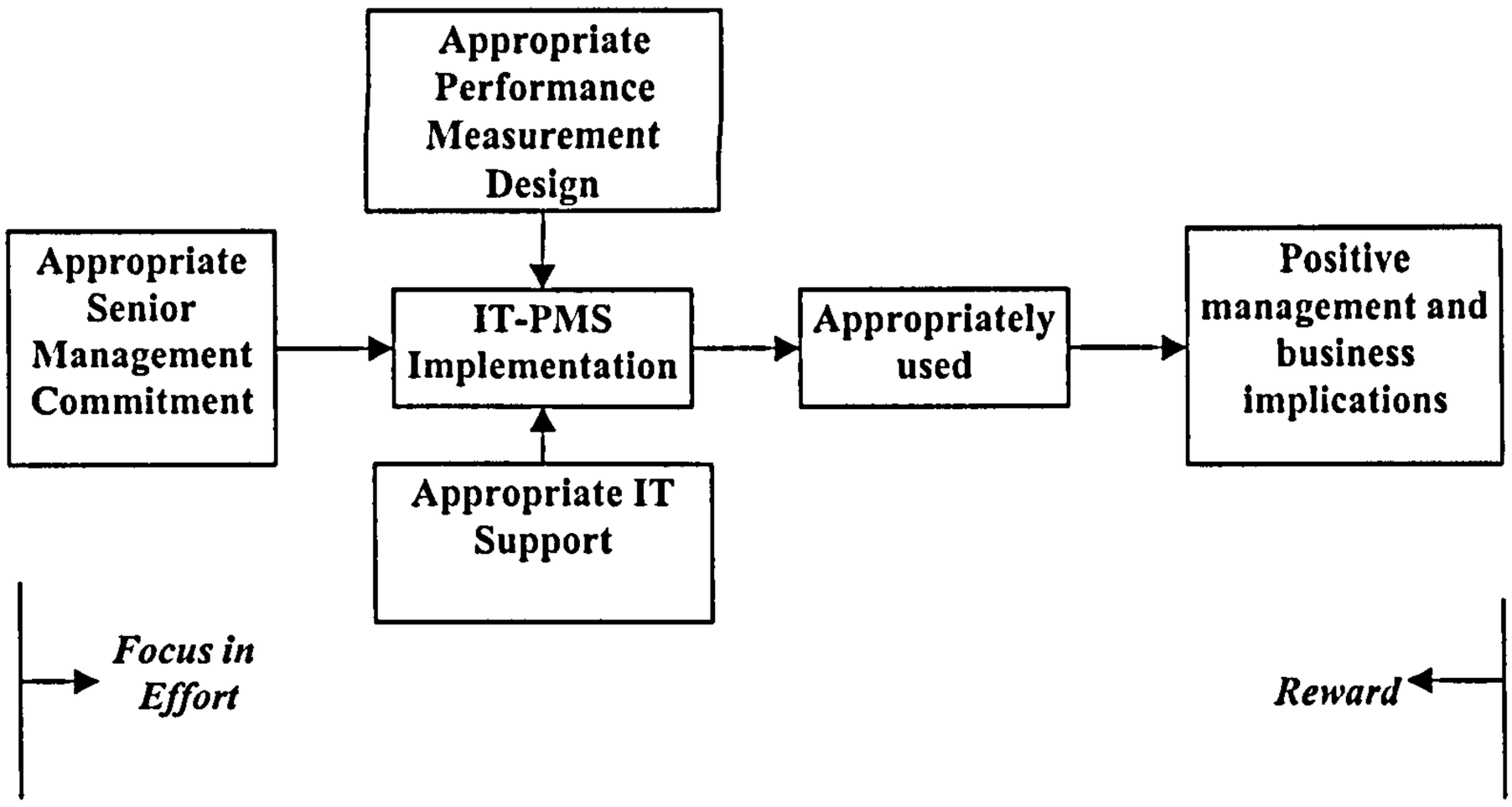


Figure 7.2 IT-PMS leading to positive management and business implications

Appropriate performance measurement design is ensured if there is a balanced set of performance indicators derived from strategy (There are several other factors, which are discovered in literature to ensure appropriate performance measurement design. However all of this is not a new knowledge).

Appropriate IT support is ensured if the data collection, analysis and communication are automated.

Appropriate senior management commitment should be ensured to:

- Implement IT-PMS as a holistic approach[1]
- Implement IT-PMS with necessary pauses[2] for the users to settle down (with the software, new procedures, etc.)
- Identify a champion[3] to update and keep IT-PMS up and running

An appropriate IT-PMS implementation in a company will ensure (the following technical factors in place):

- Data accuracy[4]
- Up-to-date information presented in real-time[5]
- Open communication[6]

These three factors will disseminate the information and knowledge throughout the organisation, which also builds confidence in information. This confidence initially

gains senior management[7] attention and they will take the drive[8] into their hands by making people use IT-PMS

IT-PMS implemented in the company should ensure its appropriate usage by:

- Communicating perceived benefits of IT-PMS
- Providing training where necessary
- Overcoming resistance (the above two factors help for this factor)
- Making people use IT-PMS in decision-making for the business (if once people are not resistant they will start using the system)
- Initiating team culture
- Empowering people

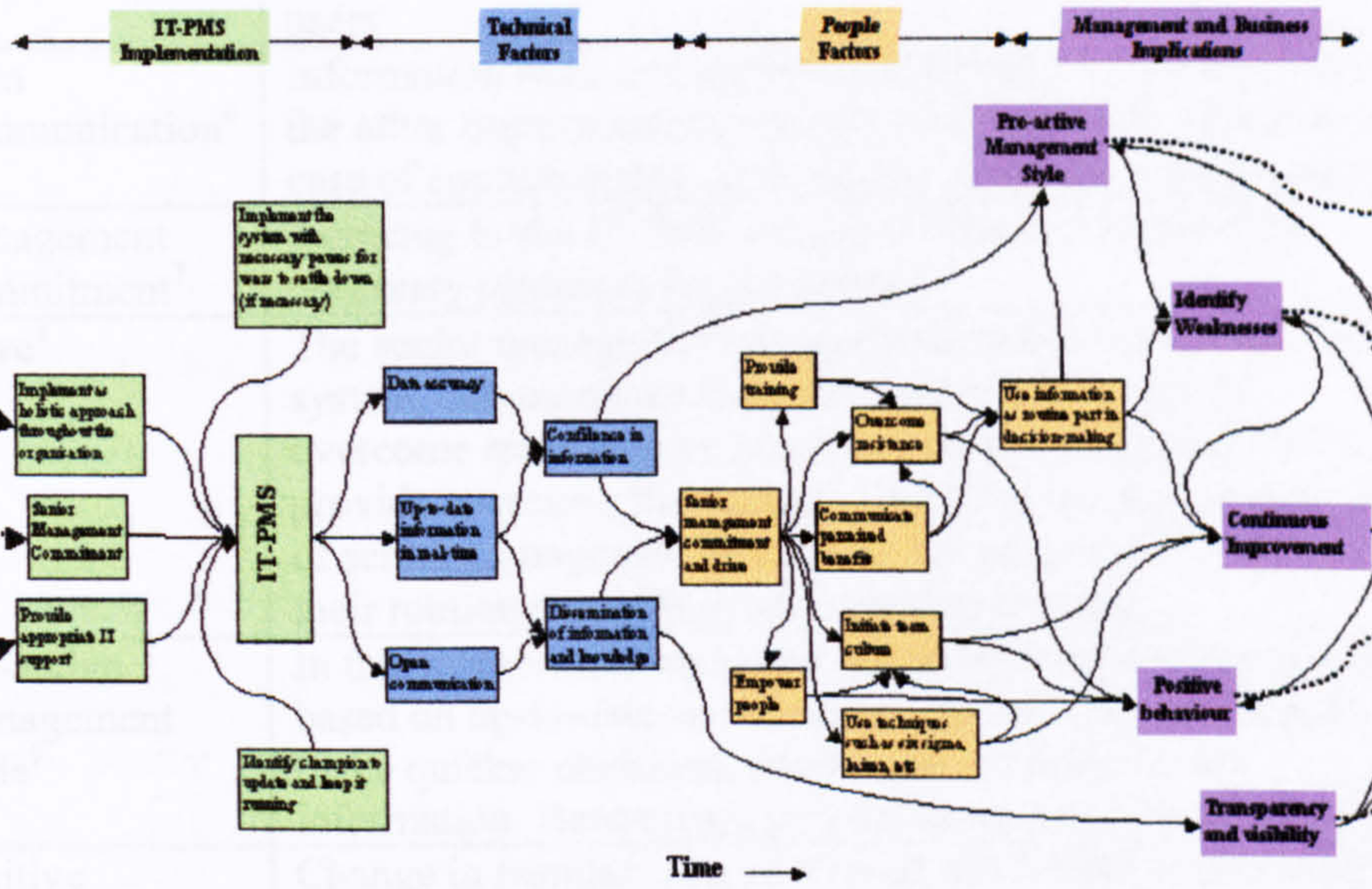
Doing all the above will ensure the company with the following positive implications:

Management Implications

- *Increases pro-active management style*[9]
- *Increases positive behaviour*[10] *such as focusing on facts, communication, empowerment and teamwork*

Business Implications

- *Creates transparency and visibility of information*
- *Identifies weak areas of the business*
- *Promotes continuous improvement*



(*See Figure 6.50 for bigger Version*)

This diagram represents a causal relationships between the phenomena observed during the research. Most of the phenomena are self-explanatory. However the following table explains those phenomena, which may require clarification.

Phenomena	
Phenomenon	***Detailed Explanation***
Holistic Approach[1]	Implementing IT-PMS for the whole business, instead of implementing IT-PMS for islands of the business
Necessary Pauses[2]	While implementing IT-PMS in companies, in some cases it will be implemented as a long project starting from buying new computers and training people in data capturing and data entry. In such cases provided necessary time periods for the users to settle down before moving on to the next stage of implementation. If these settling time periods are not provided the users will be de-motivated to involve in the project and use IT-PMS
Champion[3]	In some cases, companies bring expertise (usually from Consultancies and Universities) for implementing IT-PMS. However the company should identify a person, who takes the responsibility of keeping the implemented IT-PMS, up and running. He/she should up-date the system as the new measures change the old ones.
Data Accuracy[4]	The company should ensure that the data going and coming out of IT-PMS is accurate and reliable for the users to use it and build confidence in it
Up-to-date information in real-time[5]	The company should ensure that the data collected by IT-PMS is in real-time (to the maximum possible extent), which will then do the analysis and present up-to-date information to the users
Open Communication[6]	Information from one department should be made available to the other departments (to people who require it) in real-time. In case of confidentiality, it should be protected with password
Management Commitment[7]	Agreeing to the IT-PMS implementation and providing necessary resources for the project
Drive[8]	The senior management should understand the system, use the system, communicate the potential benefits to people, overcome resistance by non-threatening management style, provide necessary training, etc. In doing this the ultimate goal of senior management is to make the people use IT-PMS in their routine part of business decision-making
Pro-active Management Style[9]	In this research the managers are being able to make decisions based on up-to-date and accurate information. They could make quicker decisions, as they are confident in the information. Hence managers are more pro-active than before.
Positive Behaviour[10]	Change in peoples' acts as a result of IT-PMS implementation. It improves communication, as people see same information, they will talk about same information without arguing on the validity of data. This also promotes team culture. As management are confident about the information, they would empower people in using the information from IT-PMS in decision-making. People can now focus on the facts presented by the information.

7.5 Contribution

Any research should demonstrate that it has contributed to theory and preferably also to practice. In fact most of the researches provide an evidence of both practical and theoretical. Since the current research is submitted for doctoral degree, it should show a strong evidence of theoretical contribution. However, since the research adopted action research with four companies, it should also provide practical contribution without which the companies wouldn't have come forward. Hence the following section is subdivided into theoretical contribution and practical contribution.

7.5.1 Theoretical Contribution

In order to contribute to theory, the research should propose something new (knowledge), which is not known before. In the current research, it contributed to knowledge by answering the research questions, which are not answered in the literature. The research:

- Identified the management and business implications that resulted from IT-PMS implementation as reported in Section 6.5.2. No research had successfully reported in identifying these implications. Hence the results reported add new knowledge to the literature
- Identified the factors (of IT-PMS implementation) that are responsible for the impact on management and business and classified them as technical and people factors as reported in Section 6.5.2. Since there was no research reported in literature in finding the impact of performance measurement, there was no research focused in identifying the factors that are responsible for that impact. Hence the results reported add new knowledge to the literature
- Built a relationship between technical and people factors as well as management and business implications as reported in Figure 6.52, within Section 6.5.2. No research until now has reported in building relationships between IT-PMS implementation, technical factors, people factors as well as management and business implications. Hence the results reported add new knowledge to the literature

7.5.2 Practical Contribution

Since the research adopted action research as the main methodology, it is essential to show practical contribution. The current research includes the following contribution to the practise:

Primary Contribution:

- The reward usually comes in companies in the form of impact, when IT-PMS was implemented. Hence in order to maximise that impact, it is also essential for the companies to know technical factors, people factors as well as management and business implications. Hence the knowledge generated in Section 7.4.3 can be used by the companies, for focusing their effort (IT-PMS implementation) in winning the reward (positive management and business implications).

