A NEW APPROACH TO PERFORMANCE MEASUREMENT USING DATA ENVELOPMENT ANALYSIS:

Implications for Organisation Behaviour, Corporate Governance and Supply Chain Management

Alex Manzoni
Victoria Graduate School of Business
Faculty of Business and Law
Victoria University

A thesis submitted in partial fulfillment for the degree of Doctor of Business Administration, Victoria University, March 2007

Doctor of Business Administration Declaration

I Alex Manzoni declare that the DBA thesis entitled *A New Approach to Performance Measurement Using Data Envelopment Analysis: Implications for Organisation Behaviour, Corporate Governance and Supply Chain Management* is no more than 65,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. The thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

Alex Manzoni

Signed …………………………….

Date ……18 July 2007

Acknowledgements

I am indebted to many people who have helped me in many ways to complete this work. After a long and successful career it is but fitting to complete a thesis in a discipline I have found exciting all my working life. I would like to acknowledge and thank all those people I have dealt with that have made this field special to me. I group the contributions of these people into four categories: supervisory support and guidance, academic and professional colleagues, friends, and family.

My supervisors Professor Sardar Islam and Dr Ian Sadler have helped me in complementary ways. Dr Sadler as a friend and work colleague is responsible for instigating this study and supporting me in dealing with the stumbling blocks created by bureaucracy. As the secondary supervisor his role has also been to give an alternative viewpoint and to be scathingly critical when asked. I am sure this has helped me. Professor Sardar (Naz) Islam has brought to my study his wealth of experience in supervising doctoral students and a guiding path to the completion of this type of academic venture. His background knowledge and experience in tangential fields has been an inspiration for me to broaden the scope of my own research. Both supervisors have been invaluable resources providing me with superlative mentoring and practical help. I can proudly say that they also belong to the other categories of colleagues and friends.

It is impossible to overemphasize the contribution of my academic colleagues and friends in my career, spanning vocational education, training, lecturing, and consulting for industry. There have been too many acquaintances to name them individually, but it would be remiss of me to not acknowledge them collectively. I thank them all.

This research required long periods of uninterrupted work, usually after already having completed a day’s employment and always on weekends. My family has been wonderfully supportive throughout this journey. Jenny, Jess and Nick have all motivated me in different ways and on occasions providing me with the necessary distractions that are needed to interrupt the work ethic required to complete such a project.

Publications arising from this thesis

Refereed Publications in Proceedings of International Conferences

1 Manzoni, A 2005, ‘A Performance Scorecard in the Australian Context: the role of DEA’, Victoria University Business Research Conference, Victoria Graduate School of Business, Victoria University, Melbourne, 29 November.

2 Manzoni, A and Sadler, I 2005, ‘An Improved Performance Scorecard in the Australian Context’, in *Proceedings of the 19th ANZAM Conference*, University of Canberra, Canberra, 7-10 December.

3 Manzoni, A and Islam, SMN 2006, ‘An Improved Performance Scorecard for Supply Chain Networks in the Australian Context’, in *Proceedings of the International Conference on Logistics and SCM (LSCM2006)*, Department of Industrial and Manufacturing Systems Engineering, The University of Hong Kong, Hong Kong, 5-7 January.

4 Manzoni, A and Islam, SMN 2006, ‘Measuring the Performance of Supply Chain Networks in Australia: A Business Process Model using DEA’, in *Proceeding of the 4th International Conference on SCM and Information Systems (SCMIS 2006),* National Chung Hsing University, Taiwan, 5-7 July.

5 Manzoni, A and Islam, SMN 2006, ‘Measuring the Performance of Collaborative Relationships in Supply Chain Networks Using DEA: A CG Perspective’, in *Proceedings of the 4th International Logistics and Supply Chain Congress*, Izmir University of Economics, Turkey, 29 November to 1 December.

International Journal Publications (invited and refereed)

1 Manzoni, A and Islam, SMN 2007, ‘Measuring the Effectiveness of Collaborative Relationships in the Logistics of Globalised Supply Networks: an Application of DEA’, *International Journal of Logistics, Economics and Globalisation.* Vol.1, no.1, pp. 77-911 (invited submission).

2 Manzoni, A and Islam, SMN 2007, ‘Measuring the Performance of Supply Chain Networks in Australia: A Business Process Model using DEA’, *International Journal of Value Chain Management.* (accepted, publication pending)

3 Tan, HB, Hooy, CW, Islam, SMN and Manzoni, A 2007, ‘Relative Efficiency Measures for the Knowledge Economies in the Asia Pacific Region’, *Journal of Modelling in Management.* (accepted, publication forthcoming)

Papers Under Review in International Journals (refereed)

1 Manzoni, A and Islam, SMN 2006 ‘An Improved PM Model for Supply Chain Networks in an Australian Context’, *The International Journal of Logistics Management*

Table of Contents

A New Approach to Performance Measurement using Data Envelopment Analysis: Implications for Organisation Behaviour, Corporate Governance and Supply Chain Management

Chapter 3 Conceptual Framework and Research Methodology: A New Approach to Performance Measurement

Chapter 4 DEA: Theory, Methods and Applications

Chapter 5 DEA of Corporate Governance: The Model and its Application

Chapter 6 Results and Validation of DEA Application to Corporate Social Responsibility

List of Tables

Table of Figures

Key to Acronyms

ABC	Activity Based Costing
ABS	Australian Bureau of Statistics
AE	Allocative Efficiency
AHP	Analytical Hierarchy Process
AM	Additive Model
ASCI	Australian Council of Superannuation Investors
ASX	Australian Stock Exchange
B2B	Business to Business
B2C	Business to Customer
B2E	Business to Employee
BCC	Banker, Charnes and Cooper
BITC	Business in the Community
BM	Benchmarking
BPR	Business Process Re-engineering
BSC	Balanced Scorecard
C2C	Customer to Customer
CA	Comparative Advantage
CCR	Charnes Cooper Rhodes (DEA Model)
CG	Corporate Governance
CI	Consistency Index
CR	Consistency Ratio
CRI	Corporate Responsibility Index
CRS	Constant Returns to Scale
CSF	Critical Success Factors
CSR	Corporate Social Responsibility
CSRMC	CSR Management Capacity
DEA	Data Envelopment Analysis
DEACSR	DEACSR model
DJSI	Dow Jones Sustainability Index
DMU	Decision Making Unit
DP	Dynamic Programming
DRS	Decreasing Returns to Scale
EDI	Electronic Data Interchange
EE	Economic Efficiency
ERP	Enterprise Resources Planning
ESRC	Economic and Social Research Council
EVA	Economic Value Added
FTSE4	Global Index of London Stock Exchange and Financial Times
GDP	Gross Domestic Product
GSCF	Global Supply Chain Forum
GP	Goal Programming
ICT	Information Communication Technologies
IFSA	Investment and Finance Services Association
IMF	International Monetary Fund
IO	Input Oriented

IP	Integer Programming
IPMS	Integrated PM System
IRS	Increasing Returns to Scale
KE	Knowledge Economy
KM	Knowledge Management
KPI	Key Performance Indicator
LHS	Left Hand Side
LP	Linear Programming
MIP	Multiple Integer Programming
MM	Matrix Model
MNE	Multinational Enterprises
MOP	Multiobjective Programming
NLP	Non-linear Programming
OB	Organisation Behaviour
OBPM	Organisation Behaviour Performance Measurement Model
OECD	Organisation for Economic Cooperation and Development
OEEC	Organisation for European Economic Cooperation
OLS	Ordinary Least Squares
OO	Output Oriented
OR	Operations Research
OSTS	Open Socio-Technical Systems
P2P	Person to Person
PDEA	Parametric DEA
PE	Price Efficiency
PM	Performance Measurement
PMS	Performance Measurement System
PP	Partial Productivity
RHS	Right Hand Side
RTS	Returns to Scale
SBM	Slack-Based Model
SBS	Socio-technical Business Systems
SC	Supply Chain
SCC	Supply Chain Council
SCM	Supply Chain Management
SN	Supply Networks
SDWT	Self Directed Work Teams
SP	Stochastic Programming
SRI	Social Responsibility Index
STS	Socio-Technical System
TBL	Triple Bottom Line
TdeB	Tableau de Bord
TFP	Total Factor Productivity
TD	Technological Determinism
TE	Technical Efficiency
TOC	Theory of Constraints
TP	Total Productivity
TQM	Total Quality Management
VRS	Variable Returns to Scale

Abstract

Background, Issues, Existing Literature and Limitations

Traditionally, the operational performance of enterprises has been measured in terms of financial accountability and profit since they provide a monetary yardstick of performance evaluation and comparisons. However, in the global knowledge economy, performance should be analysed beyond financial ratios criteria and systems, and should be measured in terms of corporate governance (CG), organisation behaviour (OB) and supply chain management (SCM) because these factors determine the performance of enterprises in the broader socio-economic perspective generally, and corporate social responsibility (CSR) specifically.

Conceptual and Theoretical Framework – A New Approach to Performance Measurement

An integrated approach to performance measurement requires an assessment of the contributions of stakeholders and the major tenets of modern organisation theory, namely OB, CG, SCM and corporate social responsibility because these are determinants of performance and missing in previous work.

This dissertation develops a contemporary organisation behaviour performance measurement (OBPM) framework for enterprises in the emerging global knowledge economy. It integrates the dimensions of OB, CG and SCM by the development of an open socio-technical systems (OSTS) framework within a new model called ‘data envelopment analysis of corporate social responsibility’ (DEACSR). This framework addresses the importance of stakeholders at various stages of the supply chain, the style of management and design of organisation, as well as the need to be able to measure qualitative contributors, such as CSR, to organisation performance. In all instances of performance management however, present levels of performance must be measured before they can be improved. Therefore, this proposed framework embeds extended appropriate dimensions of measures of corporate operations and performance in the contemporary world.

The Methodology and Data

To implement the OBPM framework, the data envelopment analysis (DEA) linear programming technique of operations research is used to generate a ranking of CSR-related efficient performing business units. DEA is widely regarded as an effective modelling technique for the measurement of efficiencies in similar decision-making units (DMUs). The software, DEA Solver Pro 4.1, was applied to the ‘corporate social responsibility management capacity’ (CSRMC) dimensions of the OBPM framework in an Australian bank with national and international operations, thus providing a new application. DEA was applied to 231 DMUs of the bank to identify which were the most efficient CSR performers even though the bank itself, has achieved premier gold star ratings on national CSR indices for the last four years.

Results and Implications

The DEA results have listed 11 fully efficient (100%) units and rank ordered the remainder. The efficient units have strong characteristics of humanistic participative management, organisational support and empowerment, a commitment to business ethics and stakeholder acknowledgement and support. In addition, inter-item correlations of these characteristics for the efficient DMUs show that the results are not only plausible, but comprehensive and intuitively correct. Therefore the results support an OBPM framework on the basis that:

1) DEA is an effective instrument in the operations research methodology used to elicit efficiently performing business units; since

2) CSR is validated as a significant dimension of corporate governance; due to

3) the organisational behaviour inherent in an humanistic OSTS-designed enterprise which enhances corporate citizenship.

The implications of an OBPM framework and the DEA results obtained by applying this framework are as follows:

1) The OBPM framework is consistent with the need to redesign the corporation of the future, as the OSTS-designed organisation can display synergies in the technical and social subsystems

through the enhanced performance of collaborative relationships within the organisation and the whole supply network.