Secondary Contribution:

- A review of software available in the market to support performance measurement implementation. It includes ERP solutions, BI Solutions as well as dedicated software for performance measurement. The companies can define their own requirements and compare against these software to select one of them
- IT-PMS was implemented at four companies. Hence the same implementation can be replicated at other companies, which are interested

Amongst the four companies where IT-PMS was implemented, at three companies the contribution was demonstrated by showing some to moderate impact. At one company it had only little impact, however it contributed to this company by identifying data in-accuracy, which was otherwise a major threat to the company in future.

Apart from contribution to practise, this action research answered the three un-answered research questions with structured methodology. Hence it made a clear contribution to theory/knowledge by characterisation and conceptualisation of the experiences in more meaningful way and passed the authenticity test.

7.6 Assessing the Quality of this Research

At the start of the research (Section 5.4), a set of quality criteria was defined to assess the quality of research and its findings. It is the time to assess this research against the criteria and pass all these tests and head towards a success. Hence the following sections include each criterion to assess this research

7.6.1 Construct Validity

There are three steps for this test. First is to identify the changes being studied with multiple sources of evidence. Second is to define metrics to demonstrate the change resulted does indeed reflect the specific type of changes that have been selected. Third is specific to action research, which is to exploit the opportunities for triangulation to validate the construct

At the start of this research, it was identified that by implementing IT-PMS, there would be positive management and business implications (For details of these implications see Chapter 3). These management and business implications were identified from a structured pilot case study as well as literature from different sources as demonstrated in Chapters 2, 3 and 4. Hence this research passed the first step of this test.

The research has successfully demonstrated that there was an improvement in management and business implications. This improvement was demonstrated using a Likert scale (metric), by comparing the interview results before and after the implementations (as demonstrated in Chapter 6). Hence this research passed the second step of this test.

The research was phenomenological research and includes a number of phenomena, which were not directly observable such as management behaviour, people behaviour resistance, etc. In order to understand these phenomena, the current research had used EEM diagram as well as cognitive mapping and built the relationship (based on personal observations and interviews with the management) between IT-PMS implementation with its management and business implications as shown in Figure 6.52. The final relationships-construct built between factors and implications was validated through data triangulation between pilot case study results, interview results in action cases, and personal observations in action cases. Hence it passed the third step of construct validity.

7.6.2 Internal Validity

This test is applicable only to an explanatory approach. If the research has a pre-test, implementation and post-test, and the researcher demonstrated that the factors A and B of implementation had caused the difference between pre-test and post-test. It is then said to be internally valid. For action researchers, Eden et al (1996) suggested the following characteristics of outcomes, to pass internal validity test:

- *Action research will generate emergent theory, in which the theory develops from synthesis of data, which is obtained from the use of existing theory in practise. In short, action research usually retests the theory and develops it further*
- *Theory building in action research is incremental, moving from the particular to the general in small steps*
- *Action research requires a high degree of method and orderliness in reflecting on the emerging research content of each episode of involvement in organisation*
- *In action research opportunities for triangulation that cannot be offered through other methods should be exploited*

This action research includes a "before" and "after" scenario. The difference between these scenarios was demonstrated as an improvement in management and business implications. This research demonstrated that the technical and people factors (as demonstrated in Chapter 6) of IT-PMS implementation had caused the difference (improvement) between "before" and "after" scenarios. However this action research also demonstrated that:

- The predictions established from the pilot case study were retested in action cases. The theory was synthesised from results obtained from the action cases based on predictions (existing theory). In short, the predictions (existing theory) were tested to generate theory (developed existing theory)
- The theory building this research was incremental in small steps. Initially the anecdotal evidence obtained from four companies were backed up for conducting structured pilot case study from which predictions were obtained. These predictions were then tested through action cases to generate theory.
- A high degree of method and orderliness in doing the research starting from analysing the situation of each action case before implementing IT-PMS, during the implementation as well as six months after implementation. In each case it also developed an implementation plan based on the resources available within each company and established steering committee and implementation committee for doing the actual implementation. Structured standard data collection and analysis tools were used across all four-action cases.
- The final relationships obtained between implications and factors were validated through data triangulation between pilot case study results, interview results in action cases, and personal observations in action cases.

Hence from the above discussion and four characteristics of Eden et al 1996, it was evident that this action research passed the internal validity test.

7.6.3 External Validity (Generalisability)

In phenomenological approach, it is concerned with whether the patterns, concepts and theories generated in particular environment can be applied for other environments. For action researchers, Eden et al (1996) suggested the following characteristics to pass external validity test:

- *Beyond theory generation in the current situation, action research should envisage talking about the theories developed in relation to other situations*
- *Action research should be presented in the form and style, that is appropriate to the consumer (readers of theory generated and the practitioners for whom the research was done)*
- *In action research opportunities for triangulation that cannot be offered through other methods should be exploited*
- *The history and context in action research for intervention must be taken as critical to the interpretation of the range of validity and applicability of results*

The results obtained in this research were based on process oriented and manufacturing companies. Therefore, this research has strong evidence that IT-PMS can be implemented in similar companies and experience the same management and business implications, provided certain conditions (the existence of technical and people factors) were met. This research also demonstrated that:

- Apart from the theory generated, it goes beyond these four action cases and talks about that, the same results can be enjoyed by other organisations. However the research makes many prescriptions (conditions) to get these results. Under these circumstances only the results can be replicated
- The action cases were presented with a style and structure that was understood to other researchers (it was tested with few researchers)
- The results obtained from one action case were validated against the other action cases (triangulation)
- History and context of each action case was carefully studied across three stages of the implementation, "before", "after" and "after six months". It also took into consideration

the factors such as management commitment, drive, IT resources available, etc. while interpreting the results

Hence this research passed the external validity test (the theory is generalised for similar organisations). The research results are not guaranteed for other type of companies (such as service companies), as the author did not implement IT-PMS in such companies. This is one of the limitations of action research. However, the author has a "gut feeling" that the same results could be replicated provided the conditions are met.

7.6.4 Reliability

Demonstrating that the operations of a research such as implementations, data collection procedures, etc can be repeated, with same results. However in phenomenological research, the emphasis is on repeating the case rather than having the same results in two cases. For action researchers, Eden et al (1996) suggested the following characteristics to pass repeatability test:

- *For action research, the process of exploration of data, in the detection of emergent theories, must be replicable or demonstrable through argument*
- *There are several forces, which act against getting reliable data through action research. However it should be demonstrated that the method used is likely to produce insights, which cannot be gleaned with any other method. Hence it is necessary to justify the use of action research rather than other approaches.*

Since this research was a phenomenological research, the reliability was tested through the repeatability of IT-PMS implementation and its impact at other cases. This action research demonstrated that

- There was a structured IT-PMS implementation plan developed, describing the activities to be performed at each stage. The implementation plan and actual implementation of IT-PMS were successful and documented in Sections 6.4.1 to 6.4.4. The impact resulted as management and business implications at each company were tested through data triangulation (from pilot case study, personal observations at action cases and management perception at action cases). Even though the same impact would be observed on management and business implications at all companies, the amount of impact would differ from company to company based on the technical and people factors

existing at each company. Hence it was demonstrated the process of exploration of data is well documented and repeatable in other cases

- The justification of using action research in spite of other approaches was given in Section 5.5

From the above discussion it was demonstrated that this research has also passed the reliability test.

7.6.5 Summary for Quality of Research

Table 7.1 Assessing the quality of this research

No	Criteria	Pass/Fail?
1	**Construct Validity**	
	▪ Demonstrate changes being studied should have multiple source of evidences	**Pass**
	▪ Demonstrate selected measures of these changes do indeed reflect the specific types of changes that have been selected	**Pass**
	▪ Demonstrate opportunities for triangulation that cannot be offered with other methods are exploited	**Pass**
2	**Internal Validity**	
	▪ Generate emergent theory, in which the theory develops from synthesis of data, which is obtained from the use of existing theory in practise.	**Pass**
	▪ Demonstrate theory building is incremental, moving from the particular to the general in small steps	**Pass**
	▪ Demonstrate high degree of method and orderliness in reflecting on the emerging research content of each episode of involvement with the organisations	**Pass**
	▪ Demonstrate opportunities for triangulation that cannot be offered through other methods should be exploited	**Pass**
3	**External Validity**	
	▪ Demonstrate the theories developed in relation to other situations	**Pass**
	▪ Present the results in the form and style, that is appropriate to the consumer (readers of theory generated and the practitioners for whom the research was done)	**Pass**
	▪ Demonstrate opportunities for triangulation that cannot be offered through other methods should be exploited	**Pass**
	▪ Demonstrate the history and context was taken as critical to the interpretation of the range of validity and applicability of results	**Pass**
4	**Reliability**	
	▪ Demonstrate that the process of exploration of data, in the detection of emergent theories are replicable or demonstrable through argument	**Pass**
	▪ Demonstrate that the methods used are likely to produce insights, which cannot be gleaned with any other method.	**Pass**

5	**Contribution** ▪ Demonstrate that the research contributed to practise ▪ In addition to the contribution made to practise, the research should also make a clear contribution to theory	 **Pass** **Pass**

Chapter 8: Limitations and Future Work

8.1 Introduction

The previous chapter has concluded the summary of research. It has thoroughly discussed research problems and research findings of this research. It demonstrated the contribution made by this research to both theory and practise. It also assessed the quality of the research and its outcome.

This chapter starts by highlighting the limitations of the research, which is followed by a discussion on future work. The last section of this chapter includes author's personal reflections on this research.

8.2 The Limitations of this Research

While discussing the research presented, it is also essential to identify the weaknesses and limitations of the research:

- *Lack of experience for the researcher while implementing IT-PMS in different companies and observing the impact.*
- *The initial predictions were based on management perceptions identified from only one pilot case study*. Hence there was a great deal of scope for the biased results obtained from single pilot case company. In order to minimise the bias, the implications and factors selected for the study were supported by multiple sources of evidence in literature. However, the initial results were used only for building predictions, which were tested at other companies. Therefore this limitation was not considered very serious to the research.
- The research paradigm was phenomenological and hence it used most of the qualitative tools and techniques in methodology. Personal observation supported with management perceptions at the four action companies supported the researcher to build a causal relationship between technical and people factors as well as business and management implications as shown in Figure 6.52. *There was no attempt made to statistically test the relationships between these factors and implications*. It would not be possible to infer causality from statistical validation without building such a qualitative model first. Hence this limitation was not considered very serious to the research. *A few researchers also argue that it is not possible to represent the causality of impact* (McAdam et al

2001). However the researcher attempted to build this causality relationship based on a proven methodology (EEM Diagram).

- There can be biases introduced by the management in the interviews and the researcher in personal observations that *the tendency to attribute any and all improvement (impact) to IT-PMS.* This is not only a limitation for this research, in fact for most of the qualitative research. However the researcher could not find any other data collection tools in qualitative research that would have collected data without any biases (in this research). Amongst these existing tools, the researcher has selected interviews and personal observation by being facilitator and collected a richer data, which wouldn't have been possible with any other tools (Eden et al 1996).
- The research results obtained from the interviews were qualitative based, using Likert scale, before and after the implementations. *The improvement made before and after the implementations was quantified in terms of percentages to show the amount of impact made on each business and management implication.* Even though the interview results were based on management perceptions (subjective), the researcher felt percentages were logically the best way to show the amount of impact it made on each implication in each company. However the idea of using these percentages was to show a comparison between factors and their absolute values do not have much weightage.
- *The length of study and observation at each action case company was restricted to six months after implementation of IT-PMS*, as it has to be adjusted within the time scales available for the research. The research findings obtained were based on the results gathered after six months of implementation at each action case. Hence there is a chance of change in these results if they are observed after one or two years. This had an impact of not proving the impact of IT-PMS on the business implication (improving the relationship on customers and suppliers), which requires one to two years after implementation. However since the researcher had to complete his research on time, he had to define his boundaries and limits at certain stages. Six months after the implementation was set as boundary because the company and researcher mutually agreed to support each other in implementing IT-PMS as well as monitoring and observing its impact on business and management only during this period.
- *The research results were based on a sample of small group of companies (four).* However since the research adopted action research as main methodology, it provided an in depth study at each action company to understand the complex relationships. If the researcher had selected large group of companies, he would not have time to carry in depth studies. Hence there should be a trade-off between small group with in-depth

studies or large group with non-in-depth studies. Therefore it was not a serious limitation.

8.3 Future Work

The current research identified the existence of technical factors, people factors as result of IT-PMS implementation and their impact on business and management implications. It also built the causal relationship between the technical and people factors as well as business and management implications. *However the relationships were not tested*, which was also mentioned as a limitation in the previous section. *Hence the relationships between the factors and the implications can be tested as future research.* However, in order to obtain consistent results, the IT-PMS should be implemented in a similar way to the ones' presented in this research.