2) Humanistic styles of management, with the characteristics of business ethics and stakeholder empowerment, contributes to organisation performance.

3) CSR is a platform for stakeholder engagement and an essential element of organisation performance.

Limitation, Contribution and Conclusion

The limitation to this study is that the non-parametric nature of DEA means it is not applicable to the measurement of performance in every instance.

This thesis has made an original contribution to the literature in the area of performance measurement theory; by developing a new approach to performance measurement which goes beyond traditional financial measures, by implying new developments in OB and management theory, CG, and SCM, and by implementing this new performance measurement approach with DEA.

The quest for enterprises to be competitive in the contemporary global economy will inevitably lead them to a reconfiguration of the OSTS design presented in this thesis.

Chapter 1

Performance Issues in the Global Knowledge Economy: The Need for an Extended Framework for Enterprises

I keep the subject of my inquiry constantly before me, and wait till the first dawning opens gradually, by little and little, into a full and clear light.

Sir Isaac Newton 1643-1727

1.1 Introduction

The subject of this dissertation is the development of an extended organisation behaviour (OB) and performance measurement (PM) model for a commercial enterprise in an Australian supply chain by the use of DEA. The chapter is structured to present the background to PM in the Australian context against the backdrop of international competitiveness in a global business environment. It also identifies the movement towards governance and corporate citizenship with their implications for OB and management style. The limitations of traditional methods for measuring performance are visited to introduce a measurement approach for the extended organization behaviour performance measurement (OBPM) framework. It then lists the objectives of this research followed by the methodology that is adopted. The chapter concludes with the contribution of this study and an outline of the structure for the thesis.

1.1.1 Background: The Global Knowledge Economy

Australia has experienced a period of unprecedented economic growth and commercial prosperity. It has sustained and enjoyed a positive economic growth trend since 1990 (ABS 2006b) and been the envy of many other nations. It is ranked 13th in the top 100 economies and 7th most attractive market worldwide (World Bank 2004). The OECD has applauded Australia's initiatives to maintain this impetus. Business and commerce in

Australia are booming with productivity growth surging in the second half of the 1990s, and real gross domestic product (GDP) growth averaging 4% since the turn of the millennium. Living standards now surpass all G7 countries with the single exception of the United States (OECD 2006b). In this modern economic era, Australian enterprises find a commercial world where survival is contingent on performing to standards of 'world best practice', while navigating the forces of multiple stakeholders. Whether proactive in pursuing political and trade agendas or reactive in assessing, diagnosing and responding to extraneous forces, Australia's commercial enterprises have reaped the benefits of adopting sound business principles.

The concept of competitive advantage is familiar to businesses which for many years enjoyed the protections of the 'barriers of distance' and have recently recognized that these barriers no longer exist. Business has also learned the lesson that there is no 'level playing field' and the ruthless pursuit to win or serve customers is the only chance for success. Integral to the quest for betterment and the need to outdo competitors in their industry, is the assessment of one company against its peers. The comparisons that organisations make in an evaluation of their own standing against their competitors is in fact a measure of performance. PM, in its most ubiquitous sense, is the simple process of comparison; comparison to some standard that is meaningful and of value to the entity making the comparison. For the individual employee the measure informs about their own behaviour against the organisation's goals, for the organisation it informs about the performance of various units, departments or cost centres, against corporate goals (Inman and Simmering 2006), while for the corporation it provides feedback on the degree to which it is fulfilling its stakeholders' expectations. But, performance is not a unitary concept. To some it is related to results, such as the financial achievements over a given period, while others are focused on the determinants of such results, i.e. factors such as quality, responsiveness, flexibility and innovation, while still others discuss the increasing relevance of governance and partnership relationships. The differences suggest that there is a need for an inclusive framework which caters for all.

In business, the result of these performance comparisons becomes a harbinger of decline or a catalyst for change-it is a challenge. Fortunately, to date Australia has accepted the challenge and responded in a rewarding fashion. Today the challenge is one posed by the advent of the globalisation of business furnished by the international corporatization of companies and the networking of their supply chains. Some of these multi-national enterprises (MNEs) have economic power bigger than many sovereign nations. Global competitiveness is the mantra which distinguishes this economic era from previous ones. What has been responsible for the Australian achievement outlined at the beginning of this section? The key drivers for such a sustained effort are many and all subject to academic, political and social debate (OECD 2006b; Parham 1999, 2002). However, in all arenas there is agreement that progress has been made because of sound management and leading performance practices. Managers have adopted and used techniques that create and sustain superior performance within the organisation and transplanted these to partners in the supply network (Porter 2004). Performances have been measured by benchmarking comparisons but achieved by utilizing all resources effectively. The human resource with its knowledge capital should not be dimmed on this agenda. In other words, the mechanistic techniques for achieving competitiveness should be synthesized with the OB cultures that promote them.

1.1.2 The Behaviour of Management and the Role of Companies in Society

In the developed world there is now a re-thinking of the best way to optimize the human resource. The 'productivity-through-people' strategy recognizes the importance and value of the 'knowledge capital' available to firms through its employees (Senior and Swailes 2004). OB theories have moved in favour of teams, based on empowered employees as the linchpin which gives a competitive advantage against the threat of low-cost unskilled labour. In this sense, competitiveness is about fully utilizing knowledge capital and harnessing the synergy of teams.

This is the kernel of paradigms such as the open socio-technical systems (OSTS) theory adopted in this research. OSTS is a convergence of: 1) the socio-technical model propounded by Fred Emery (1982) of the Tavistock Institute and developed by Dutch researchers; 2) Ludwig Bertalanffy's (1968) general systems theory; and 3) Jay Forrester's (1961,1968) provision for information feedback and mathematical modeling.

Organisation theory posits that outcomes and achievements are the consequences of organisation structure, policies, management culture and leadership style. The OSTS model prescribes a joint optimisation of technical and social subsystems. The social subsystem is one where the employee stakeholders bring knowledge, skills, attitudes, values and personal relationships to the work environment, which has hierarchical and organisational structures but which operates on humanistic principles of industrial democracy. Humanistic values within the firm and its management according to these principles, translates into an associative, democratic style where external stakeholders have a strong influence on corporate decision-making. In the transactional environment the stakeholders have an immediate connection with the firm as partners in the supply chain, whereas in the contextual environment the connection is a more nebulous one with the community and the general economy.

Corporate governance (CG) is the way in which the firm is controlled, and therefore reflective of the leadership and culture of the organisation. It is the stewardship of the firm, in a system comprising formal and informal institutions, laws, regulations and rules, ownership, and delegated power, to achieve financial, environmental and social goals. These goals are often stated as ‘the triple bottom line’. It is much touted to underpin organisational competitiveness and success, yet its measurement is frequently myopic, usually dimensionally-limited and often qualitative. However, its importance stipulates that it be included in any framework that claims to view organisational performance from a holistic vantage. In this study it forms the foundations for a performance model.

1.1.3 The Supply Chain Imperative

Supply chains (SC) have existed and been important for millennia but it is since the industrial revolution that business practices evolved into refined 20th century commercial systems characterized by an emergence of partly integrated supply chains. The supply chain concept has an intrinsic appeal because it encompasses all business transactions and has the potential to service and add value to customer needs. The concept implies an efficient and effective network of business linkages which, through the productivities of specialization, core competencies and economies of scale, provide valuable end-customer services and products. The traditional SC business model is one where the raw materials, components and other resources journey through value adding processes, such as manufacturing or service extensions, through distribution conduits to end users. Typically material, product and service flows go from suppliers to end users while financial flows are reversed, from customers to initial suppliers. Information and knowledge, on the other hand, is bi-directional (Hakansson and Person 2004).

In the 1990s the world of commerce was irrevocably changed by the impact of computerization and information communication technologies (ICT). The internet provided a myriad of inexpensive information transferring capabilities. The speed, flexibility, accessibility, accuracy and reliability of web-based communication established the norm in conducting business transactions. The impact on business is immediate, pervasive and unavoidable (Paganetto 2004). As opportunities have expanded through the globalisation of markets, so have the global competitors become more threatening to local businesses. The firm that operates as an independent entity with loosely-linked arrangements with suppliers and customers is facing the threat of becoming economically unable to survive, a small backwater business, or being taken over by a more competitive and efficient company. While in the past the pursuit of operational excellence may have kept a firm competitive against others that had a similar goal, it no longer succeeds with such a strategy when the others have tackled the goal of attaining greater efficiencies by challenging performances along the whole supply chain.

Traditionally the field of operations management has been concerned with the effective planning, organizing and controlling of the resources and activities necessary to produce goods/services for customers. The framework of a systems model reflecting this typically comprises Input (resources)-Transformation-Output (goods/services) with a feedback loop, This effectively defines the organisation and establishes its operational imperative, that of converting and using resources to provide quality products to customers, as efficiently as possible (Kidd, Richter and Stumm. 2003). It should be noted that this input-output model becomes seminal to this thesis as detailed later. However, there are numerous aspects and various determinants of organisational performance within the conventional supply chain and many of these are now outdated with the advent of ICT and the internet. The sheer pervasiveness and economy of ICT has launched new business models based on various e-commerce platforms (Croon 2001).

Extending the model to all business transactions which employ ICT, e-business can be further defined by the nature of the transaction, for example; business-to-business (B2B), business-to-customer (B2C), consumer-to-consumer (C2C), people-to-people (P2P), and even business-to-employee (B2E). Other transactions include government to citizens, intranets, and mobile (wireless) business. This overarching information technology has also irrevocably changed the mode of supply chain management (SCM). A generalized model of the concept of an integrated SC network, adapted from the Bowersox, Closs and Cooper framework (2007), is shown in Figure 1.1 below.

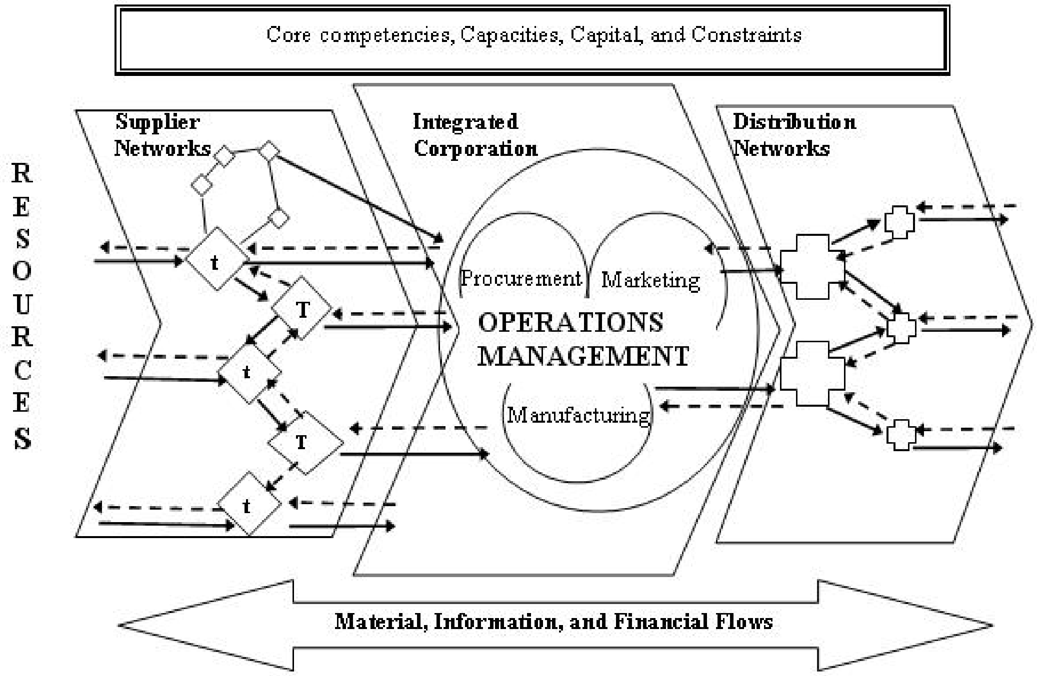


Figure 1.1 Generalized Model of the Supply Network

Modern supply chains are driven by a number of interwoven forces: integrative management, responsiveness, financial complexity and globalisation. Integrative management is the recent challenge to redirect management focus on process outcomes of the SC rather than the operational efficiency of specialised functions compartmentalised by organisations structured on the principles of the division of labour. The aggregation of individual ‘best in class’ functional performers does not translate to synergistic optimal performance (Doran 2003). Integrative management seeks to extract efficiencies through collaboration with partners, extending the enterprise by crossing ownership boundaries, and integrating service providers by outsourcing. Responsiveness can be an outcome of integrative management. Traditional business practices were based on predicting customer demands and therefore then performing essential work in anticipation of future requirements. This anticipatory work was duplicated along the SC. Joint planning and rapid information exchange between SC partners can, through synchronization of operations, provide a response-based business model that reacts to committed demand (Duffy and Fearne 2004). The customer not only initiates the order, but specifies its degree of customization as well. This also augers well for financial investment.

Since fast delivery means less ‘turnaround’ time, the time it takes for the investment to achieve its return is also reduced, hence a higher return on investment. Utilisation is a SC measure of the ratio of time an asset is idle to the time it takes to complete its task. Reducing time across the SC reduces investment necessary for it to perform its role and thus releases capital. This investment benefit is sometimes referred to as ‘cash spin’. The main enabler of the integrated SC is ICT as the force that drives globalisation. Globalisation can be seen as normal social evolution, albeit exponentially rapid in recent times, or a new force driven by technological innovation. Irrespective of definition, it is acknowledged as part and parcel of the current business arena and must be addressed. There are challenges which are significantly different to regional or even national operations. Distances are longer, governing authorities have laws and regulations which can complicate business transactions, consumers may exhibit different demand characteristics, and cultural diversity can be significant (Macbeth, 2002). Under these conditions and with these broader jurisdictions management has had to re-define itself and its role, and embrace more collaborative relationships with stakeholders.

1.1.4 Organisational Performance Management and Measurement

The need for PM to communicate achievements, good and poor, has never been greater, yet the field of PM is not new. It has been a human activity as long as humanity itself but perhaps more formalized since the publication of Domenico Manzoni’s 1540 AD *Quaderno*, which explains the expository technique of ‘double entry book-keeping’ still practiced today. But the finance discipline is not the only discipline involved in PM. There are many others (Lowson 2002). The diversity of disciplines includes organisation theory, strategic management, operations management, human resource management, economics, operations research and information systems. Relatively new to the literature is performance management in its own right and the emergence of productivity theory. To view organisational performance solely from any of these perspectives would be simplistic and myopic.

This thesis recognizes the importance of performance being studied by a multi-disciplinary approach and attempts to do so by crossing boundaries where necessary.

The management of performance is hinged on the knowledge of what it currently is, at what level the competitors are performing, and what performance could and should be. In other words, the management of performance is centred on its measured values, hence the importance of measurement above all else. It is the umbilical cord for improvement (Neely, Bourne and Adams 2003b). Often the measurement of performance has been viewed as simply the systematic collection of numbers to operational functions, resulting in metrics which purportedly allows meaningful comparisons. The accounting, financial and economic fraternities certainly accept that the financial metrics are suitable indicators of comparative performances amongst companies, industries and nations. Why is it so difficult to get meaningful information? Sink (1985) perceptively observed that most people who address the task of developing measurement systems eventually come to the conclusion that measurement is a mystery, and he notes that experts readily admit that measurement is complex, frustrating, difficult, challengingly important, abused and misused.

Performance, its perception, measurement, and management, is pertinent at every stage of the supply chain, from the primary supplier to the ultimate end-user (Neef 2004). At every stage and in every way there are stakeholders that are making comparative judgments. Consequently it is not dismissive to state that performance must be measured at various stages of the supply chain but also at the different levels within each process of those stages. In other words, it should be measured in a multi-faceted and multi-dimensional way. This should imply a multitude of measures and some mechanism for their synthesis. However, simply doing the exercise and obtaining them for 'their own sake' will not provide the motivational impetus to improve.

1.1.5 The Elements of Performance

The need for new measures of performance arises because of the change of direction from introspectively focused operational analysis of functional processes, individually within the firms of the supply chain, to customer-centred orientations which commence at the start of the supply chain through to the end-user (Hill and Alexander 2000). Every link in the chain has a customer at one end, including the internal customers as defined in the quality management literature.

Strategic direction and policy setting should be encouraged by measured performance (results) which encourage actions congruent with the company's business strategy (Vollmann et al. 2005) and which are critical to 'world class competition' (Sink 1985). This, in a global forum, means every facet of the competitive imperative of the modern marketplace should be measured. The elements of performance are therefore; i) OB through its application of modern management theory, ii) SCM through its relationships with transactional stakeholders, iii) and CG for its stewardship of the firm to satisfy all stakeholders, and through its corporate citizenship for contextual stakeholders. An extended OBPM framework can thus be visualized as of a performance pyramid, in Figure 1.2. Note that the foundation of the structure is CG. One of its sides reflects internally measured performance of the firm. The other side represents the performance of the supply chain in which the firm conducts business, while the third side of the pyramid measures the customer relationship.

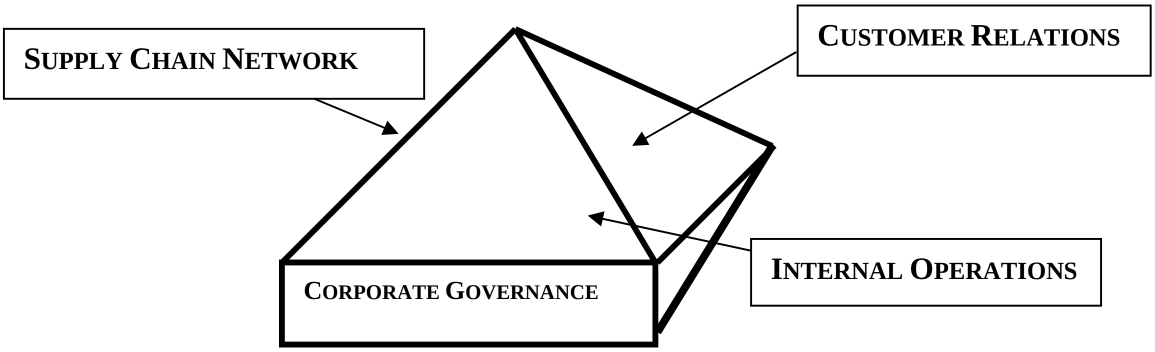


Figure 1.2 The Extended OBPM Framework structured as the Performance Pyramid

The OBPM framework purposely recognizes the interdependence of each of the elements of performance while maintaining that organisational performance is ultimately a multi-dimensional phenomenon. In an ideal scenario all necessary metrics of performance provide a display of how the company is faring. Perhaps a 'performance dashboard' is an apt description of a pragmatic performance pyramid.

1.1.6 Measures of Performance

Traditional measures of organisational performance were financial and accounting based, and evolved into sophisticated systems which had several functions. Firstly, financial measures as tools were used to manage the financial resources of companies to support organisational objectives. Secondly, as financial performance measures they acted as barometers to signify achievement against major organisational objectives. Thirdly, they acted as motivators for future achievements. By providing a window of the past they were thought to be the instigators of future successes. The fact that they were cost-based and backward-looking provided little motivation to improve, and in some instances even hindered improvement (Kaplan 1986, Johnson and Kaplan 1987).

The difficulties with traditional measures of performance are many (Eccles 1991).

These include:

- Cost based accounting metrics are well over half a century old. (DuPont method, in Gardner 2004)

- Cost accounting is still often dated and thus misleading in its information (Otley and Fakiolas 1995).
- Performance is usually isolated to individual units, rather than holistically measured and interpreted (Otley 2002).
- Many managerial decisions are historically founded in concepts such as return on investment and payback period.
- Financial information used in managerial decision making is often far removed from operational relevance, resulting in a failure to understand the implications on processes (Keegan et al. 1989).
- The importance of the customer is often ignored or downplayed in financial decisions (Hill and Alexander 2000).
- There is no distinction in the use of management accounting rules applied to different types of operational processes such as: service operations, manufacturing to high volumes or wide variety, mass customisation, or other combinations (Otley 1999).
- Bottom-line financial results are historically focused when the firm should be intent on going forward (Elkington 1997).

The inadequacies of traditional finance-based measures of performance spurred the search for better metrics. Financial specialists adopted measures such as activity based costing (ABC), economic value added (EVA, Otley 1999), and triple bottom line (TBL, Elkington 1997) to their portfolio but it was the advent of the 'balanced scorecard' (BSC, Kaplan and Norton 1992) that heralded an innovative approach to measuring performance (Appendix 11). This new American framework had four dimensions, with the financial perspective still maintained as an important one of them. The others were the internal business perspective, customer perspective, and the innovation and learning perspective. The BSC has been well received and drawn so much attention in the world of commerce that it was the most cited work at the 1998, 2000, and 2002 PM Association conferences (DeWaal 2003). The Cranfield University response to the BSC is the 'Performance Prism (Neely, Adams, and Crowe 2001) which has five 'facets of performance'; stakeholder satisfaction, strategies, processes, capabilities and stakeholder contribution (Appendix 12). These PM models and other similar ones, such as the performance tree of Lebas (1995), the performance matrix of Keegan, Eiler and Jones (1989) or even the Tableau de Bord (TdB, Epstein and Manzoni 1997), recognize the need for including non-tangible performance indicators in a broad-based metric. In many ways the elements of performance mentioned in section 1.1.5 above, or their surrogates, should be included in such models. They are not (Olve, Roy and Wetter 1999).

The BSC for example, fails to address the role and standing of competitors, and lacks prescriptive detail (Norreklit 2000), while the performance prism and BSC both fail to address the significance of CG. Similar arguments can be applied to other models which generally lack methods for measuring the extended OBPM framework presented in this study.

The approach taken in this research, namely of an extended OBPM framework, is possible because of the use of DEA. DEA is a linear programming technique for measuring productivity across a myriad of 'decision making units', and ranking the contenders in order of their performances. The best performers are benchmarked and assigned a rating of unity in comparison to lesser performers. This as a generic approach is not unique (Rouse 1997), but its application is. The DEA algorithm is applicable to all stages in the supply chain, commencing with an evaluation of CG. Such an approach has not been attempted before. While DEA has been successfully used to measure individual performance relationships in singular research dimensions and in different fields, it has never been used in an extended framework of PM which covers OB, supply chains and CSR. This is done in this dissertation.