As shown in Figure 8.1 this research has identified the impact of IT-PMS on organisation. However, the impact of organisation (such as organisation type, structure, culture) on performance measurement and IT was not yet explored. Therefore, there is an opportunity to work in this area in the future. The potential research objectives are:

- *What is the impact of different organisations on the performance of the IT-PMS?*
- *How does different cultural environments affect the performance of IT-PMS?*

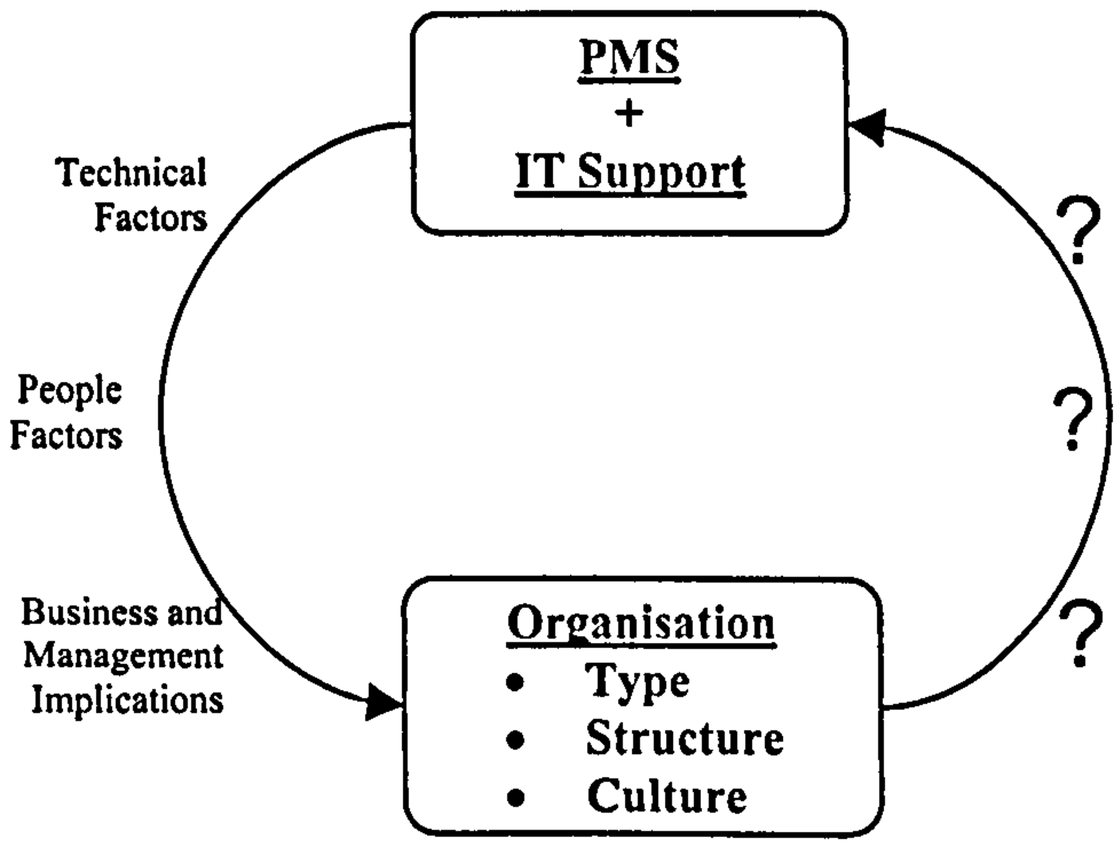


Figure 8.1 Impact of IT-PMS on organisation and vice versa

It was also proved in this research that the results obtained are generalisable to most of the process or manufacturing based organisations. The author has a strong feeling that the same results could be obtained in other type of organisations (service based), however this

research has not implemented IT-PMS in such organisations. *Hence as future work, IT-PMS could be implemented in service-based organisations and the impact can be studied.*

As identified as a limitation of this research in a previous section, the impact of IT-PMS on the relationship with customers and suppliers was not tested, as there was not enough time. Implementation of IT-PMS for supply chains, extended enterprises, etc. could be an entire research in itself. The potential research objectives in this field are:

- *Designing IT-PMS for supply chains and extended enterprises.*
- *How does IT-PMS perform in supply chains and extended enterprises?*
- *How does IT-PMS impact the relationship between enterprises as well as the enterprise itself?*
- *Identify different factors that can make the positive impact of IT-PMS on supply chains and extended enterprises.*
- *Identify the impact of organisational factors on IT-PMS success*

8.4 Personal Reflections

The researcher started this research with an ORS grant and University Studentship in his hand to cover the necessary financial assistance to carry out the research for a PhD degree. The department also provided the necessary resources (such as NWA Quality Analyst Web Server) to do this research. The research idea was strongly supported by a research proposal made to EPSRC (UK local research council for funding).

The initial research objective presented in this thesis was set out to study the impact of IT-PMS on business and management implications. In studying these implications at AFE, it was identified that several technical and people factors existing in the company, caused that impact. Hence the main research objectives were set to test the implications and factors (predictions) identified at AFE as well as to build the relationship between them. The research was designed to test these predictions and build relationships through action research at the four companies.

Doing this research has provided the researcher with an in depth knowledge and experience in implementing performance measurement with an appropriate IT support (from the resources available). The interaction with the people in the companies improved the researcher's communication skills. The interaction with senior management in meetings and

personal interviews had provided many insights to the research. In exchange for the work done by the researcher, the companies sponsored the researcher to go to international conferences to present papers, which are published on the work done in these companies. At ADL, the researcher also accepted a fixed term contract in extending the work of performance measurement into cause and effect analysis, failure mode effect analysis, root cause analysis, statistical analysis, etc within their quality department. In addition to the financial assistance received, this also allowed the researcher gain experience in quality management as well as performance measurement.

Following a critical quality assessment of the work done, the thesis concluded that the research made a positive contribution to the field in terms of new knowledge to both theory and practise. This was also reflected in the number of publications, which emerged from this research (see Appendix I). This research also passed against construct validity, internal validity, external validity and reliability.

References

Adair C. E., Simpson L., Birdsell J. M., Omelchuk K., Casebeer A. L., Gardiner H. P., Newman S., Beckie A., Clelland S., Hayden K. A. and Beausejour P. (2003), *Performance Measurement Systems in Health and Mental Health Services: Models, Practices and Effectiveness*, The Alberta Heritage Foundation for Medical Research.

Ananthanarayanan, *What The River Has Taught Me*, The Divine Life Society Publications, India.

Andersen B. and Fagerhaug T. (2002), *Performance Measurement Explained: Designing and Implementing your State-of-the-Art System*, ASQ Quality Press, Wisconsin.

Ansoff I. (1988), *The New Corporate Strategy*, John Wiley & Sons, New York, NY.

Atkinson A. and Epstein M. (2000), "Measure for Measure – Realizing the power of the balanced scorecard", *CMA Management*, September 2000.

Badham R., Garrety K. and Kirsch C. (2001), "Humanistic redesign and technological politics in organisations", *Journal of Organizational Change Management*, MCB University Press. Vol. 14, No.1, Pages 50-63.

Ball R. (1971), "Index of Empirical Research in Accounting", *Journal of Accounting Research*, Vol.9, No.1, pages 1-31.

Battista P. and Verhun D. (2000), "Customer Relationship Management" at www.ifac.org (Dated 21 Apr 2002). This article first appeared in *CMA Management* in May 2000.

Bierbusse P. and Siesfeld T. (1998), "Measures that Matter", *Journal of Strategic Performance Measurement*, Vol. 1, No. 2, Pages 6-11.

Bititci U. S., Nudurupati S. S., Turner T. J. and Creighton S. (2002a), "Web enabled Performance Measurement System: Management Implications", *International Journal of Operations and Production Management*, Vol. 22, Issue 11, Pages 1273-1287.

Bititci U., and Nudurupati S. (2002b), "Using Performance Measurement to drive Continuous Improvement", *Manufacturing Engineer*, Vol. 81, No. 5, Pages 230-235.

Bititci U., Nudurupati S., Turner T. and Creighton S. (2002c), "Developing Competitive Advantage through Web enabled Performance Measurement Systems" *Control Magazine*, Vol. 28, No. 7, Pages 24-28.

Bititci U. S., Turner T. and Begemann C. (2000), "Dynamics of Performance Measurement Systems", *International Journal of Operations and Production Management*, Vol. 20, No. 6, pp 692-704.

Bititci U. S. and Carrie A. S. (1998), *Integrated Performance Measurement Systems: Structures and Relationships*, EPSRC Final Research Report, Grant No. GR/K 48174, Swindon UK.

Blackler F. and Brown C. (1987), "Management, Organizations and The New Technologies" – *Information Technology and People: Designing for the Future*, edited by Blackler F. and Oborne D., The British Psychology Society, Leicester, 1987.

Blili, S., Raymond, L. (1993), "Information Technology: Threats and Opportunities for SMEs", *International Journal of Information Management*, Vol. 13, Issue 6, Pages. 439-448.

Booth R. (1998), "Enterprise-wide performance management", *Management Accounting*, October 1998, Pages 16-16.

Bourne M, (2001), "Implementation Issues", *Hand Book of Performance Measurement*, GEE Publishing Ltd., 100 Avenue Road, Swiss Cottage, London, NW3 3PG.

Bourne M and Neely A, (2000a), "Why performance measurement interventions succeed and fail", *Proceedings of the 2nd International Conference on Performance Measurement*, Cambridge UK, pp 165-173.

Bourne M., Mills J., Wilcox M., Neely A. and Platts K. (2000b), "Designing, implementing and updating performance measurement systems", *International Journal of Operations and Production Management*, Vol. 20, Issue. 7, Pages 754-771.

Bourne M. and Wilcox M. (1998), "Translating strategy into action", *Manufacturing Engineer*. Vol. 77, Issue 3, Pages 109-112.

Brancheau J. C. and Wetherbe J. C. (1987), "Key Issues in Information Systems Management", *MIS Quarterly*, 11(1), Pages 23-45.

Brown, J. D. (1988), *Understanding research in second language learning: A teacher's guide to statistics and research design*, Cambridge University Press, London.

Buckley J., Buckley M. and Chiang H. (1976), *Research Methodology & Business Decisions*, National Association of Accountants, 919 Third Avenue, New York, N.Y. 10022 and The Society of Industrial Accountants of Canada, 154 Main St., Hamilton, Ontario, Canada.

Bullers W. I. and Reid R. A. (1991), "Information System Capabilities and Organizational Applications: An Evolutionary Perspectives", edited by Szewczak E., Snodgrass C. and Khosrowpour M., *Management Impacts of Information Technology: Perspectives on Organizational Change and Growth*, IDEA Group Publishing, Harrisburg, Pennsylvania U.S.A.

Burns T. and Stalker R. (1961), *The Management of Innovation*, Tavistock Publications, London.

Burrell G. and Morgan G. (1979), *Sociological Paradigms and Organisational Analysis*, Ashgate Publishing Limited, Hants, England.

Busby J. and Williamson A. (2000), "The appropriate use of performance measurement in non-production activity: the case of engineering design", *International Journal of Operations and Production Management*, Vol. 20, No.3, Pages 33-358.

Cash J. I. and McLeod P. L. (1985), "Managing the Introduction of Information Systems Technology in Strategically Dependent Companies", *Journal of Management Information Systems*, Vol. 1, No. 4, Pages 5-23.

Cash J. I., McFarlan, F. W. and McKenney, J. L. (1988), *Corporate Information Systems Management: The Issues Facing Senior Executives*, Dow Jones-Irwin, Homewood, IL.

Checkland P. and Scholes J. (1991), *Soft Systems Methodology in Action*, John Wiley & Sons, Chichester.

Checkland P. B. (1981), *Systems Thinking, Systems Practice*, John Wiley & Sons, Chichester.

Child T. and Smith C. (1987), "The Context and Process of Organizational Transformation", *Journal of Management Studies*, Vol. 24, No. 6, Pages 565-593.

CIMA, The Chartered Institute of Management Accountants (2001), "The Balanced Scorecard – An Overview", *A Technical Briefing on Developing and Promoting Strategy* at http://www.cima.org.uk/downloads/tec_balanced_scorecard.pdf (Dated: 31 May 2002)

Coch L. and French J. (1948), "Overcoming resistance to change", *Human Relations*, Vol. 1, No. 4 Pages 512-532.

Coghlan D. and Brannick, T. (2001), *Doing Action Research in Your Own Organisation*, Sage Publications, London.

Collis J. and Hussey R. (2003), *Business Research: A practical guide for undergraduate and post graduate students*, Palgrave Macmillan publishers, Hampshire.

Coughlan P. and Coghlan D. (2002), "Action Research: Action research for operations management", *International Journal of Operations and Production Management*, Vol. 22 No. 2, Pages 220-240.

Crawford I. M. (1997), *Marketing Research and Information Systems*, Food and Agriculture Organization of The United Nations, Rome, 1997. electronic version available at http://www.fao.org/docrep/W3241E/w3241e00.htm#Contents

Cross K F and Lynch R L, (1988 -1989), "The SMART way to define and sustain success", *National Productivity Review*, vol. 9, no 1, 1988-1989.

Davenport T. H. (1997), *Information Ecology*, Oxford University Press, US.

Davis A. and O'Donnell J. (1997), "Modellig complex problems: system dynamics and performance measurement", *Management Accounting*, May 1997, Pages 18-20.