1.1.7 Data Envelopment Analysis

DEA, an optimizing technique based on the linear programming method, was originally designed to tackle the task that parametric models failed in, to assess relative performance of firms which were not-for-profit organisations and where outputs are not quantifiable in conventional measures such as dollars, volumes or quantities. The non-commercial nature of these types of organisations rendered the traditional financially-based indicators of performance inappropriate and in many ways misleading or meaningless. Consequently, other metrics were devised for specific instances and particular organisations but they lacked the ability to provide benchmark performance indicators that could provide objective analytical comparisons of the roles of successful, detrimental or influential factors.

Furthermore, they were incapable of unambiguously specifying where the poor performers were failing and what was the scope for improvement. The other less tangible variable in the performance matrix is the value or quality of the input resources required to achieve the desired outputs. For example, in recent times, knowledge capital has been touted as a valuable resource yet if fails to be successfully quantified, especially in relation to its contribution to organisational performance. Traditional easily counted resources such as workforce numbers, buildings, facilities and equipment have been financially valued but inadequately evaluated in their contribution to the organisational mission. In many ways their contributions may have been underestimated, and in some instances over-inflated. For example, state-of-the-art technological equipment in schools may be cited as the reason for academic excellence while life experiences and subject knowledge of teachers may be regarded as less important. Despite the subjectivity of the conventional metrics employed in assessing the performance of non commercial organisations, DEA has been successful in adapting these to determine the relative efficiencies of schools (education), health care (hospitals, clinics, etc), police forces, transport, banking, housing and other public sector utilities. A bibliography of DEA until 1992 is provided in Charnes, Cooper, Lewin and Seiford (1994).

In more recent times DEA has been tested in wider and diverse situations such as global economic studies, alternate technologies and environment pollution comparisons and it has enjoyed success with such larger units of study. In all cases reported, the technique succeeded on the basis that it made comparisons between units of the same population. It operates as a comparative instrument which allows the best performing units to be rated as the most efficient, equally so if there are several, and assigns the lesser performers decreasing grades by rank. Schools were compared with other schools, police patrols with other police patrols, hospitals with hospital, etc. The basis for comparison was the efficiency expressed by the ratio of outputs to the inputs. The outputs were the services or goods produced and often intangibly defined, and the inputs were the resources required and used in the production of these outputs. The fundamental DEA analysis is the ability to make comparisons of ratios with differing contributors to input resources and some defined differences in the outputs, and then discriminate between the various combinations to find the best ones. The best possible ratio is assigned the premier rating of 100% (or 1) and the others ranked against this are expressed as a percentage.

The organisational unit achieving this ‘best score’ is viewed as the most efficient under the given circumstances, and the one that others are compared against but it is not suggested nor implied that this is the “best possible” score in absolute values. How far others fall short of this 100% value expresses their potential for improvement under current conditions. In a fashion the best performer is set as the ‘current benchmark (BM)’ for others to aspire to, even though best performance is only ascribed as best relative to the field rather than an absolute ranking.

1.2 Objectives

The objectives of this thesis are to demonstrate the development of an extended OBPM model for a commercial enterprise in an Australian supply chain.

This will be done by:

- Identifying the role of management style in creating OB which affects the performance of the enterprise.
- Identifying the competitive forces, processes and methods that drive the need for PM in a modern business enterprise.
- Identifying all stakeholder groups and their contribution and importance to every stage of production and the supply chain.
- Critically reviewing and assessing past research in the field of OB related to performance.
- Developing a new approach to analyse organisational behaviour and PM by using DEA to embed the essential elements of CG and SCM in the measurement of performance in a modern business enterprise.

- Analyzing performance metrics and measurement processes, past and present.
- Testing and applying the developed new approach and quantitative methodology with field data.
- Validating the framework by identifying strengths and weaknesses in the model, and
- Delineating the path forward for further research and development in this field.

1.3 Methodology

The research methodology used in this thesis is based on the positivist stance that allows mathematical modeling of a commercial environment. Operations research techniques are specific to this task. Here an optimization algorithm, available through the linear programming derived DEA, is used on empirical data from a large Australian publicly listed company to test the performance of 231 business units on their achievements in CSR as pronounced in corporate vision and promulgated in corporate policy and procedures. The data was originally collected and used by Black (2004) to establish a 'Corporate Social Responsibility Management Capacity' construct. This research uses that data in an explanatory and evaluative identification of the key factors in the conceptual framework of the OBPM model, the interrelationships of those factors, and the roles played by stakeholders. Key factors from the various concepts are operationalised and then subjected to quantitative analysis to reveal the strengths of causal relationships among these factors.

The advent of powerful computing resources at a cheap cost has made many tedious mathematical tasks simple through spreadsheet applications. Linear programming is such a task, essentially a recursive process. The DEA algorithm has similar requirements but these can be addressed through 'plug-in' spreadsheet applications as well as commercial software. The commercially available software DEA-Solver PRO (professional Version 4.1) was intentionally chosen for this research because of its specificity for DEA computation and the expansive selection of DEA models available. DEA was chosen as the operations research technique because it allows the efficiency of selected entities to be studied and analysed comparatively, without the need for an absolute ideal performance standard. The relationships tested by DEA have origins in production economics. Here efficiencies are depicted as the production frontier established by those units which display the best productivity, efficiency being the ratio of input resources to outputs of goods, services or other outcomes.

These production functions are evident in a multitude of relationships within the OBPM model of a business enterprise operating in a supply network. The methodology adopted in this thesis is routine operations research but novel in application. Model formulation, as the first step, requires problem definition, selection of decision variables and parameters, and choice of mathematical technique. The next step is data gathering, followed by model execution to obtain the optimal solution. This in turn is validated and tested before results are implemented. Some of the steps are iterative as new information becomes evident and adjustments are required.

1.4 Contribution of this Thesis

The impetus for this thesis comes from the failures of past and present performance measurement models to fully address the multi-dimensional nature of corporate performance. While many disciplines have been interested in organisation performance their research has been mostly myopic. Cross-fertilization of ideas has been sparse and holistic integrative approaches rare. Further motivation comes from the inability of current models to explain emerging issues such as the effect of globalisation and knowledge economy on corporate governance, supply networks, organisation behaviour, and enterprise design; let alone their ability to describe and measure performance in these areas.

1.4.1 Limitations of Existing Literature

The critical review of the literature has revealed a number of flaws in traditional approaches to gauging organisational achievements as a precept for competitive performance. The major criticisms of existing models can be summarized by the following limitations:

1) Short-termism. Established financial measures are historical and short-term. They emphasize recent past performances as a basis for going forward. They are short term focused because of accounting and regulatory practices which require yearly reporting intervals.

2) Non contemporary. They are also accused of not being interpretive of real business situations, presenting a veneer of everyday operations, and not addressing emerging issues (Otley and Fakiolas 1995).

3) Non-integrated. They further fail because of their inability to integrate the styles of management, leadership, and OB dogmas which play important roles in making a company competitive, responsive to stakeholders, and socially attuned.

4) Stakeholder relationships. Other measures of performance fail to address the importance and contributions of all stakeholders including the intra and inter-relational network partners in the whole supply chain in which the modern enterprise operates.

5) Although some recent literature has attempted to redress these failings, particularly in commercial performance management frameworks, they are limited because of no formal rigorous mathematical modelling, no empirical testing, and little reporting in academic avenues.

1.4.2 A New Approach-Overcoming the Limitations

This thesis makes a significant contribution by developing a new framework for an integrative approach to PM. It incorporates the essential elements of: OB, SCM, PM and a novel use of operations research methodology as follows:

1) OB through a management model based on OSTS theory, and its application in humanistic styles of management reflected in CG and CSR. This also incorporates the concerns of all stakeholders.

2) SCM through the technical and social networks that connect stakeholders operationally through the SC and contribute to its performance.

3) A PM framework developed from successful contemporary models, and built on to integrate the critical success factors in each performance dimension.

4) An application of operations research methodology using DEA applied in a novel situation, enabling the quantification of qualitative information through relative, rather than statistical or absolute comparisons of efficiency, and paving the way for future new applications of this non-parametric tool.

In addition, this approach veers away from traditional practices by focusing on the emerging needs of a new era and developing a PM framework that is dynamic and maintains its relevance by evolution.

1.5 Structure of the Dissertation

A general overview of the structure of the dissertation is shown in Figure 1.3 below, with an explanation following.

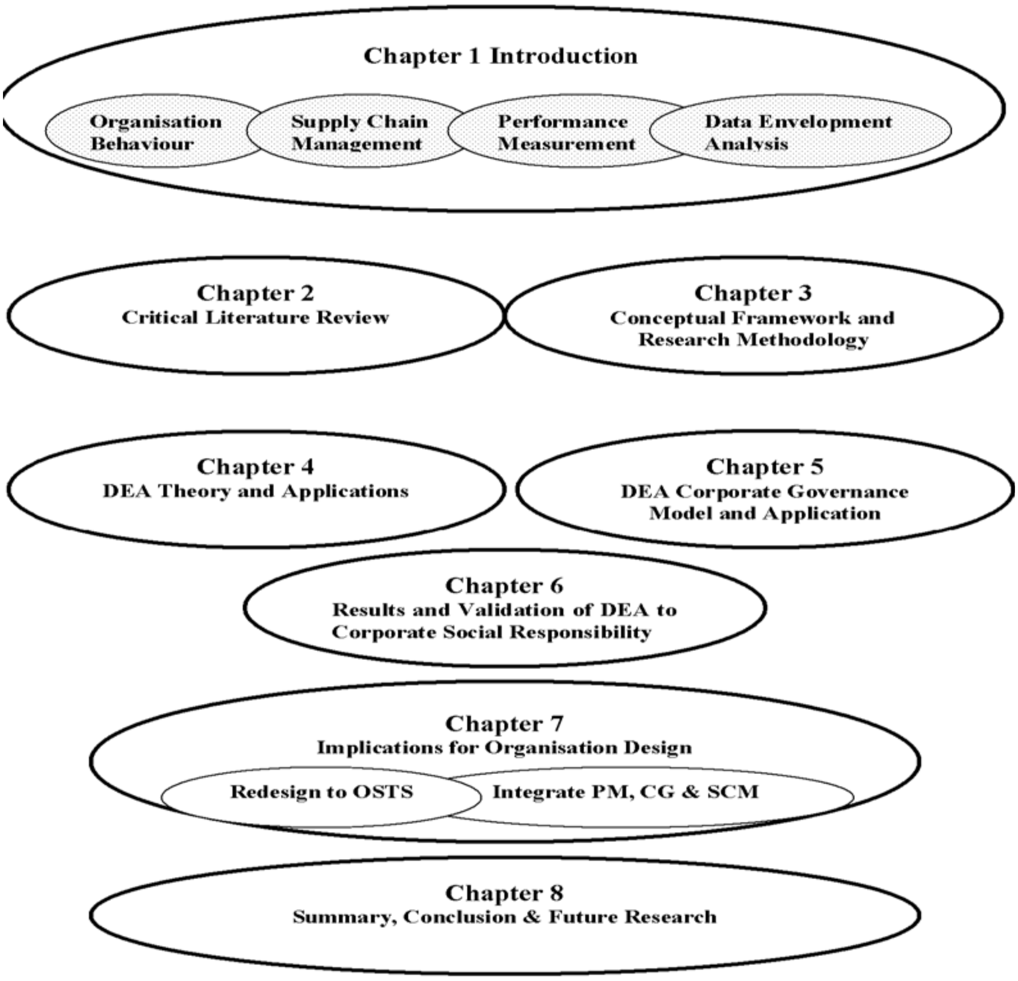


Figure 1.3 Structure of the Dissertation

A critical review of the literature pertaining to PM, OB, CG, SCM and the global backdrop for Australian enterprises is presented in Chapter 2. A proposed conceptual framework for this thesis, of an extended OBPM framework to facilitate analysis and evaluation, is given in Chapter 3. This includes the methodology and the rationale for using the DEA algorithm as the instrument chosen for the measurement of performance at the various stages of the SC, commencing with the helm of the enterprise, CG.

Chapter 4 describes the workings of the DEA algorithm so that the requirement for providing a benchmarking analysis is understood in terms of comparative efficiencies and potentials for improvement. It also introduces the application of DEA to the study of CSR in the chapter following.

Chapter 5 develops a corporate governance model of CSR so that it can be analysed within the DEA non-parametric framework. It then describes the application of DEA through trials and tests conducted on empirical data from a large Australian commercial enterprise, and presents the results of all tests.

Chapter 6 reports the results of the study with an interpretation of these findings, both in terms of CSR and the efficacy of the DEA algorithm as a diagnostic tool for this purpose. It reinforces the findings by conducting a correlation analysis of the significant variables. This chapter strongly supports the OBPM framework by demonstrating its positive relationship with the humanistic management style, inherent in OSTS and CSR. This achievement also strengthens the support for an operations research methodology by the demonstrated success of DEA.

Chapter 7 discusses the implications of the DEA and CSR findings in the previous chapter as an opportunity to redesign the organisation to meet its future needs. The strategy for redesign is to integrate the PMS into OSTS and adopt this design for both CG and the supply network. DEA becomes the measurement instrument for pivotal points in the integrated PM framework. This integrated framework provides the basis for an holistic 'enterprise performance scorecard'. In this fashion it contributes to the advancement of knowledge in this field with a concept that has not been previously proposed.

Chapter 8 provides a summary of the thesis with an integration of the diverse concepts. It also discusses the limitations to the present research. It concludes with a proposed optimization model as the recommendation for future direction.

Chapter 2

Critical Literature Review:

OB, CG and SCM in the Measurement of Performance for Commercial Enterprises in a Global Knowledge Economy

> *Between knowledge of what really exists and ignorance of what does not exist lies the domain of opinion. It is more obscure than knowledge, but clearer than ignorance.*
>
> *Plato 428-348 BC*

2.1 Introduction: Issues and Developments in Contemporary Global Knowledge Economics and Business

This chapter will present a critical review of the contemporary literature for measurement of performance of modern commercial enterprises as they strive to succeed in the competitive global knowledge economy. The review will commence with issues and developments in the contemporary global economic and business marketplace in which commercial enterprises must now compete. This is discussed in the first section where the new business arena is preponderant with information communication technologies (ICT) and their rapid evolutionary benefactions. The evidence of this is witnessed through the emergence of a global knowledge economy. With this backdrop, how management handles the task of running the firm is studied through the contribution of OB to organisational performance by the emergence of new OSTS paradigms, and is reviewed next.

This is then followed by an analysis of how the emerging issues and new developments are changing society. In particular, the research focuses on CG and citizenship and the societal pressures of external stakeholders as they impact on organisational performance. Strategic direction emanates from the highest levels of an organisation's hierarchy and is translated into the dictums of senior management as it seeks to ensure the organization remains profitable and competitive. These are studied through the myriad of PMS organisations used to gauge their success. Extending beyond the firm's sovereign boundaries allows us to then further study the impact of the multi-faceted supply chain interactions on organisational performance. It is the contemporary nature of these issues and emerging trends that motivates us to develop an inclusive OBPM framework which is currently absent in the literature.

The above are all elements of PM that should form part of any framework devised to give a full and coherent view of the firm's current competitive status and long-term likely health. They form the construct which dilineates the forces that drive business. This is illustrated in Figure 2.1 which shows the motivating forces driving competitiveness through an inter-connectedness of the elements of performance. The demands and whims of the globalised marketplace are expeditiously promulgated to all interested parties by efficient communication technologies. Knowledgeable stakeholders are thus armed to pressure companies to comply with their demands. Under an array of different demands, the senior managers of an enterprise devise strategies to meet these needs. This is the starting point for the OBPM framework as developed in the thesis. Consequently, it is these strategic decisions and policy directions that are disseminated to company operations and impact the supply network. Note that this diagram takes on a form analogous to the performance pyramid as it approaches the lower portion of the representation.

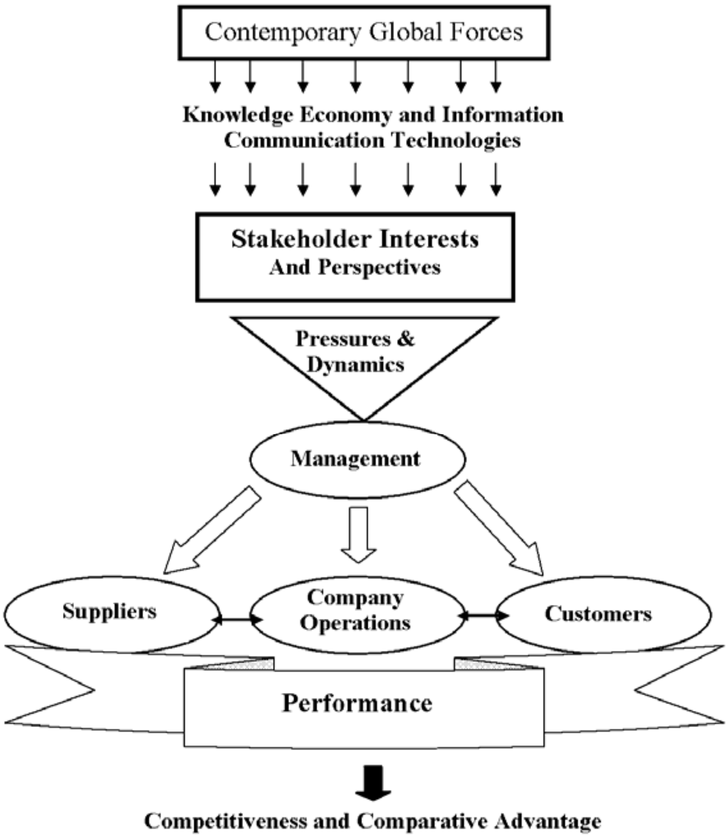


Figure 2.1 The Connected Elements of PM

2.2 The Emergence of a Global Knowledge Economy

2.2.1 Globalisation of Australian Business

The development of global networks to facilitate investment, procure resources and distribute goods and services, provides opportunities for companies to access domestic and regional markets anywhere in the world. This in turn has increased competitive pressures on local firms (Atkinson et al. 1997). Lowered barriers to entry by foreign firms have confronted incumbent organisations with new challenges, in some cases ending oligopolistic or monopolistic structures.

New reporting standards have emerged (see IIA 2004 and ISEW 2004 for reference to AA 1000) and comparisons between competitors have been conducted. The need for PM to communicate achievements, good and poor, has never been greater.

Globalisation is the economic and social phenomena which diminishes the impact of distance on trade and difference insocial cross-border interactions to the extent that inter-regional and transcontinental trade, investment and flow of capital act as if they are always part of the local economic business environment (Ricks 2003). The International Monetary Fund (IMF) describes it as the growth in interdependence of countries through the increasing cross border transactions in volumes and variety of goods and services, and international capital flows expedited through the pervasiveness of ICT. This interdependence also means that CG mechanisms need to reflect fairness, transparency and social responsibility (Sgro 2003). To this extent it is responsible for increasing the competitive forces on business strategy to the world. In Australia for example, this trend can be traced to the unilateral lowering of tariffs in 1986 (Oxley 2000).

In simple neoclassical economic terms, the beneficiaries of capital inflow, investment and business development, are those countries where domestic costs are lower than elsewhere. These countries have a comparative advantage (CA) and benefit at the expense of those that have lost business because they are not cost competitive. These are not necessarily only the poorer countries. Investment and international trade are seen as the engines of world growth. While it is credited that globalisation has been responsible for the elevation from poverty of three billion people over the last 50 years it is also estimated that if trade were liberalized further by a reduction of 50% in protection levels, Australia would benefit to the value of $7 billion per year (Globalisation Guide 2005). Rich and poor both benefit. Wolf (2004) sums this up by saying that never before have so many people or so large a proportion of the world’s population enjoyed such large rises in their standard of living. This dictum of capitalism can only promote further globalisation. It is therefore necessary to view this phenomenon as a major force in the contemporary business arena.

The fluidity of capital flow and the ease with which commercial investments can target regions has created a platform of instability for many companies.

Companiesare constantly under scrutiny for their operational performance and are liable to face closure or relocation to less costly regions. The only strategy for self preservation, predominantly within control of the organisation, is that of performing well and adopting a ‘competitive advantage’ ethos.

Michael Porter’s (1998) seminal work on CA has lower costs and product differentiation as locational advantages which describe the organisation’s leadership standing in its industry. How a company achieves an advantage pertains to the way in which it uses its resources and capabilities in the form of distinctive competencies which enable it to create value in its own activities as well as the value system of upstream suppliers and downstream channel members (Gunasekaran, Patel and Tirtiroglu 2001). Implicit in the processes of striving for CA are methods of comparative analyses including those referred to as benchmarking. Sometimes alternative strategies involve a rethinking of how the firm conducts business (Hammer and Champy 1993) or seeking the value streams in all company operations (Hines et al. 2000).

Benchmarking can take various forms but it generally entails making comparisons of processes or functions against recognized best practitioners. While at the higher level these comparisons can be made across industries and with competitors, there are often obstacles to disclosure of information. Subsequently, the comparisons are made at cascading lower levels where operational information is less confidential. Since the value of comparative information relates proportionally to its hierarchical level, it invites organisations to aim for the highest level where meaningful and accurate information is available. Unfortunately, this often restricts the company to its own operations with little scope for including supply chain partners (MacAdam and Bailie 2002). And, when access to information at this level is not hindered, it may simply not exist. Since benchmarking requires a comparison to identify the gap in performance, if a metric is missing then the comparison is not possible. This highlights the need for performance metrics for functions and processes at all levels of company operations (Grunberg 2004). Accordingly, they are created as needed and when required. They are commonly referred to as key performance indicators and are usually used to measure areas of strategic importance regarded as critical success factors (CSF) (Maull, Tranfield andMaull. 2003).

The benchmarking strategy is ideally suited to DEA methodology as described in this study.

2.2.2 Competition for Australian Business in a Global Economy

While globalisation has added a new element to the force of competition, it has merely strengthened the business imperative of creating wealth for the owners of commercial enterprises. Some organisations are capable of providing product differentiation through mechanisms such as brand imaging or genuine uniqueness of product or service. The majority of other organizations do not have this ability and when the only option left is to seek a cost advantage, we see a strategy of profit maximization through cost reduction and operational efficiency improvements. Initially this attention may be inwardly focused and rewarding but as incremental improvements are achieved at diminishing rates of return on effort, the focal area broadens to include the complete supply chain in its global setting. Inefficiencies in the supply chain resulting from firms operating in a self-centered fashion are there to be exposed and exploited to the benefit of the partners, albeit not necessarily in equal proportions.