Dawson P. (1994), *Organizational Change: A Processual Approach*, Paul Chapman Publishing Ltd, London.

Denzin N. (1970), *The research act in sociology: a theoretical introduction to sociological methods*, Butterworth, Oxford.

Dixon JR, Nanni AJ, Vollmann TE, (1990), *The new performance challenge: measuring operations for world class competition*, Dow Jones –Irwin Homewood Il, 1990

Donovan M., (1999) "Performance Measurement: Connecting Strategy, Operations and Actions" at *http://www.rmdonovan.com/pdf/perform_99_4.pdf* (Dated 21 Apr 2002)

Doumeingts G, Clave F and Ducq Y, (1995), "ECOGRAI - A method for designing and implementing Performance Measurement Systems for industrial organisations", in Rolstadas A (ed) *Benchmarking Theory and Practice*, Chapman & Hall, London 1995

Dunphy D. and Stace D. (1990), *Under New Management: Australian Organizations in Transition*, McGraw-Hill, Sydney.

Easterby-Smith M., Thorpe R. and Lowe A. (1991), M*anagement Research: An Introduction,* Sage Publications, London.

Eccles R. and Pyburn P. (1992), "Creating a Comprehensive System to Measure Performance: Financial results should not generate the most rewards", *Management Accounting*, October 1992. Pages 41-44

Eccles, R.G. (1991) "The Performance Measurement Manifesto", *Harvard Business Review*, January-February, 1991, Pages131-137

Eden C. and Huxham C. (1996), "Action Researcher for Management Research", *British Academy of Management*, Vol. 7, Pages 75-86.

EFQM (1999), "Self-assessment Guidelines for Companies", *European Foundation for Quality Management*, Brussels, Belgium.

Eisenhardt K. (1989), "Building Theories from Case Study Research", *Academy of Management Review*, Vol. 14, No. 4, Pages 532-550.

Feeny D. and Plant R. (2000), "IT: a vehicle for project success" – *Mastering Information Management* edited by Marchand D., Davenport T. and Dickson T., Financial Times, Prentice Hall, London. Pages 22-26.

Fitzgerald L., Johnston R., Brignall T. J., Silvestro R. and Voss C. (1991), *Performance Measurement in Service Industries*, CIMA, London.

Galbraith J. R. (1973), *Designing Complex Organizations*, Addison-Wesley Publishing, Reading, Massachusetts.

Garnett C. (2001), "Aged Pioneer to Retire – Gradually: New Clinical Research Information System Planned to Replace MIS", *The NIH Record*, Vol. LIII, No 21. 16 Oct 2001 at http://www.nih.gov/news/NIH-Record/10_16_2001/main.htm (Dated: 13 Jun 02)

Ghalayini A. M. and Noble J. S. (1996), "The changing basis of performance measurement", *International Journal of Operations and Production Management*, Vol. 16, No. 8, Pages 63-80.

Ghalayini A. M., Nobke J. S. and Crowe T. J., (1997) "An integrated dynamic performance measurement system for improving manufacturing competitiveness", *International Journal of Production Economics* 48-1997, pp207-225.

Gill J. and Johnson P. (1991), *Research Methods for Managers*, Paul Chapman Publishing Ltd., London.

Glaser B. and Strauss A. (1967), *The Discovery of Grounded Theory: Strategies for Qualitative Research*, Aldine Publishing Company.

Goldratt E. M. and Cox J. (1986), "*The Goal: A Process of Ongoing Improvement*", North River Press, NY.

Green D. (1966), "Evaluating the Accounting Literature", *Accounting Review*, January 1966, Pages 54 57.

Gummesson E. (2000), *Qualitative Methods in Management Research*, Sage Publications, London.

Haag S., Cummings M. and McCubbrey D. J. (2002), *Management Information Systems for the Information Age*, third edition, McGraw-Hill Companies, Inc.

Hatch, E., & Lazaraton, A. (1991), *The research manual: Design and statistics for applied linguistics*, Newbury House, Rowley, MA.

Hayes R. H. and Abernathy W. J. (1980), "Managing our way to economic decline", *Harvard Business Review*, July-August 1980, Pages 67-77.

Hayes R. H. and Clark K. B. (1986), "Why some factories are more productive than others", *Harvard Business Review*, Sep-Oct 1986, Pages 66-74.

Hiatt J. and Creasey T. (2002), "The Definition and History of Change Management" at *http://www.prosci.com/tutorial-change-management-history.htm*

Ho S. K. M. (1999), *Operations and Quality Management*, International Thomson Business Press, Holborn, UK.

Holloway J. (2001), "Investigating the impact of performance measurement", *International Journal of Business Performance Management*, Vol. 3, Nos. 2/3/4. Pages 167-180.

Hope J. and Fraser R. (1998), "Measuring Performance in the new Organisational Model" *Management Accounting*, June 1998, Pages 22-23.

Hudson M, Bennet J P, Smart A and Bourne M, (1999), Performance measurement in planning and control in SME's, *Global Production Management* edited by Mertins K, Krause O and Schallock B, Kluwer Academic Publishers, isbn 0-7923-8605-1

IFAC Information Technology Committee (1999), "Managing Information Technology Planning for Business Impact" at *www.ifac.org* No. 2, January 1999.

Imai M. (1986), *Kaizen: The Key to Japan's Competitive Success*, McGraw-Hill Publishing Company.

Ittner C. D. and Larcker D. F. (1998), "Are Nonfinancial Measures Leading Indicators of Financial Performance? An Analysis of Customer Satisfaction", *Journal of Accounting Research*, Vol. 36 Supplement 1998. Pages 1-35.

Johnson H. T. and Kaplan R. S. (1987), *Relevance lost: the rise and fall of Management Accounting*, Harvard Business School Press, Boston, MA.

Kaplan R. (1983), "Measuring Manufacturing Performance: A New Challenge for Management Accounting Research", *The Accounting Review*, Oct 1983, Pages 686-705.

Kaplan R. (1984), "The Evolution of Management Accounting", *The Accounting Review*, Vol. LIX, No. 3, July 1984, Pages 390-418.

Kaplan R. S. and Norton D. P. (1992), "The Balanced Scorecard – Measures That Drive Performance", *Harvard Business Review*, January-February 1992 issue.

Kaplan R.S. and Norton D.P. (1996), *Translating strategy into action: The balanced scorecard*, Harvard Business School Press, Boston, Mass 1996.

Kaplan R.S. and Norton D.P. (2001), *The Strategy-Focused Organization: How Balanced Scorecard Companies Thrive in the New Business Environment*, Harvard Business School Press, Boston, Mass 2001.

Kasanen E., Lukka K. and Siitonen A. (1993), "The Constructive Approach in Management Accounting Research", *Journal of Management Accounting Research*, Fall 1993, Pages 243-264.

Keegan D. P., Eiler R. G. and Jones C. R. (1989), "Are your performance measures obsolete?", *Management Accounting*, June 1989, Pages 45-50.

Kennerly and Neely (2003), "Measuring performance in changing business environment", *International Journal of Operations and Production Management*, Vol. 23, No. 2, Pages 213-229.

Kerlinger F. (1979), *Behavioural Research: A Conceptual Approach*, Rinehart & Winston, New York.

Kerlinger F. (1986), *Foundation of Behavioral Research*, Holt, Rinehart and Winston, New York.

Kinnear C. and Taylor J. (1979), *Marketing Research: an Applied Approach*, McGraw Hill NY.

Kochhar A, Kennerly M and Davies A, (1996), *Improving Your Business Through Effective Manufacturing Planning and Control*, Workbook produced by researchers at UMIST as part of an EPSRC Funded research programme.

Kolb D., Rubin I. and McIntyre J. (1979), *Organisational Psychology: An Experimental Approach*, Prentice Hall, London.

Kotter J., Schlesinger L. and Sathe V. (1979), *Organization*, Irwin, Homewood, IL.

Krause O, (1999), "Performance Management", *Global Production Management* edited by Mertins K, Krause O and Schallock B, Kluwer Academic Publishers, isbn 0-7923-8605-1

Kueng P. (2001), "Performance Measurement Systems in the Service Sector – The potential of IT is not yet utilized" *Internal Working Paper* No. 01-05, Department of Informatics, University of Fribourg, Rue Faucingy 2, 1700 Fribourg, Switzerland.

Kueng P., Meier A. and Wettstein T. (2000), "Computer-based Performance Measurement in SMEs: Is there any option? *Proceedings of the International Conference on Systems Thinking in Management*, Greelong, Australia, 8-10, pp 318-323

Kueng P and Krahn A. (1999), "Building a process performance measurement system: some early experiences", *Journal of Scientific and Industrial Research*, Vol. 58 No.3/4, Pages 149-159.

Leavitt H. J. and Whistler T. L. (1958), "Management in the 1980s", *Harvard Business Review*, Vol. 36, Nov-Dec 1958, Pages 41-48.

Lebas M. (1995), "Performance measurement and management", *International Journal of Production Economics*, Vol. 41, No. 1-3, Pages 23-35.

Lebas M. and Euske K. (2002), "A conceptual and operational delineation of performance", edited by Neely A., *Business Performance Measurement: Theory and Practice*, Cambridge University Press, Pages 65-79.

Lewin K. (1947), "Frontiers in Group Dynamics", *Human Relations*, Vol. 1. Pages 5-41.

Lewin K. (1951), *Field Theory in Social Science*, Harper and Row, London.

Lillrank P., Holopainen S. and Paavola T., (2001), "Catching Intangible IT Benefits", The *Electronic Journal of Information System Evaluation*, Vol. 4, No. 1. (at http:/is.twi.tudelft.ni/ejise/vol4/papers/IntangibleIT.htm)

Lucey T. (1997), "*Management Information Systems*", 8th edn. London, Letts Educational.

Macrosson W. (1998), "Human Factors and Productivity: Social Aspects of Computer Integrated Manufacture" *Internal Course Material* 54316 edited by Carrie A. S., DMEM, University of Strathclyde, UK.

Marchand D., Davenport T. and Dickson T., (2000a), *Mastering Information Management,* Financial Times, Prentice Hall, London.

Marchand D., Kettinger W. and Rollins J., (2000b) "Company Performance and IM: the view from the top" – *Mastering Information Management* edited by Marchand D., Davenport T. and Dickson T., Financial Times, Prentice Hall, London. Pages 10-16.

Markus M. L. (2000), "How workers react to new technology" – *Mastering Information Management* edited by Marchand D., Davenport T. and Dickson T., Financial Times, Prentice Hall, London. Pages 233-238.

Martinez V. and Albores P. (2003), "Performance indicators for the evaluation and control of research in OM: the qualitative research case", *Implementation and Impact of Performance Measurement,* IFIP Workshop, Bergamo, Italy, June 19-20.

Marr B. and Neely A. (2002), *Balanced Scorecard Software Report*, A Business Review Publication from Cranfield School of Management with contributions by Gartner, Inc. Connecticut, USA.

Maskell B. (1989), "Performance measurement for world class manufacturing", *Management Accounting*, Vol. 67, May 1989.

McAdam R. and Bannister A. (2001), "Business performance measurement and change management within a TQM framework", *International Journal of Operations and Production Management*, Vol. 21, No. 1/2, Pages 88-107.

McNurlin B. C. and Sprague R. H. (2002), *Information Systems Management in Practice* fifth edition, Prentice-Hall International, Inc. Pages 211-214.

McNurry R. (1973), "The problem of resistance to change in industry", edited by Bartlett A. and Kayser T., *Changing Organisational Behaviour*, Prentice Hall, Englewood Cliffs, NJ.

Meekings A. (1995). "Unlocking the Potential of Performance Measurement: A Practical Implementation Guide", *Public Money & Management*, Oct-Dec, Pages 5-12.

Meltzer M. F. (1981), *Information: The Ultimate Management Resource.* New York: AMACOM.

Mendibil K., Turner T. and Bititci U. (2002), "Measuring and improving business process reliability", *International Journal of Business Performance Management*, Vol. 4, No. 1, Pages. 76-94.

Miles M. B. and Huberman A. M. (1984), *Qualitative data analysis: a sourcebook of new methods,* Sage Publications, Thousand Oaks.

Miller D. and Friesen P. H. (1984), *Organizations: A Quantum View*, Englewood Cliffs: Prentice-Hall.

Mintzberg H. (1973), *The Nature of Managerial Work*, Harper & Row Publishers, London.

Mintzberg H. (1987), "Crafting Strategy", *Harvard Business Review*, July-August Pages 66-75.

Mockler R. J. (1989), *Knowledge-Based Systems for Management Decisions.* Englewood Cliffs, NJ, Prentice-Hall.

Mooraj S., Oyon D. and Hostettler D. (1999), "The Balanced Scorecard: a necessary good or an unnecessary evil?", *European Management Journal*, Vol. 17, No.3, Pages 481-491.

Morgan G. (1979), "Response to Mintzberg: A letter to the editor", *Administrative Science Quarterly*, Vol. 24, Issue 1. Pages 137-139.

Mumford E. (2001), "Advice for an action researcher", *Information Technology & People*, Vol. 14, No.1, Pages 12-27.