The Australian commercial environment is based on free market economics, within government regulation, where the firm has to compete and survive on the basis of some local advantage, be it knowledge and expertise, responsiveness, service or some other feature. The transnational and global corporations that operate in Australia have, in a fashion, the luxury to respond to international pressures in a fluid and dynamic way which serves the corporation at the expense of the host nation, and avails them of a multitude of strategies to combat competition. Local industries are not so fortunate. They are impacted by the forces of international business yet limited in their response capability (Porter 2004). Most often they are not players on the international scene yet are subject to some of its pressures. Their survival mechanism is to operate locally, in a cost effective and customer-service focused way, so that their product or service has a local identity attraction.

To some degree this may entail an attempt at product differentiation (as a short-term strategy) but to a large extent this must be a cost neutral offering of a product that has overseas-manufactured rivals. If the product is overly costly, and hence not cost competitive, then its attractiveness can only lie in other features for which customers are willing to pay. Stability of government, reliability of supply, cheapness of resources and an educated workforce displaying a capital of knowledge, are examples of factors of attractiveness which can counter the cheaper option.

An Australian commercial enterprise is a valid candidate for research in this field. Australia's share of global GDP is 2% yet it has a population approaching 21 million (ESRC 2005), only a fraction (0.33%) of the world's 6.4 billion. It is a developed country with an advanced economy and high global trade. It thus displays many features that are common to other advanced economies, and benchmarks for developing countries. There were 610 893 operating businesses in Australia in 2001 (ABS 2006a) and by 2003 had grown 6% (ABS 2006b). Large businesses contributed 38% to the national income (ABS 2006c) and manufacturing industries were the largest contributors to export earnings, 53% of total exports in 2004-2005 (Year Book Australia, ABS 2006e). Many of these are foreign owned and operate globally. The other locally owned enterprises that operate in the Australian market must compete with the international best. They must operate competitively, meaning they must offer similar but preferably superior products and services. How do they do this? In the most embryonic of strategies this is done by an analysis of how well the company fares compared against the offerings of competitors (Terzvioski 2002). If this comparative analysis is taken further and to a more sophisticated level then the application of benchmarking as an alternative strategy, is often adopted. As a comparative tool for improvement, benchmarking is well established and widely used, even though it is a 'satisficing' rather than optimizing technique. It compares performances and then identifies and measures the gap. Attempting to close this differential becomes the motivating force that drives changes in an attempt to instigate improvements. And in so doing, firms can often embrace the current fashionable management mantras which promise a 'quick fix' to their woes, or the 'technology fix', or both. Unfortunately these rarely provide the solution and often act as mere distractions to the fundamental task of establishing a system of sound managerial control based on measures of performance.

Other times, firms may focus on process management through philosophies based on quality, teams, empowerment and continuous improvement (Evans and Lindsay 2005; Evans 2008) and benefit from such strategies.

Measuring the performance of a firm is not new (Neely, Gregory and Platts 1995; Carter, Klein and Day 1992; Dixon, Nanni and Vollman 1990). In fact the financial and accounting functions that pertain to business are probably as old as business itself. Financial record-keeping and the managerial controls associated with it have been a stalwart of commerce in the modern era to the extent that they were regarded as the only measures of performance of any value. Australian businesses have been no different in this respect and have treated them as equally paramount. But, like all commerce that was managed on past performances and past successes, the rising profitable strategies of visionary competitors cannot be matched by simply adopting historically dated policies and projecting them forward (Kaplan 1990).

The comparisons that are made against market leaders show that they have had vision while the others have had established but possibly entrenched structures. Forward thinking, innovation and forecasting skills have provided successful companies with a winning formula that others have found hard to match (Kaplan and Norton 1996; Lowson 2002). And these strategies have been cemented in managerial idiom with discourses about 'balanced' approaches to managing and directing companies. The Balanced Scorecard of Kaplan and Norton (1992) for example, has been so prolific in this respect that it has achieved its own icon status in performance management, especially in America, while in Europe a similar approach is reflected in the Performance Prism. Financial and accounting perspectives have also been invigorated by innovations such as Activity Based Costing and Economic Value Added. These are discussed in Section 2.6.

2.2.3 The Emergence of Global Knowledge as Capital

Thomas Friedman (1999) provides a view of globalisation that is widely held. He says it is:

> …the inexorable integration of markets, nation-states, and technologies to a degree never witnessed before - in a way that is enabling individuals, corporations and nation-states to reach around the world farther, faster, deeper and cheaper than ever before...the spread of free-market capitalism to virtually every country in the world. (p 7)

What has facilitated this integration? It is the advent of the enormously powerful technology of computerization and the exponential growth of the associated information technologies. Information communication technology has witnessed a process of general cumulative advances rather than a succession of discrete unlinked innovations. It has expanded contagiously, taking an increasingly integrative form, offering substantial contributions to the systematic coordination of business functions. It is a contemporary view of an established concept in economic geography where the 'flattening of the world' means that "we are now connecting all the knowledge centers on the planet together into a single global network" (Friedman 2005, p. 8). It is so pervasive that authors such as Jones (1999) claim that we are now in the post-industrial 'information age' of intense intellectual, cultural and political activity. It has the characteristics of a shift in employment patterns, from capital intensive employment for production to increases in services in sophisticated economies.

The description of a global knowledge economy is increasingly being used to label the present economic era. In Australia more people are engaged in collecting, processing, storing and retrieving information i.e., in creating knowledge than are engaged in agriculture and manufacturing,. The knowledge economy sees the emergence of new structures, arrangements, and processes for the creation, production, and distribution of goods and services. It is characterised by an intensification of knowledge globally (Houghton and Sheehan 2000) and is a contributor to increases in labour productivity as measured by value-added per employee. For example, in the Asian region, China's productivity (real GDP/employee) grew by 7.3% per annum for the 1995 to 2000 period (Grewal et al. 2002).

The emergence of MNEs with their economic and knowledge power, greater than many nations, unleashed by instantaneous communication has led to an international division of labour dictating where and how business will be conducted. ‘Information rich’ employees who understand the new technology will be more valuable, while the unskilled ‘information poor’ computer illiterates will become the new *lumpenproletariat* (Marx’s ragged workers). The gap widens and knowledge becomes capital in Drucker’s (1968) knowledge economy. How has information technology contributed to this intensification of knowledge? Sheehan et al. (1995) attribute enhanced economic growth to five features of the information technology revolution.

These are:

1) chip technology where miniaturisation through micro-electronics has provided exponential increases in output at decreasing capital investment;
2) photonic communication technologies facilitated by optic fibre and wireless networks;
3) digitisation of products, processes and services through open-system integrated circuits;
4) a convergence of standards and protocols, supporting technologies, such as the capture, storage and display of data, augmenting other technological advances; and
5) continuing software development to enable these technologies.

Kuhn (1970) suggests that this break with continuity from the past is unprecedented in economic history and provides a ‘paradigm shift’ in the way we live, work and do business. The drop in the cost of technology while at the same time improving its reliability, capacity and range, as depicted by ‘Moore’s Law’, will mean the simplification and integration of manufacturing, the displacement of labour and the growth of an international economy. Alvin Toffler (1971) coined the term ‘future shock’ to illustrate the impact of the ‘information explosion’ where people are no longer capable of making rational choices from the vast array of information thrust at them. The sheer volume of information leads to ‘reductionism’ where the ideas are so complex that they can only be fully understood by analysing their components.

Alternatively, a greater reliance is placed on specialists who are experts in their field but who lack the wider picture. In an organisational sense, as the enterprise becomes too large and complex for decision-makers to have a synoptic vision of all factors relevant for policy-making, it adopts a ‘disjointed incrementalism’ as its *modus operandi.* The specialists who are experts in their field but do not understand the whole, take power from the generalists who do not understand the parts but are responsible for the whole. The key is the power of information through its application as knowledge.

Information has four inherent properties that make self propagation possible and knowledge dissemination fragmented. It is inconsumable because it does not reduce or disappear with use. It is also non-transferable because while it moves from A to B it still remains at A. Information is indivisible because it can only be used as a complete unit or set but these units are cumulative. It can be used over again, to be added to and to grow, as a building block of knowledge. The computer provides concentration, dispersion, circulation and feedback, all at exceptional speeds. Together with these four additional properties provided by computers it becomes the almost completely flexible tool for all configurations of communication. The technological capacity now available primes us for a ‘technological determinism’ where basic decisions are shaped by the technology at hand and every problem has a technological fix (Sheehan et al. 1995). The more complex the problem the more high tech the fix. For example, augmented cognition focuses on the computer deducing a decision-maker’s cognitive state with the aim of somehow enhancing it because we live in an era of ‘continuous partial attention’ where information is flowing in faster than the person can absorb, and therefore needs programmed assistance in decision making.

Knowledge management (KM) is a term increasingly used in the literature to explain those processes of capturing or creating knowledge, storing and protecting it, updating it and using it whenever necessary. Since 1975, 2727 authors have contributed to this discussion (Nonaka and Peltokorpi 2006). Knowledge is collected and created from internal and external sources and facilitated by ICT. As the repository for the firm’s information and a vehicle for its dissemination, ICT allows knowledge to be shared between employees, customers and business partners (Lee and Whang 2000).

The payoff potential of this is huge, with improvements in customer service, shorter delivery cycle times and increased collaboration within the firm and with external partners. Knowledge can also be sold or traded, as well as shared. It is for this reason that the 'information stream' is now regarded as one of the key elements of supply networks and a critical characteristic for global supply chains (Rungtusanathan et al. 2003, Ross, Venkataramanan and Einstberger, 1998). However while information is personality-free, as a construction of data building blocks that simply reside in databases, knowledge is the human value-added interpretation of information, and resident in mortal beings (Carr and Pearson 1999). Knowledge is thus organic, fluid and reflective, within the human vessel where it resides. It is subject to all things human and used in all ways human. It is therefore, the basis for how employees of the organisation behave, individually, collectively and culturally, and a contributing factor in OB (Mitchell and Nault 2003). It is a feature of the learning organisation. It is the *modus operandi* of the organisation through its people and is as idiosyncratic of the organisation as of its members. Organisations, like people, differ in every possible way. They have uniqueness yet commonality. Uniqueness is the synergistic sum of all the individual features of the organisation while commonality is the similarity of individual characteristics. This suggests a need for the study of OB and the theories of management which explain these behaviours in the new economic era.

There are many theories of OB which attempt to explain why managers behave in particular ways, yet few ascribe styles of management to organisational performance. Those that are performance-focused appear to display a re-emerging theme, one of the importance and valued contribution of the individual employee. Recent organisation theory sees a renewal in themes of 'empowerment' (Mumford 1995), collectivism, through teams such as 'quality circles', and other job-enriching policies aimed at enhancing the human resource and utilising its knowledge capital (Niepce and Molleman 1998). It is therefore imperative that OB be included in a study of organisational performance but not at the exclusion of other determinants of performance, such as technological advantages. Few theories, other than sociotechnical systems-type paradigms, acknowledge the symbiosis of the social and technical subsystems and their conjunctive roles (Mumford 2003).

2.3 The Emergence of an OSTS Approach to OB

2.3.1 Introduction

The competitiveness of the corporation and its performance is judged by comparison with its peers and against world best practice, but its standing is bedded in more than the governance that directs it and the global supply networks it operates in. It is genotypic organisational theory which subsumes its existence. Therefore, results of any PM study should be analysed within the interdisciplinary boundaries of organisation theory, SCM and PM. Is the organisation modeled on the bureaucratic ideas and formist (ideal type typologies centered on bureaucracy) images of Max Weber, or the structured functionalism of Talcott Parsons? Alternatively, does the modern version of Newton's 17th century mechanistic science express itself through an enriched Tayloristic 'scientific management', facilitated by advances in information technology (Niepce and Molleman 1998)? Or, does the organic metaphor of the firm provided by Henri Fayol suffice? This section traces the development of organisation theory to arrive at the paradigm of OSTS as the one that has a substrate of CG which permeates the performance of organisations trading in the commercial field of global supply networks.

This section also examines the origins of OSTS through conventional organisation theory, and develops a systems approach which encompasses the Human Relations 'humanistic' school of thought with the 'mechanistic' one which posits that technologically efficient processes dictate the efficient resource, information and financial flows in a supply network. An integrated approach to the application of an OSTS stance and its productive fit for the management of the supply chain is developed to address the measurement of firm performance through the adoption of a PM conceptual framework. Such a concept caters for the needs of all supply chain partners and provides a mechanism for organisations to measure performance by iterative applications of a performance pyramid.

2.3.2 The Founding Fathers: Weber, Durkheim and Pareto

Max Weber, Emile Durkheim and Vilfredo Pareto are the sociological theorists of the 19th Century who provide us with the legitimate cornerstone of organisational theory (Wren 1994). This intellectual triad gave us ‘bureaucracy’, ‘organic and mechanical’ societal types and the notion of ‘social systems’. Weber’s version of scientific management, which was being promulgated in America while he was working on his book on economics and society, was the standardisation and rationalization of large scale undertakings by pronouncing management to be by position rather than by person. His conceptualisation of ‘bureaucracy’ was posited in three types of legitimate authority: rational-legal, traditional and charismatic, because some form of authority was a necessity for any organisation. Without an authority structure the organisation could not be guided to its objective. He also put forward the notion of the Protestant work ethic.

Durkheim divided societies into two types; ‘organic’ and ‘mechanical’. Mechanical societies were characterized by friendliness, kinship and neighbourliness, and dominated by a collective consciousness, while organic ones were those characterized by specialization, the division of labour and societal interdependence. According to Durkheim the lack of solidarity in organic organisation led to a state of confusion, insecurity and normlessness which he called ‘anomie’. The restoration of social solidarity in these organic societies must come from the ‘collective consciousness’ which created and imposed norms and values on the individual. Durkheim’s idea of groups as the source of values and norms was later used by Mayo to prescribe industrial solidarity (Smith 1998).

Vilfredo Pareto provided the notion of the ‘social system’, a state of society which changes over time and is characterized by mutually interdependent but variable units which contribute to the goal of achieving equilibrium between the parts. Disturbances to the system would create such an imbalance that the system would work towards re-establishing the equilibrium. Talcott Parsons, George Homans and Elton Mayo were converts to the ideas of Pareto and saw organisations as interacting social systems. A colleague of Mayo, Fritz Roethlisberger, together with the chief of employee relations research at the Hawthorne Plant, William Dickson, gave impetus to the connection between technical efficiency and the workplace as a social system (Sonnenfeld 1985). The technical needs for efficiency and economic return should be seen as interrelated with a concern for the human aspect of organisation, and these need to be maintained in equilibrium. Economic goals should be achieved "while maintaining the equilibrium of the social organisation so that individuals through contributing services to this common purpose obtain personal satisfaction that makes them willing to cooperate" (Roethlisberger and Dickson 1939, p 569).

2.3.3 The Human Relations School and the Tavistock Institute

Elton Mayo borrowed Durkheim's 'anomie' to develop his thesis for human collaboration. He maintained that anomie represented the social disorganisation in personal lives and communities which was brought about by industrialization and the technically-oriented and engineering interpretation of the meaning of work. Because the social needs of the individual were pushed into the background, the capacity for collaboration in work was reduced. A 'new administrator', being trained in understanding the social and human problem, would be able to restore collaboration by recognizing people's need for social solidarity in work and life. He stressed the need for humanistic leadership to overcome anomie and social disorganisation and reached one of the same goals as Frederick Taylor, that of collaboration and cooperation in industry. The philosophical rationale for the ensuing human relations movement was the goal of effective human collaboration as the means of restoring a social code which facilitated adjustment to industrial life (Niepce and Molleman 1998). This social concept of organisation was further supported by Chester Barnard. He said that "the formal organisation is that kind of cooperation among men that is conscious, deliberate, and purposeful" (Wren 1994, p. 266). The formal organisation survives by maintaining an 'equilibrium of complex character' in a continuously fluctuating environment, examining the external forces to adjust to, and analyzing the functions of all executives in managing and controlling the organisation.

Barnard's notion of internal equilibrium and external adjustment was contrary to the traditional view at the time that organisations had boundaries and that analysis of the organisation should be contained within these boundaries. His construction of the collaborative system included investors, suppliers, customers, employees and other contributors to the firm interacting in a social relationship to a community contract. This is not unlike one contemporary 'stakeholder', the modern supply chain. The Tavistock Institute (Trist 1981), through the efforts of Bamford, Trist and Emery, provided empirical support for Barnard's theory by finding that social adaptation, facilitated by the redesign of social relationships, was necessary for the successful introduction of technological and organisational changes (Trist and Murray 1993). It was from this work that Emery coined the word 'empowerment' to represent the situation where workers have a greater say in how work is done and accept a greater responsibility for its performance. This devolution of power to employees results in their ownership of these jobs and a feeling that by accepting the authority to control work related decisions they can share and contribute to the purpose of the enterprise.

2.3.4 Systems Theory

While the early theorists provided the seeds for current thinking on the theory of organisations, it was the biologist Ludwig Bertalanffy (1968) that observed similar characteristics of systems across various disciplines. The parallelism in systems that germinated his "general systems theory" showed the similarities to include:

1) a study of the whole organism;

2) a tendency towards steady state or equilibrium; and

3) an openness of all systems in that the organism affects, and is affected by, the environment in which it operates.

While the open system theory of organisation may present an environment that is placid, benevolent, turbulent or even harsh, the survival of the organisation depends on matching the congruent factors of organisational and environmental characteristics which best suit these settings. Organisational factors should match environmental ones. Such a congruence would suit the Darwinian analogy of 'survival of the fittest' without

Darwin's additional constraint imposed by the requirement of an 'ecological niche'. Social organisations are unfettered by the niche constraint because they are able to contrive to achieve economic, social or political ends. Nevertheless there is much sympathy with the biological model of systems. In 1950 Norbert Weiner for example, coined a word 'cybernetics' to convey the idea that all systems are designed to control themselves through a communications loop which feeds information back to the organism so that it can adjust to the new environment (Weiner 1967). This feedback loop means organisations are able to learn and adapt to future situations. General systems theory provided the theoretical and philosophical framework for recognizing the openness of systems and their ability to achieve steady state, while cybernetics identified the mechanism by which feedback was provided. Technology would provide the means for communication and control by knowledge transfer.

Jay Forrester (1961, 1968) took general systems theory one step further. By focusing on the information-feedback system he was able to model industrial and economic systems mathematically to understand decision-making processes and gauge their impact. His 'industrial dynamics' is the study of information-feedback characteristics in an industrial framework to show how the structure of the organisation, amplification through policies and delays in decisions and actions, interact to govern the success of the firm. The interaction factors are: the information flows, materials, customer orders, human resources and capital equipment in a company, industry or economy. It is an experimental and quantitative approach to understanding how organisational structures and corporate policies affect growth and stability. He believes that there are four foundations on which to draw an understanding of social systems as represented by organisations:

1) a theory of information-feedback systems;

2) a knowledge of decision-making processes;

3) mathematical modeling of complex systems; and

4) advances in computing speed and power.

The concept of an information-feedback system is the crux of his approach so he defines it explicitly:

> An information-feedback system exists whenever the environment leads to a decision that results in action which affects the environment and thereby influences future decisions. (1968, p 14)

It encompasses every conscious and subconscious decision and through iteration leads to new decisions and new results in a way that maintains the system in a dynamic state. It is principal to the other foundations and dictates their interpretation and application. In all, if reflecting on the value of industrial dynamics to the sociotechnical theory of organisation, it could be asserted that it is primarily focused on the technical sub-system without regard to its interaction with the social subsystem. This may provide an illustration of the 'technological determinism (TD)' of business. TD is broadly understood as the extent to which a society's technology determines its social, cultural, political and economic form (Smith and Marx 1994).

2.3.5 Open Socio-technical Systems

Contingency and other theories may have attempted to appropriate mechanistic and organic ideas into other formalisms but they purportedly lack the framework required for an analysis of the modern corporation. Open Systems Theory (OST), based on general systems theory, seems to be a more appropriate approach (Van Der Zwaan 1975; Van Der Zwaan and Vries 1999). An interpretation and development of OST forms the foundation on which this thesis is built.

OST in its simplistic interpretation is the metaphor provided by the reductionist labels: input-transformation-output, feedback cycles, differentiation and integration. From this perspective it is often criticized for grossly simplifying the multiplicity of incoherencies, fragmentations and pluralities of the 'real living system'. But these criticisms can be negated if OST is reformulated to include its social and economic origins in the sociotechnical field. Sociotechnical Systems (STS) theory predates the open systems model and is rooted in the Human Relations School which emanated from the Hawthorne Studies (Smith 1998) and earlier as discussed above. It views the social and technical sub-systems as independent constituents of complex large human-machine organisational systems which operate in 'turbulent' environments that change at an ever increasing pace. The technical sub-system includes the tools, techniques and technologies needed to transform inputs into outputs in a value-adding way so that the organisation is economically rewarded. The social sub-system comprises those structures created by employee stakeholders and includes the knowledge, skills, attitudes, values and personal relationships they bring to the work environment, notwithstanding that these operate within organisational authority and reward structures (Adler and Docherty 1998). By broadening the definition to include other stakeholders, i.e. customers, suppliers, regulators and the community, STS approaches the concept of 'open system'.

The main tenet of STS is based on two principles: The first principle is that work processes are best represented by social and technical dimensions, and that these dimensions are interdependent (Cherns 1987). The second principle, named 'joint optimization', states that the reciprocally interdependent dimensions must be designed conjointly. The goal is to integrate the social requirements of people doing work with the technical requirements necessary for work processes to be viable in their operational environment. Although intuitively the attraction is to study work processes along these dimensions separately, attempts to optimize each dimension in isolation will result in the suboptimization of the sociotechnical whole. Because each dimension also performs to fit the requirements of the other, optimal results come from the 'best fit' of these dimensions working in harmony. In this sense 'joint optimization' is an idiosyncratic concept where each situation can claim individuality.

The STS approach has had a number of criticisms, from being a reductionist set of categories, an abstract analytical construct, to a gross metaphor for a conflict-excluding ideological unitary model of organisations (Adler and Docherty 1998). Often, it seems that these arise because of the attention fettered to the two sub-dimensions unequally, or the subjugation of these by an overall system. For example, the social sub-system, promoted by the belief that humanistic principles and industrial democracy are paramount, competes with the technical subsystem proposition which says that efficiency attainment through technological advances is the goal.