Neely A. (2002), "Research Priorities", *Centre for Business Performance*, Cranfield University at http://www.som.cranfield.ac.uk/som/cbp/

Neely A. (1999), "The performance measurement revolution: why now and what next?", *International Journal of Operations and Production Management*, Vol. 19, No. 2. Pages 205-228.

Neely A. and Austin R. (2002), "Measuring performance: The operations perspective", edited by Neely A., *Business Performance Measurement: Theory and Practice*, Cambridge University Press. Pages: 41-50.

Neely A. and Adams C. (2001), "The Performance Prism Perspective", *Journal of Cost Management*, January/February 2001.

Neely A, Mills J., Platts K., Richards H., Gregory M., Bourne M. (2000), "Performance measurement system design: developing and testing process a process-based approach", *International Journal of Operations and Production Management*, Vol. 20, No. 9-10, Pages 1119-1145.

Neely A., Mills J., Gregory M. and Platts K. (1995), "Performance measurement system design – a literature review and research agenda", *International Journal of Operations and Production Management,* Vol.15, No.4, Pages 80-116.

Neely A., Mills J., Gregory M., Richards H., Platts K. and Bourne M. (1996), *Getting the measure of your business,* University of Cambridge, Manufacturing Engineering Group, Mill Lane, Cambridge.

Nudurupati S. S. and Bititci U. S. (2003) "Implementation and Impact of IT enabled Performance Measurement", *IFIP 3rd International Workshop*, Bergamo, Italy, 19-20 June 2003.

Nudurupati S. S. and Bititci U. S. (2000) "Review of Performance Management Information Systems (PerforMIS)", *Internal Report*, Centre for Strategic Manufacturing, DMEM, University of Strathclyde, UK.

Oakland J. S. (2003), *Total Quality Management: Text with cases*, Butterworth-Heinemann, Oxford.

Oliver N, (1996), "Design and Development Benchmarking", *5th Operations Strategy and Performance Measurement Workshop*, Loughborough University, 8 May 1996.

Orlikowski W. J. (1996), "Improvising Organisational Transformation Over Time: A Situated Change Perspective", *Information Systems Research,* Vol. 7, No. 1, Pages 63-92.

Orlikowski W. J. (2000), "Managing use not technology: *a view from the trenches*" – *Mastering Information Management* edited by Marchand D., Davenport T. and Dickson T., Financial Times, Prentice Hall, London. Pages 253-257.

Pettigrew A. (1987), "Context and Action in the Transformation of the Firm", *Journal of Management Studies*, Vol. 24, No. 6, Pages 649-670.

Pettigrew A. (1990), "Longitudinal Field Research on Change: Theory and Practice", *Organization Science*, Vol. 1, No. 3, Pages 267-292.

Porras, J. I. and Robertson P. J. (1992), "Organizational development: Theory practice, and research", edited by Dunnette M. D. and Hough L. M, *Handbook of Industrial and Organizational Psychology*, Consulting Psychologists Press, CA.

Porter M. E. (1980), *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. New York, The Free Press.

Prahalad C. K. and Krishnan M. S. (2002), "The Dynamic Synchronisation of Strategy and Information Technology", *MIT Sloan Management Review*, Summer 2002. Pages 24-33.

Reilly G. P. and Reilly R. R. (2001), "Improving Corporate Performance Measurement", *Journal of Cost Management*, July/August 2001, Pages 42-44.

Remenyi D. (2000), "The Elusive Nature of Delivering Benefits from IT Investment", *The Electronic Journal of Information Systems Evaluation*, Vol. 3, March 2000. at http://is.twi.tudelft.nl/ejise/ (Dated 2 May 2002)

Riordan P. (1995), "The philosophy of action science", *Journal of Management Psychology*, Vol. 10, No.6, Pages 6-13.

Robson C. (1993), *Real World Research: A Resource for Social Scientists and Practitioner Researchers*, Oxford Publishers, Blackwell.

Roland Bee and Frances Bee (1999), *Managing Information and Statistics,* Institute of Personnel and Development, Camp Road, London SW19 4UX.

Sauer C (1993), *Why information systems fail, A case study approach*, Alfred Waller, Oxfordshire.

Sayles L. and Straus G. (1966), *Human behavior in organizations*, Prentice hall, London.

Schaffer R. S and Thomson H. A (1992), "Successful Change Programs Begin With Results" *Harvard Business Review*, Jan-Feb 1992, Pages 80-89.

Schein E. H. (1996), "Three Cultures of Management: The Key to Organisational Learning", *Sloan Management Review*, Fall 1996. Pages 9-20.

Schneiderman, A.M. "Why Balanced Scorecards Fail", *Journal of Strategic Performance Measurement*, (1999) Special Edition, Pages 6 – 11.

Schonberger R. J. (1982), *Japanese Manufacturing Techniques: Nine Hidden Lessons in Simplicity*, The Free Press Publishers.

Scudder G. and Hill C. (1998), "A review and classification of empirical research in operations management", *Journal of Operations Management*, Vol. 16, Pages 91-101.

Silverman D. (1993), *Interpreting Qualitative Data: Methods for Analysing Talk, Text and Interaction*, Sage Publications, London.

Simon H. A. (1965), *The New Science of Management Decision*, Harper and Brothers, New York.

Simons R. and Davila A. (1998), "How high is your return on Management", *Harvard Business Review*, January-February 1998, Pages 71-80.

Skinner W. (1974), "The decline, fall, and renewal of manufacturing", *Industrial Engineering*, October, Pages 32-38.

Slack N. (1983), "Flexibility as a Manufacturing Objective", *International Journal of Operations and Production Management,* Vol. 3, No.3, Pages 4-13.

Suwingnjo P., Bititci U. S. and Carrie A. S., (1997), "Quantitative Models for Performance Measurement System: An Analytical Hierarchy Process Approach", *Managing Enterprises –*

Stakeholders, Engineering, Logistics, and Achievement, Mechanical Engineering Publications Ltd., pp. 237-243.

Suzaki K. (1987), *The New Manufacturing Challenge: Techniques for Continuous Improvement*, The Free Press Publishers.

Toulmin S. (1958), *The Uses of Argument*, Cambridge University Press.

Turner T. J. and Bititci U. S., (1999), "Maintaining reliability of business processes using active monitoring techniques." *International Journal of Business Performance Measurement*, Vol. 1. No. 2, Pages 186-199.

Turner T. J., Mendibil K., Bititci U. S., Daisley P. and Breen T. H. J. (2002), "Improving the reliability of the customer order fulfilment process in a product identification company", *International Journal of Production Economics*, Elsevier Science, Vol. 78, Pages 99-107.

Vogt W. (1993), *Dictionary of Statistics and Methodology*, Sage Publications, London.

Waddell D. and Sohal A. S. (1998), "Resistance: A constructive tool for change management", *Management Decision*, MCB University Press. Vol. 36, No 8. 1998. Pages 543-548.

Waggoner D., Neely A. and Kennerley M. (1999), "The forces that shape organisational performance measurement systems: an interdisciplinary review", *International Journal of Production Economics*, Vol. 60-61, Pages 53-60.

Whipp R., Rosenfeld R. and Pettigrew A. (1987), "Understanding Strategic Change Processes: Some Preliminary British Findings", edited by Pettigrew A., *The Management of Strategic Change*, Oxford: Basil Blackwell.

White D. and Bednar D. (1991), *Organizational Behavior*, Allyn & Bacon, Boston, MA.

Wight O. (1984), *Manufacturing Resource Planning: MRP II*, Oliver Wight Limited Publications, Essex Junction, VT 05452.

Wight O. (1993), *The Oliver Wight ABCD Check List* - 4th Edition, John Wiley & Sons, Inc, New York.

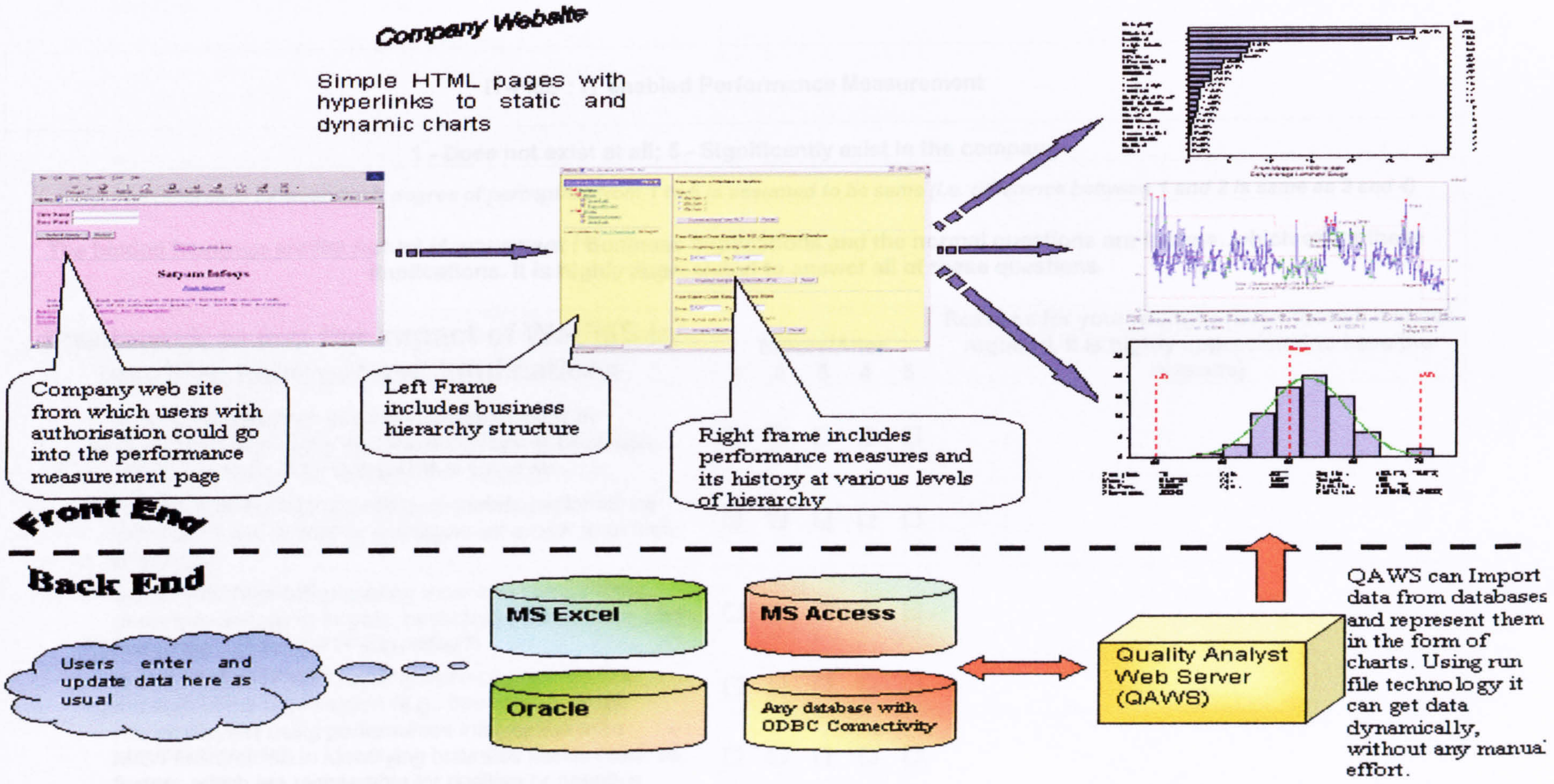
Wight O. (2000), *The Oliver Wight ABCD Check List* - 5th Edition, John Wiley & Sons, Inc, New York.

Willcocks L P and Lester S (1999), *Beyond the IT Productivity Paradox*, John Wiley & Sons Ltd, Chichester.

Woods A. (2001), "Performance Organiser", *JIT Software Ltd.*, 8 Nadder Road, Tidworth, Hants, SP9 7QA. e-mailed the document on 06 July 2001.

Yin R. (2003), *Case Study Research: Design and Methods*, Sage Publications, London.

Appendix A


Company Website
Simple HTML pages with hyperlinks to static and dynamic charts
Company web site from which users with authorisation could go into the performance measurement page
Front End
Left Frame includes business hierarchy structure
Right frame includes performance measures and its history at various levels of hierarchy
Back End
Users enter and update data here as usual
MS Excel
Oracle
MS Access
Any database with ODBC Connectivity
Quality Analyst Web Server (QAWS)
QAWS can Import data from databases and represent them in the form of charts. Using run file technology it can get data dynamically, without any manual effort.

Appendix B

IT-PMS : IT enabled Performance Measurement

1 - Does not exist at all; 5 - Significantly exist in the company

Note: The difference between each degree of perception from 1 to 5 is assumed to be same (i.e. difference between 1 and 2 is same as 3 and 4)

The bolded headings are the Actual Management / Business Implications and the normal questions are factors, which effect these implications. It is highly appreciated to answer all of these questions

	Framework to test the impact of WePMS in resulting management implications	Before/After 1	2	3	4	5	Reasons for your rating!!! (Even though it is not required, it is highly appreciated to have the reasons)
1	**Is MIS/PMS/WePMS assisting continuously in identifying Strengths and Weaknesses of business, which are critical for competitive success .....**	☐	☐	☐	☐	☐	
1.1	Is MIS/PMS/WePMS providing up-to-date performance information and access to managers (at a click from their computer)	☐	☐	☐	☐	☐	
1.2	Is MIS/PMS/WePMS providing means to compare the performance against targets, best-class performance and competitors (if so, is it IT supported?)	☐	☐	☐	☐	☐	
1.3	Is MIS/PMS/WePMS providing open communication throughout the organisation (e.g.: through the Web)	☐	☐	☐	☐	☐	
1.4	Are employees using performance information from MIS/PMS/WePMS in identifying business trends (such as factors, which are responsible for positive or negative trends)	☐	☐	☐	☐	☐	

2	**Is MIS/PMS/WePMS promoting the relationship with customers & suppliers .....**	☐	☐	☐	☐	☐
2.1	Is the company using MIS/PMS/WePMS to provide access and open communication to its customers and suppliers (through the Web)	☐	☐	☐	☐	☐
2.2	Are the suppliers and customers using performance information from MIS/PMS/WePMS, to identify activities on the problems initiated by / to them (such as quality of raw-material, quality of finished products etc.)	☐	☐	☐	☐	☐
2.3	With MIS/PMS/WePMS, are employees acting as a team (representing from customers and suppliers) to solve the issues raised above	☐	☐	☐	☐	☐
3	**Is MIS/PMS/WePMS facilitating the managers to be more proactive in making decisions .....**	☐	☐	☐	☐	☐
3.1	Is MIS/PMS/WePMS providing consistent and accurate information when required	☐	☐	☐	☐	☐
3.2	Are employees using MIS/PMS/WePMS in identifying business trends and constraints (such as quality problems, customer complaints etc.)	☐	☐	☐	☐	☐
3.3	With MIS/PMS/WePMS, are employees acting as a team to solve the issues raised above	☐	☐	☐	☐	☐
3.4	Are employees enthusiastic about using MIS/PMS/WePMS in making decisions	☐	☐	☐	☐	☐
3.5	Is the time and effort spent on data collection, analysis and communication has significantly reduced with MIS/PMS/WePMS	☐	☐	☐	☐	☐
3.6	Are people using MIS/PMS/WePMS as their routine part of business in making decisions	☐	☐	☐	☐	☐

4	**Is MIS/PMS/WePMS facilitating as critical component of an ongoing process improvement .....**	☐	☐	☐	☐	☐
4.1	Are employees using results-oriented approach (facilitated by MIS/PMS/WePMS) in controlling the processes	☐	☐	☐	☐	☐
4.2	Are employees looking into MIS/PMS/WePMS regarding monitoring processes	☐	☐	☐	☐	☐
4.3	Are employees making improvement decisions based on performance information provided by MIS/PMS/WePMS	☐	☐	☐	☐	☐
4.4	Is MIS/PMS/WePMS enabling people to act as a team by communicating the results to them	☐	☐	☐	☐	☐
4.5	Are employees knowledgeable enough to use MIS/PMS/WePMS	☐	☐	☐	☐	☐
4.6	Are people enthusiastic about using statistical approaches (facilitated by MIS/PMS/WePMS) to control processes	☐	☐	☐	☐	☐
5	**Is performance information and knowledge disseminated throughout the organisation .....**	☐	☐	☐	☐	☐
5.1	Is MIS/PMS/WePMS communicating the performance results to both internal and external users	☐	☐	☐	☐	☐
5.2	Are employees using MIS/PMS/WePMS for collecting data, structuring data into performance information and communicating this information	☐	☐	☐	☐	☐
5.3	Is the time and effort spent on data collection, analysis and communication significantly reduced with MIS/PMS/WePMS	☐	☐	☐	☐	☐
5.4	Are employees adopting results-oriented approach (facilitated by MIS/PMS/WePMS)? If so, did it promote continuous learning	☐	☐	☐	☐	☐

6	**Is MIS/PMS/WePMS facilitating benchmarking.....**	☐	☐	☐	☐	☐
6.1	Is MIS/PMS/WePMS providing means to compare the performance against targets, best-class performance and competitors	☐	☐	☐	☐	☐
6.2	Are people using performance information from MIS/PMS/WePMS to do the above	☐	☐	☐	☐	☐
6.3	Is MIS/PMS/WePMS providing the consistent and accurate performance information to the people who require it	☐	☐	☐	☐	☐
7	**Is MIS/PMS/WePMS improving the positive behaviour of the people .....**	☐	☐	☐	☐	☐
7.1	Is MIS/PMS/WePMS enabling team cohesion by communicating the results to them	☐	☐	☐	☐	☐
7.2	Is MIS/PMS/WePMS increasing empowerment to the employees	☐	☐	☐	☐	☐
7.3	Are employees using MIS/PMS/WePMS as their routine part of business	☐	☐	☐	☐	☐
7.4	Are employees more relaxed and confident about the performance information from MIS/PMS/WePMS in their management briefings	☐	☐	☐	☐	☐
7.5	Are employees less resistant to change because they can see the reason for change	☐	☐	☐	☐	☐

Appendix C

	Framework to test the impact of WePMS in resulting management implications	Personal Observation
1	**Is MIS/PMS/WePMS assisting continuously in identifying Strengths, Weaknesses, Opportunities and Threats (SWOT), which are critical for competitive success ……**	
1.1	Is MIS/PMS/WePMS providing up-to-date information and access to managers (at a click from their computer)	
1.2	Is MIS/PMS/WePMS providing means to compare the performance against targets, best-class performance and competitors (if so, is it IT supported?)	
1.3	Is MIS/PMS/WePMS providing open communication throughout the organisation (e.g.: through the Web)	
1.4	Are employees using information from MIS/PMS/WePMS in identifying business trends (such as factors, which are responsible for positive or negative trends)	
2	**Is MIS/PMS/WePMS promoting the partnership with customers & suppliers ……**	
2.1	Is the company using MIS/PMS/WePMS to provide access and open communication to its customers and suppliers (through the Web)	
2.2	Are the suppliers and customers using information from MIS/PMS/WePMS, to identify activities on the problems initiated by / to them (such as quality of raw-material, quality of finished products etc.)	
2.3	With MIS/PMS/WePMS, are employees acting as a team (representing from customers and suppliers) to solve the issues raised above	

3	**Is MIS/PMS/WePMS facilitating the managers to be more proactive in making decisions .....**	
3.1	Is MIS/PMS/WePMS providing consistent and accurate data when required	
3.2	Are employees using MIS/PMS/WePMS in identifying business trends and constraints (such as quality problems, customer complaints etc.)	
3.3	With MIS/PMS/WePMS, are employees acting as a team (representing customers and suppliers) to solve the issues raised above	
3.4	Are employees enthusiastic about using MIS/PMS/WePMS in making decisions	
3.5	Is the time and effort spent on data collection, analysis and communication has significantly reduced with MIS/PMS/WePMS	
3.6	Are people using MIS/PMS/WePMS as their routine part of business in making decisions	
4	**Is MIS/PMS/WePMS facilitating as critical component of an ongoing process improvement .....**	
4.1	Are employees using results-oriented approach1 (facilitated by MIS/PMS/WePMS) in controlling the processes	
4.2	Are employees looking into MIS/PMS/WePMS regarding monitoring processes	
4.3	Are employees making improvement decisions based on information provided by MIS/PMS/WePMS	
4.4	Is MIS/PMS/WePMS enabling people to act as a team by communicating the results to them	
4.5	Are employees knowledgeable enough to use MIS/PMS/WePMS	
4.6	Are people enthusiastic about using statistical approaches (facilitated by MIS/PMS/WePMS) to control processes	

5	**Is information and knowledge disseminated throughout the organisation .....**	
5.1	Is MIS/PMS/WePMS communicating the results to both internal and external users	
5.2	Are employees using MIS/PMS/WePMS for collecting data, structuring data into information and communicating this information	
5.3	Is the time and effort spent on data collection, analysis and communication significantly reduced with MIS/PMS/WePMS	
5.4	Are employees adopting results-oriented approach (facilitated by MIS/PMS/WePMS)? If so, did it promote continuous learning	
6	**Is MIS/PMS/WePMS facilitating benchmarking against competitors .....**	
6.1	Is MIS/PMS/WePMS providing means to compare the performance against targets, best-class performance and competitors	
6.2	Are people using information from MIS/PMS/WePMS to do the above	
6.3	Is MIS/PMS/WePMS providing the consistent and accurate information to the people who require it	
7	**Is MIS/PMS/WePMS changing the behaviour of the people .....**	
7.1	Is MIS/PMS/WePMS enabling team cohesion by communicating the results to them	
7.2	Is MIS/PMS/WePMS increasing empowerment to the employees	
7.3	Are employees using MIS/PMS/WePMS as their routine part of business	
7.4	Are employees more relaxed and confident about the information from MIS/PMS/WePMS in their management briefings	
7.5	Are employees less resistant to change because they can see the reason for change	

Appendix D

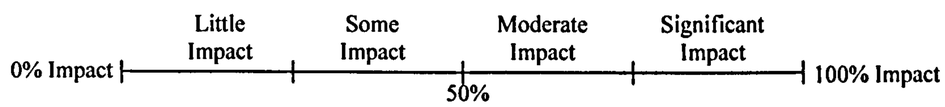
		Managing Director				Operations Manager				TCS Associate				Quality Manager				Team Leader				Marketing Manager				Average Rating				
		Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	% Impact
	Technical Factors																													
1.1	Up-to-date information and access to managers	1	1	1	0	3	4	4	1	2	4	3	1	1	1	1	0	2	2	2	0	2	2	2	0	1.8	2.3	2.2	0.4	12.5
1.2	Means to compare against targets and best-class performances	2	2	2	0	2	3	3	1	1	3	2	1	1	1	1	0	2	2	2	0	1	1	2	1	1.5	2	2	0.5	14.29
1.3	Open communication of information throughout the organisation	2	2	2	0	1	2	2	1	1	3	4	3	2	2	2	0	3	3	4	1	3	3	4	1	2	2.5	3	1	33.33
1.4	Secured access to customers and suppliers	2	2	2	0	1	2	3	2	1	1	2	1	1	1	1	0	1	1	1	0	1	1	1	0	1.2	1.3	1.7	0.5	13.16
1.5	Consistent and accurate information	2	2	2	0	2	3	2	0	1	2	2	1	2	2	2	0	2	2	3	1	2	2	2	0	1.8	2.2	2.2	0.4	12.5
1.6	Reduction in time and effort required in data collection and analysis	1	1	1	0	1	4	4	3	2	3	5	3	2	2	2	0	1	1	2	1	2	2	2	0	1.5	2.2	2.7	1.2	34.29
1.7	Statistical analysis for controlling and monitoring processes																									1	2	2	1	25
1.8	Simple and easy for the users	3	3	3	0	3	3	3	0	3	2	1	-2	2	2	2	0	2	2	2	0	3	3	3	0	2.7	2.5	2.3	-0.4	-17.4
																													Average	15.96
	People Factors																													
2.1	Senior management commitment and drive																									2	3	2	0	0
2.2	Using the system in identifying business trends	3	3	3	0	1	1	3	2	2	2	2	0	1	1	1	0	2	2	3	1	1	1	1	0	1.7	1.7	2.2	0.5	15.15
2.3	Using the system for decision-making	1	1	1	0	1	2	3	2	2	2	3	1	2	2	2	0	1	1	2	1	2	2	2	0	1.5	1.7	2.2	0.7	20
2.4	Acting as teams to solve the issues	2	2	2	0	1	1	3	2	3	3	4	1	2	2	2	0	2	2	3	1	1	1	2	1	1.8	1.8	2.7	0.9	28.13
2.5	Using the system as a routine part of their business	1	1	1	0	1	2	3	2	2	2	3	1	2	2	2	0	1	1	2	1	2	2	2	0	1.5	1.7	2.2	0.7	20
2.6	Not resistant to use the system	3	3	3	0	2	4	4	2	3	2	4	1	3	3	3	0	3	3	3	0	5	5	5	0	3.2	3.3	3.7	0.5	27.78
2.7	Knowledgeable enough to use the system	3	3	3	0	3	3	3	0	3	2	1	-2	2	2	2	0	2	2	2	0	3	3	3	0	2.7	2.5	2.3	-0.4	-17.4
2.8	Empowered to make decisions based on information	1	1	1	0	1	2	3	2	3	1	3	0	1	1	1	0	1	1	1	0	1	1	1	0	1.3	1.2	1.7	0.4	10.81
2.9	Confident about the information	3	3	3	0	1	3	3	2	1	1	1	0	1	1	1	0	2	2	3	1	2	3	2	0	1.7	2.2	2.2	0.5	15.15
2.10	Customers and suppliers are using the system	1	1	1	0	1	1	1	0	1	1	3	2	1	1	1	0	1	1	2	1	1	1	1	0	1	1	1.5	0.5	12.5
																													Average	14.68
	Impact on business and management																													
3.1	Identified weak areas of business	2	2	2	0	2	3	3	1	1	3	3	2	1	1	1	0	2	2	3	1	2	2	3	1	1.7	2.2	2.5	0.8	24.24
3.2	Improved relationship with customers and suppliers	2	2	2	0	1	1	2	1	1	1	3	2	1	1	1	0	1	1	2	1	1	1	1	0	1.2	1.2	1.8	0.6	15.79
3.3	Facilitated proactive management style	2	2	2	0	1	2	3	2	2	2	3	1	2	2	2	0	2	2	3	1	2	2	2	0	1.8	2	2.5	0.7	21.88
3.4	Facilitated ongoing process improvement	2	2	2	0	1	2	2	1	2	3	3	1	2	2	2	0	1	1	2	1	2	3	3	1	1.7	2.2	2.3	0.6	18.18
3.5	Created transparency and visibility of information	2	2	2	0	1	2	4	3	2	3	3	1	2	2	2	0	1	1	2	1	2	2	2	0	1.7	2	2.5	0.8	24.24
3.6	Improved positive behaviour	2	2	2	0	1	3	3	2	2	2	3	1	2	2	2	0	2	2	3	1	3	3	3	0	2	2.3	2.7	0.7	23.33
																													Average	21.28

% Impact Calculations

$$\% \text{ Impact} = \frac{(\text{Actual Change from the Management Responses})}{(\text{Maximum Change Possible from the Management Responses})} * 100$$

$$= \frac{(\text{Average Rating of Impact})}{(5 - \text{Average Rating of Before})} * 100 \rightarrow \text{From the above Table}$$

Converting the % Scale to the Semantic Scale



Appendix E

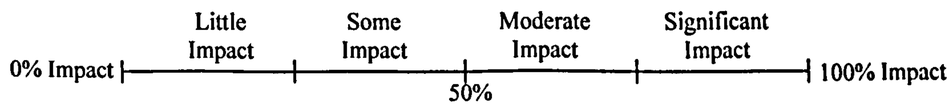
		IT designer				TCS Associate				TCS Associate				Operations Manager				Director				IT designer				Average Rating				
		Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	% Impact
	Technical Factors																													
1.1	Up-to-date information and access to managers	3	5	5	2	2	3	5	3	2	2	5	3	1	3	3	2	1	3	3	2	4	4	4	0	2.2	3.3	4.2	2	71.43
1.2	Means to compare against targets and best-class performances	2	4	3	1	2	3	3	1	2	2	4	2	1	3	4	3	1	3	3	2	4	4	5	1	2	3.2	3.7	1.7	56.67
1.3	Open communication of information throughout the organisation	4	5	5	1	2	4	4	2	2	3	5	3	1	3	3	2	2	4	4	2	5	4	5	0	2.7	3.8	4.3	1.6	69.57
1.4	Secured access to customers and suppliers	1	4	1	0	1	1	1	0	1	1	2	1	1	1	2	1	1	2	2	1	2	2	2	0	1.2	1.8	1.7	0.5	13.16
1.5	Consistent and accurate information	3	5	4	1	1	2	5	4	1	3	5	4	1	2	3	2	2	3	3	1	4	4	4	0	2	3.2	4	2	66.67
1.6	Reduction in time and effort required in data collection and analysis	3	2	4	1	1	1	5	4	1	2	5	4	3	3	3	0	1	2	2	1	1	2	4	3	1.7	2	3.8	2.1	63 64
1.7	Statistical analysis for controlling and monitoring processes																									1	2	3.5	2.5	62.5
1.8	Simple and easy for the users	4	4	4	0	2	2	3	1	2	3	3	1	3	3	3	0	1	2	3	2	3	3	4	1	2.5	2.8	3.3	0.8	32
																												Average		54.45
	People Factors																													
2.1	Senior management commitment and drive																									3	4	4.5	1.5	75
2.2	Using the system in identifying business trends	4	4	4	0	1	2	4	3	1	3	5	4	1	2	2	1	1	2	2	1	3	3	4	1	1.8	2.7	3.5	1.7	53.13
2.3	Using the system for decision-making	4	5	5	1	1	2	5	4	1	2	4	3	1	2	3	2	1	2	2	1	4	4	4	0	2	2.8	3 8	1.8	60
2.4	Acting as teams to solve the issues	2	4	4	2	1	2	5	4	1	3	3	2	1	1	2	1	1	2	2	1	3	2	5	2	1.5	2.3	3.5	2	57.14
2.5	Using the system as a routine part of their business	4	5	5	1	1	2	5	4	1	2	4	3	1	2	3	2	1	2	2	1	4	4	4	0	2	2.8	3 8	1.8	60
2.6	Not resistant to use the system	3	5	5	2	2	3	4	2	4	3	4	0	2	3	3	1	2	3	3	1	2	4	4	2	2.5	3.5	3 8	1.3	52
2.7	Knowledgeable enough to use the system	4	4	4	0	2	2	3	1	2	3	3	1	3	3	3	0	1	2	3	2	3	3	4	1	2.5	2.8	3.3	0.8	32
2.8	Empowered to make decisions based on information	2	3	4	2	2	3	4	2	1	3	3	2	1	2	2	1	1	2	2	1	4	4	4	0	1.8	2.8	3.2	1.4	43.75
2.9	Confident about the information	3	4	4	1	1	2	5	4	1	3	5	4	1	2	3	2	1	2	3	2	2	4	4	2	1.5	2.8	4	2.5	71.43
2.10	Customers and suppliers are using the system	1	3	1	0	1	1	1	0	1	1	2	1	1	1	1	0	1	1	1	0	1	1	2	1	1	1.3	1.3	0.3	7.5
																												Average		48.55
	Impact on business and management																													
3.1	Identified weak areas of business	2	4	4	2	2	2	5	3	2	2	4	2	1	2	2	1	1	2	3	2	3	4	4	1	1.8	2.7	3.7	1.9	59.38
3.2	Improved relationship with customers and suppliers	1	3	4	3	1	1	2	1	1	1	3	2	1	1	2	1	1	1	1	0	1	1	3	2	1	1.3	2.5	1.5	37.5
3.3	Facilitated proactive management style	2	4	5	3	1	2	5	4	1	3	3	2	1	2	3	2	1	2	3	2	3	2	4	1	1.5	2.5	3.8	2.3	65.71
3.4	Facilitated ongoing process improvement	2	4	4	2	1	2	5	4	2	3	5	3	1	2	3	2	1	2	3	2	3	3	4	1	1.7	2.7	4	2.3	69.7
3.5	Created transparency and visibility of information	2	4	4	2	1	2	5	4	1	2	3	2	1	2	3	2	1	2	2	1	2	2	4	2	1.3	2.3	3.5	2.2	59.46
3.6	Improved positive behaviour	2	4	4	2	1	2	4	3	1	3	4	3	1	2	3	2	1	2	2	1	2	4	4	2	1.3	2.8	3.5	2.2	59 46
																												Average		58.53

% Impact Calculations

$$\% \text{ Impact} = \frac{(\text{Actual Change from the Management Responses})}{(\text{Maximum Change Possible from the Management Responses})} * 100$$

$$= \frac{(\text{Average Rating of Impact})}{(5 - \text{Average Rating of Before})} * 100 \rightarrow \text{From the above Table}$$

Converting the % Scale to the Semantic Scale



Appendix F

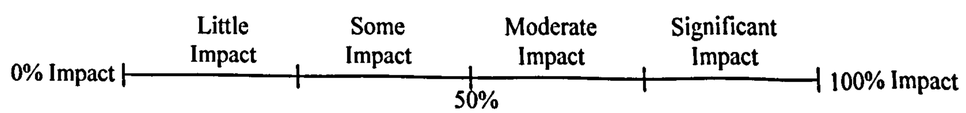
		TCS Associate				Operations Manager				Process Manager				Administration				Planning Manager				Supply Chain Manager				Teal Leader				Accounts Manager				Average Rating				
		Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	% Impact
	Technical Factors																																					
1.1	Up-to-date information and access to managers	1	3	4	3	1	3	4	2	1	3	5	4	1	4	4	3	1	3	3	2	1	3	3	2	2				1	2	2	1	1	3	3.6	2.6	65 00
1.2	Means to compare against targets and best-class performances	1	2	3	2	1	3	4	2	1	3	4	3	1	3	4	3	1	2	3	2	2	3	3	1	1				1	2	2	1	1.1	2.6	3.3	2.2	56.41
1.3	Open communication of information throughout the organisation	1	2	4	3	1	3	4	2	1	3	4	3	1	3	4	3	1	2	3	2	1	3	2	1	2				1	2	1	0	1	2.6	3.1	2.1	52.50
1 4	Secured access to customers and suppliers	1	1	2	1	1	1	1	0	1	2	4	3	1	1	1	0	1	1	1	0	2	4	4	2	1				1	2	2	1	1.1	1.7	2.1	1	25 64
1.5	Consistent and accurate information	2	2	4	2	1	3	4	2	1	4	4	3	1	1	4	3	2	3	2	0	1	3	3	2	2				1	2	3	2	1.3	2.6	3.4	2.1	56.76
1.6	Reduction in time and effort required in data collection and analysis	1	2	4	3	1	4	4	3	1	2	4	3	1	3	4	3	1	1	1	0	1	3	3	2	1				1	3	3	2	1	2.6	3.3	2.3	57.50
1.7	Statistical analysis for controlling and monitoring processes																																	1	2	3	2.0	50 00
1.8	Simple and easy for the users	1	1	2	1	1	1	2	0	1	3	4	3	1	3	3	2	3	1	1	-2	1	2	2	1	1				1	2	2	1	1.3	1.9	2.3	1	27.03
																																				Average		48.85
	People Factors																																					
2.1	Senior management commitment and drive																																	2	3	4	2	66 67
2.2	Using the system in identifying business trends	1	1	3	2	1	2	3	1	1	1	1	0	1	3	4	3	1	2	2	1	2	3	3	1	1				1	2	3	2	1.1	2	2.7	1 6	41.03
2.3	Using the system for decision-making	1	1	3	2	1	3	4	2	1	4	4	3	1	2	4	3	1	2	2	1	1	3	3	2	2				1	3	2	1	1	2.6	3.1	2.1	52.50
2.4	Acting as teams to solve the issues	1	1	2	1	1	1	2	0	1	5	5	4	1	3	3	2	1	1	1	0	1	3	3	2	1				1	3	3	2	1	2.4	2.7	1.7	42.50
2.5	Using the system as a routine part of their business	1	1	3	2	1	3	4	2	1	4	4	3	1	2	4	3	1	2	2	1	1	3	3	2	2				1	3	2	1	1	2.6	3.1	2.1	52.50
2.6	Not resistant to use the system	1	1	1	0	1	1	2	0	1	5	5	4	1	3	4	3	1	2	2	1	1	2	2	1	5				1	4	4	3	1	2.6	2.9	1.9	47.50
2.7	Knowledgeable enough to use the system	1	1	2	1	1	1	2	0	1	3	4	3	1	3	3	2	3	1	1	-2	1	2	2	1	1				1	2	2	1	1.3	1.9	2.3	1	27.03
2.8	Empowered to make decisions based on information	1	1	2	1	1	1	2	0	1	1	2	1	1	3	3	2	1	1	2	1	1	2	2	1	1				1	3	4	3	1	1.7	2.4	1.4	35.00
2.9	Confident about the information	1	1	2	1	1	1	2	0	1	4	4	3	1	3	4	3	2	2	3	1	1	3	3	2	1				1	3	4	3	1.1	2.4	3.1	2	51.28
2.10	Customers and suppliers are using the system	1	1	2	1	1	1	1	0	1	2	4	3	1	1	1	0	1	2	1	0	2	3	3	1	1				1	2	2	1	1.1	1.7	2	0 9	23.08
																																				Average		43.91
	Impact on business and management																																					
3.1	Identified weak areas of business	1	2	4	3	1	3	4	3	1	3	5	4	1	4	4	3	1	3	2	1	1	3	3	2	1				1	2	2	1	1	2.9	3.4	2.4	60 00
3.2	Improved relationship with customers and suppliers	1	1	2	1	1	1	1	0	1	3	4	3	1	1	2	1	1	1	1	0	2	3	3	1	1				1	3	3	2	1.1	1.9	2.3	1.2	30.77
3.3	Facilitated proactive management style	1	2	3	2	1	2	3	2	1	1	3	2	1	3	4	3	1	2	2	1	2	3	3	1	2				1	3	3	2	1.1	2.3	3	1.9	48.72
3.4	Facilitated ongoing process improvement	1	1	1	0	1	1	2	1	1	2	4	3	1	2	4	3	1	5	5	4	1	2	2	1	1				1	3	3	2	1	2.3	3	2	50.00
3.5	Created transparency and visibility of information	1	2	3	2	3	3	4	1	1	2	4	3	1	3	4	3	1	2	3	2	1	2	2	1	1				1	3	4	3	1.3	2.4	3.4	2.1	56.76
3.6	Improved positive behaviour	1	1	1	0	1	1	2	1	1	2	4	3	1	3	4	3	1	2	2	1	1	3	3	2	1				1	3	4	3	1	2.1	2.9	1.9	47.50
																																				Average		48.96

% Impact Calculations

$$\% \text{ Impact} = \frac{(\text{Actual Change from the Management Responses})}{(\text{Maximum Change Possible from the Management Responses})} * 100$$

$$= \frac{(\text{Average Rating of Impact})}{(5 - \text{Average Rating of Before})} * 100 \rightarrow \text{From the above Table}$$

Converting the % Scale to the Semantic Scale



Appendix G

Critical A Defects	Critical B Defects	Major A Defects	Major B Defects
Contaminated Product	*Wrong Tint*	*Damaged Closure*	*Blistered/Wrinkled Label*
Foreign Object in product	*Wrong Bottle*	*Chipped Labels*	*Cracked Bottle*
	Wrong Closure	*Closure not fully Applied*	*Cut Closure*
	Wrong Clarity	*Incomplete Packaging*	*Damaged Pack*
	Wrong Capacity	*Leaker*	*Dented Cap*
	Wrong Package/Contents	*Loose Label*	*Dirty Label*
	Wrong Spirit	*No Bottle Coding*	*Double Capsule*
	Wrong Strength	*Open Case*	*Double Label*
	Wrong Carbonation/Oxygen	*Split Bottle/Danny*	*Floater*
	Poor Seal	*Split Closure*	*High*
	Over Age	*Torn Label*	*Large Stone in Bottle*
	Flavour	*Upside Down/Wrong Panel*	*Loose Edge label*
		Wrong Pack	*Low*
		Torques not to Specifications	*Off-Centre Label*
		Excess Melt	*Scuffed Label*
		Incomplete Case Marks	*Skewed Label*
			Turn Up Label

Appendix H

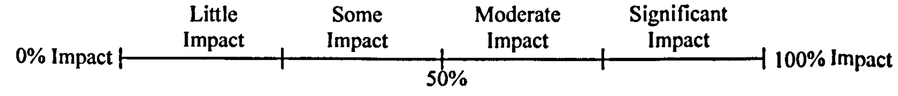
		Operations Director				Sr. Quality Manager				Line Manager				Line Manager				Head of Operations				Head of Quality				Sr. Quality Manager				Reliability Manager				Line Manager				Sr. Quality Manager				Continuous Improvement Specialist				Average Rating				
		Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	Before	After	After 6 Months	Impact	% Impact
	Technical Factors																																															
1.1	Up-to-date information and access to managers	1	4	4	3	1	3		2	1	5	5	4	2	4	5	3	2	3	4	2	1	4	4	3	1	3	3	2	1	3	4	3	1	4	5	4	1	5	4	3	1	2	5	4	1.2	3.6	4.3	3.1	81.58
1.2	Means to compare against targets and best-class performances	2	3	3	1	3	4		1	1	5	5	4	1	4	4	3	2	4	4	2	3	3	3	0	1	3	3	2	1	4	4	3	2	4	5	3	1	4	4	3	1	2	5	4	1.6	3.6	4	2.4	70.59
1.3	Open communication of information throughout the organisation	1	4	3	2	1	3		2	1	4	4	3	2	5	4	2	1	3	4	3	1	4	4	3	1	3	2	1	1	4	4	3	2	3	4	2	1	3	3	2	1	1	3	2	1.2	3.4	3.5	2.3	60.53
1.4	Secured access to customers and suppliers	1	3	3	2	1	1		0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	2	2	2	0	1	1	1	0	1	2	2	1				0	1.1	1.4	1.4	0.3	7.69
1.5	Consistent and accurate information	3	3	3	0	2	4		2	1	4	4	3	1	4	4	3	2	4	5	3	4	4	4	0	1	3	3	2	1	3	4	3	4	4	4	0	1	5	5	4	1	3	5	4	1.9	3.7	4.1	2.2	70.97
1.6	Reduction in time and effort required in data collection and analysis	2	4	4	2	2	4		2	2	5	5	3	2	5	5	3	2	4	3	1	2	4	2	0	1	3	3	2	2	4	4	2	2	2	4	2	1	3	3	2	1	3	5	4	1.7	3.7	3.8	2.1	63.64
1.7	Statistical analysis for controlling and monitoring processes																																												1	2	3	2.0	50.00
1.8	Simple and easy for the users	3	3	3	0	2	2		0	2	2	2	0	2	4	4	2	2	4	4	2	2	4	1	-1	1	3	2	1	2	3	4	2	2	2	3	1	1	2	4	3	1	2	4	3	1.8	2.8	3.1	1.3	40.63
																																													Average				55.70
	People Factors																																															
2.1	Senior management commitment and drive																																												1.5	4.0	3.5	2.0	57.14
2.2	Using the system in identifying business trends	2	4	4	2	4	4		0	3	5	5	2	1	3	3	2	2	4	4	2	3	4	3	0	4	4	3	-1	2	4	4	2	1	3	4	3	1	3	4	3	1	3	4	3	2.2	3.7	3.8	1.6	57.14
2.3	Using the system for decision-making	1	3	3	2	4	4		0	1	1	1	0	1	4	3	2	2	4	4	2	3	3	2	-1	2	2	2	0	2	2	3	1	2	3	3	1	1	2	4	3	1	2	3	2	1.8	2.7	2.8	1	31.25
2.4	Acting as teams to solve the issues	2	3	3	1	3	3		0	2	3	3	1	1	4	4	3	3	3	4	1	2	3	3	1	3	3	4	1	1	1	2	1	2	3	5	3	1	3	4	3	1	2	4	3	1.9	2.8	3.6	1.7	54.84
2.5	Using the system as a routine part of their business	1	3	3	2	4	4		0	1	1	1	0	1	4	3	2	2	4	4	2	3	3	2	-1	2	2	2	0	2	2	3	1	2	3	3	1	1	2	4	3	1	2	3	2	1.8	2.7	2.8	1	31.25
2.6	Not resistant to use the system	1	3	3	2	3	3		0	3	4	4	1	2	4	4	2	2	3	4	2	2	2	3	1	3	3	3	0	1	1	3	2	3	3	4	1	1	2	4	3	1	2	4	3	2	2.7	3.6	1.6	53.33
2.7	Knowledgeable enough to use the system	3	3	3	0	2	2		0	2	2	2	0	2	4	4	2	2	4	4	2	2	4	1	-1	1	3	2	1	2	3	4	2	2	2	3	1	1	2	4	3	1	2	4	3	1.8	2.8	3.1	1.3	40.63
2.8	Empowered to make decisions based on information	2	4	4	2	2	2		0	5	5	5	0	1	2	3	2	2	3	4	2	2	3	1	-1	1	3	2	1	1	1	2	1	2	4	4	2	1	2	3	2	1	3	5	4	1.8	2.9	3.3	1.5	46.88
2.9	Confident about the information	1	3	3	2	4	4		0	4	4	4	0	1	4	4	3	2	3	4	2	2	3	1	-1	2	3	3	1	1	1	2	1	3	3	4	1	1	2	5	4	1	3	5	4	2	3	3.5	1.5	50.00
2.10	Customers and suppliers are using the system	1	3	3	2	1	1		0	1	1	1	0	2	2	2	0	2	2	2	0	1	1	1	0	1	1	1	0	2	2	2	0	1	1	1	0	1	1	1	0	1	1	1	0	1.3	1.5	1.5	0.2	5.41
																																													Average				42.79
	Impact on business and management																																															
3.1	Identified weak areas of business	2	4	4	2	2	3		1	2	5	5	3	1	4	4	3	2	3	3	1	2	4	4	2	2	3	3	1	1	3	4	2	1	3	4	2	1	4	4	3	1	3	5	4	1.5	3.5	4	2.5	71.43
3.2	Improved relationship with customers and suppliers	1	3	3	2	1	1		0	1	1	1	0	1	2	2	1	1	4	4	3	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1	2	2	1				0	1	1.7	1.8	0.8	20.00
3.3	Facilitated proactive management style	2	3	3	1	4	4		0	2	3	3	1	2	3	3	1	3	4	4	1	1	3	2	2	2	3	3	1	1	3	3	2	2	3	4	1	1	2	4	3	1	2	4	3	1.9	3	3.3	1.4	45.16
3.4	Facilitated ongoing process improvement	1	3	3	2	4	4		0	2	3	3	1	3	4	4	1	3	4	4	1	1	4	2	3	2	3	3	1	1	3	3	2	2	3	4	1	1	2	3	2	1	2	4	3	1.9	3.2	3.3	1.4	45.16
3.5	Created transparency and visibility of information	2	4	3	2	3	4		1	2	4	4	2	3	3	4	0	2	3	4	1	1	3	2	2	2	3	3	1	1	2	3	1	3	4	4	1	1	2	4	3	1	2	4	3	1.9	3.1	3.5	1.6	51.61
3.6	Improved positive behaviour	1	3	3	2	3	3		0	3	4	4	1	2	4	3	2	2	3	4	1	1	3	1	2	2	3	3	1	1	1	2	0	3	3	4	0	1	2	3	2	1	2	4	3	1.8	2.8	3.1	1.3	40.63
																																													Average				45.66

% Impact Calculations

$$\% \text{ Impact} = \frac{(\text{Actual Change from the Management Responses})}{(\text{Maximum Change Possible from the Management Responses})} * 100$$

$$= \frac{(\text{Average Rating of Impact})}{(5 - \text{Average Rating of Before})} * 100 \rightarrow \text{From the above Table}$$

Converting the % Scale to the Semantic Scale



Appendix I

Published

Nudurupati S. S., (2000) "*Modelling Business into E-Business*", MSc Dissertation - 2000, University of Strathclyde, Glasgow, UK

Bititci U. S., Nudurupati S. S., Turner T. J. and Creighton S. (2001) "*Web Enabled Performance Measurement Systems: Management Implications*", Conference Proceedings - European Operations Management Association; Bath U.K. June 2001

Nudurupati S. S., Bititci U. S., and Maddocks S. (2002) "*Web Enabled Performance Measurement Systems*", Conference Proceedings – PMA Conference 2002 The World Trade Center, Boston, USA. 17-19 July 2002

Bititci U. S., Nudurupati S. S., Turner T. J. and Creighton S. (2002) "*Developing Competitive Advantage through Web enabled Performance Measurement System*", Control Magazine, Vol. 27, No. 7 September 2002.

Nudurupati S. S., Bititci U. S., and Maddocks S. (2002) "*Enhancing Collaboration through Web enabled Performance Measurement System*", Conference Proceedings - Collaborative Systems for Production Management, Advanced Production Management Systems (IFIP), Eindhoven, Netherlands. 8-13 September 2002

Bititci U. S. and Nudurupati S. S. (2002) "*Using Performance Measurement to drive Continuous Improvement*", Manufacturing Engineer, IEE Magazine, Vol. 81, No. 5. Pages 230-235

Bititci U. S., Nudurupati S. S., Turner T. J. and Creighton S. (2002) "*Web Enabled Performance Measurement Systems: Management Implications*", International Journal of Operations and Production Management, Vol. 22, No. 11, Pages 1273-1287, Nov 2002

Nudurupati U. S. and Bititci U. S. (2003) "*Impact of Performance Measurement on Business and Management*", 7th IFAC Workshop on Intelligent Manufacturing Systems (IMS), Budapest, Hungary, 6-8 April 2003.

Nudurupati U. S. and Bititci U. S. (2003) "*Managing with Measures*", Conference on Improving Business Performance, The Lighthouse, 11 Mitchell Lane, Glasgow, 11 June 2003

Nudurupati U. S. and Bititci U. S. (2003) "*Impact of IT enabled Performance Measurement on Business and Management*", EurOMA and POMS Joint International Conference, Como Lake, Italy, 16-18 June 2003

Nudurupati U. S. and Bititci U. S. (2003) "*Implementation and Impact of IT enabled Performance Measurement*", IFIP 3rd International Workshop, Bergamo, Italy, 19-20 June 2003

Nudurupati U. S. and Bititci U. S. (2003) *"Human Aspects of IT supported Performance Measurement"*, IFIP International Conference, Karlsruhe, Germany, Oct 2003

Unpublished

Nudurupati S. S., Bititci U. S., Turner T. J. and Creighton S. "*Alcan Foil Europe Gains Bottom-Line Benefits with Web enabled Performance Management System*", targeted for US trade publication (currently under company's review)

Software Reviews and Reports

Statistical Quality Control (SQC) Tools	SQC Provider
Quality Analyst Web Server	Northwest Analytical, Inc.

Nudurupati S. S. and Bititci U. S., "*Web enabled Performance Measurement System using NWA Quality Analyst Web Server*", NWA Application Series, Adept Scientific APS. at http://www.adeptscience.dk/nwa/weblosning.pdf

Performance Management Information Systems (PerforMIS)	PerforMIS Provider
Pilot Decision Support System	Accrue Software Inc.
ActiveStrategy Enterprise	Active Strategy
Cognos PowerPlay & Impromptu	Cognos Ltd.
Comshare MPC™	Comshare
CorManage, RapidScorecard & CorServer	CorVu Plc.
Gentia Enterprise Performance Management Suite	Gentia Software Ltd.
ProMeaSys	Global Performa Maxima
Hyperion Performance Scorecard	Hyperion
PerformancePlus™	Inphase Software Ltd.
Pbviews	*PB Views Ltd.*
QPR ScoreCard	QPR Software Plc.
Performance Profiler™	QuantiSoft, LLC
Strategic Vision	SAS Institute

Nudurupati S. S. and Bititci U. S. "*Review of Performance Management Information Systems (PerforMIS)*", Internal Report, Centre for Strategic Manufacturing, DMEM, University of Strathclyde, UK.