In a case of ‘technological determinism’ for example, the organisation is structured to meet the efficiency dictates of the current prescriptive technology. Human values versus mechanical efficiency seems to be the mantra, when in fact STS explicitly states that ‘joint optimization’ is the dominant goal. Additionally, modern STS theorists expand this proposition by accepting that there is not only an important inter-connected relationship between the two sub-systems, but also one with the outside environment (Van Amelsvoort 2000). These modern versions of STS have been sometimes labeled modern sociotechnical (MTS) or sociotechnical business (SBS) systems. Consequently the OSTS, as introduced in this thesis, is a more fitting description of an organisation in its natural setting.

Fred Emery (1982), an original proponent of STS at the Tavistock Institute, believed that the ‘turbulent environments’ in which most companies operate, require a ‘redundancy of functions’, or multi-skilling as we now know it, to enable the system to cope with unexpected occurrences and in which to handle change. This concept was later labeled ‘adaptive strategic planning’. Another significant development was the concept of Herbst’s ‘minimal critical specification’ (Emery and Thorsrud 1976) which stipulated that over-specified work designs were obsolete, meaning that workers were the best judges of how things should be done and this task should be left to them. This concept is now widespread in the fashion, that work now involves work groups, matrical arrangements and networks (Emery 1995). The primary work groups are the members who can do all tasks of that group, and thus are multi-skilled. The matricies are these groups when they include some tasks which are specialized and allow only certain members of the group to perform them. Networks are when the tasks require assistance from outside the group and this is available collaboratively elsewhere in the organisation, where they may be considered specialists in their own field.

Albert Cherns (1987), another associate of the Tavistock Institute (same as the originators of STS), brought all the ideas associated with this approach into a set of principles as follows.

1) Compatibility: where the process must align with its objectives.
2) Minimal critical specification: where only the absolutely necessary is specified.

3) Socio-technical criterion: where, if variances cannot be eliminated, they should be minimized as close to the point of origin as possible.

4) Multifunctionality: where work needs to be planned in the multi-skilled redundancy mode.

5) Boundary location: where there are natural perimeters to knowledge and experience.

6) Information: where it goes and where it is needed.

7) Support congruence: where social support must be available to reinforce desired behaviours.

8) Design and human values: which dictates high quality work identifying:

- jobs that are reasonably demanding
- an opportunity to learn
- scope for decision-making
- social support
- relating work to social life, and
- jobs that have a future

9) Incompletion: the acceptance that this is an ongoing process of discovery.

These authors maintain that traditional organisations are designed to be overly complex, with a hierarchy that encourages greater demarcation of functions and more specialised jobs based on principles of division of labour. Consequently, this results in increases in control and a tightening of hierarchical power, more rules and regulation formalizing and standardizing procedures, creating various buffers between process links, and establishing specialist functions to expand the ever wanting problem-solving capacity. Van Amelsvoort (2000, p. 39) purports that this complexity can be measured by a relationship expressed as:

$$C = f(E, R, St, Sp) \tag{2.1}$$

where: C is complexity;

E is the number of elements that can interact in a network

(known as intersection of interfaces in systems theory);

R is the number of relations;

St is stability (the capacity for variation and predictability); and

Sp is specificity (the degree of precision in timeliness, quality, reliability and completeness).

Some of these principles are evident in the characteristics of the work groups studied in this thesis as seen by a cursory review of the model adopted in Chapter 5, and particularly by the listed variables in Table 5.3.

Adler and Docherty (1998) note that contemporary STS seems to have evolved into three streams: the North American model with an emphasis on high commitment, high performance and empowered work groups, a human resources approach (Passmore 1982, 1988); the Dutch model with affinities to operations management, logistics and planning and control, an engineering approach: and the Scandinavian model with a focus on worker participation and union co-determination through programs designed to encourage ‘the social dialogue’ (Van Amelsvoort 2000). These views are consistent with the general development of giving primary work groups increased control of the links with key groups in the organisation’s operational arena, of giving these primary groups discretion in decisions concerning customers, and with giving these groups discretion in learning and knowledge development. Not interfacing with customers, not having performance feedback and not sharing information have been criticisms of STS design in the past (Passmore 1988). Adler and Docherty (1998) claim that the new STS dispels previous criticisms. They define the Sociotechnical Business Systems (SBS) as:

> … systems in which primary work groups have a high degree of actual control over purpose, context, and system dynamics…which creates prerequisites for primary work groups to perform business discretion within the top management vision. (p. 326)

In these systems all users of technology, at all levels, will play a major role in the design of the system ensuring that compatible, well-functioning elements form part of the design (Mumford 1995).

All businesses are subject to the powerful economic climate of the time. This greatly affects how they operate. For example, the efficient production of goods and services may come under threat by the cheaper import of such goods and services.

This may in turn entice the firm to operate more bureaucratically by enforcing greater and more defined job specifications while reducing the resources to provide them. In fact a regression to bureaucracy seems a more comfortable approach than the over-risky humanistic approaches. However, the evidence from organisations with good governance and a trust in the workforce suggests the contrary.

Associative democracy, seen as an extension of the humanistic values within the firm, allows the stakeholders outside the firm to have a powerful voice in how it is run. The community-oriented economy transfers powers of big government to civic groups and powers of corporations to its stakeholders. Profit-sharing, co-ownership and corporate citizenship demonstrate the strong links between local communities and the decisions of organisations. These links have strong bearings on the decisions made by the corporation, and not always with primacy for the shareholders. As an extension of the humanistic values of STS within the corporation, these ideas become congruent with the concept of CG as we now know it (Thomsen 2004).

The organisation is now seen as a system which interacts with its transactional and contextual environments (Trist 1981). The transactional environment involves those specific stakeholders who have an immediate connection with the firm, (e.g. shareholders, customers, suppliers) and those who have a relationship with the organisation and expectations from it. The contextual environment involves those developments in society and the global economy in general, which are relevant to the organisation but not specifically targeted to it. For example, a new foreign trade agreement may have imponderable ramifications on the organisation. The OSTS organisational model now takes as axiomatic that organisations can be usefully modeled as social systems consisting of people acting in roles that allow them to use the technology and knowledge available to achieve the organisational goals of economic pursuit and the social expectations of community purpose (Pitelis 2004). Implicit in this axiom is the expectation that organisations have available to them, the resources required from the environment, the customers to export output, and a discourse with the many stakeholders.

The true OSTS organisation is one that recognizes it has multiple stakeholders and therefore multiple relationships and responsibilities. Not the least of these is the supply network in which it has traditionally operated and which is becoming increasingly important for the firm's global competitiveness. There are many parallels between the way an organisation's philosophy on the conduct of business governs its internal operations and how it deals with its supply chain partners and other stakeholders. In all organisations the philosophy, vision, mission and strategic directions emanate from the highest level of management, usually the board of directors, as stewards for the owners. This field of study, with origins possibly in the seminal work of Jensen and Mecklin (1976) has been of academic interest for well over 25 years (Denis 2001) and is described as corporate governance.

2.4 The Corporate Governance and Social Responsibility Approach to Organisation Performance Strategy

2.4.1 Introduction

Corporate governance is a system. It consists of those formal and informal institutions, laws and rules that determine those organisational forms which assign ownership, delegate power and monitor decision-making, while auditing and releasing information, and distributing profits and benefits (Cornelius and Kogut 2003). Australia has adopted a 'market-centric' framework modeled on the styles of CG practiced in the UK and USA where ownership of equity is diffused across a variety of shareholders while its control is severed from them. This detachment of the ownership of the corporation from the running of it, has spawned many treatises on the efficacy of its operations. Studies in agency theory, stewardship, director board composition and executive compensation, and stakeholder engagement to mention a few, have attempted to provide an explanation of those organisational mechanisms which impact on corporate efficiency and sustainability. Also, the emergence of MNEs, the globalisation of trade and the reduction or elimination of trade barriers, have also drawn the attention of important global economic organisations such as the World Trade Organisation, World Bank, the International Monetary Fund and the OECD (Sgro 2003). Often however, studies of these issues have only provided myopic exegeses.

2.4.2 The Current Corporate Governance Forum

There are many ways in which CG can be studied. Its scope is so broad that a review of all important theories of CG is beyond this thesis, but a working model can be advanced. As a system of controls, it adopts certain standards, including business ethics, which regulate how the enterprise functions in the wider socio-economic community. "Firms are being forced to recognize a 'triple bottom line' of financial, environmental, and social performance" (Cornelius and Kogut 2003, p. 19). Sound CG is now viewed in the broader social context where performance is monitored and deviant behaviour ostracized by affected stakeholders (Fitsgerald and Storbeck 2003), while still maintaining the more traditional financial view (Williamson 1988). It is however, also viewed in the context of global economics (Business Sector Advisory Group 1998). The stakeholder perspective provides a useful basis for the taxonomy of research to date. The groupings of this perspective are the economic shareholder studies with a grounding in agency theory, the political and regulatory enforcements of responsible authorities, and the societal and community pressures of the environment in which the firm operates. The author believes that an appropriate breakdown may be subsumed under six dimensions, one of which will be the subject of this study:

1) legal and regulatory compliance;

2) equity and ownership structures;

3) profitability and performance;

4) control mechanisms;

5) operational processes; and

6) CSR, the dimension analysed in this thesis.

The legal and regulatory compliance factors dictating CG standards can include the impact of authorities such as CLERP9, the ASX (2003) principles, the Investment and Finance Services Association, Australian Council of Superannuation Investors and the external impact of requirements as set out by the *Sarbanes-Oxley Act* 2002, as well as the Heugens and Otten (2005) review of global reforms.

The equity and ownership structures dimension has roots in the whole principal-agent debate (Jensen and Meckling 1976) where owners' control of the organisation is severed and management of the firm is delegated to a board of directors duly authorised to act on behalf of the best interests of the owners (stockholders) and parties with financial interests in the organisation (Hirschey 2003; Agrawal and Knoeber 1996; Keasey and Wright 1993). For example, Stapleton (2005) asks: how does a Packer family 37% ownership of PBL, a 50.1% Government ownership of Telstra, or a 34% ownership of Coca Cola Amatil by Coca Cola affect the CG of the company? Ownership is a core issue (Caplan 2002).

Profitability and performance are well analysed and widely discussed dimensions. They are typically summarized in the mandatory annual reporting of performance in financial and accounting statements. These public documents invite scrutiny, analysis and debate about how well the company is performing. But, it is the question of how much CG contributes to organisation performance that is widely debated (Leblanc 2005; Donaldson 2005; Alves and Mendes 2004; Bradley 2004; Brown and Caylor 2004; Letza, Sun and Kirkbride 2004; Young 2003; Morin and Jarrell 2001, Keasey and Wright 1993). The contribution debate is also viewed from the stance of major corporate failures. In Australia of recent times, HIH Insurance, OneTel and Harris Scarfe are examples of companies that have failed because of poor CG (Buchanan 2004).

The control mechanisms that organisations institute are those processes which give feedback to the ultimate authority, the board, so that it can judge performance against established standards or goals. Thus studies focusing on the Board are prevalent (Conger, Finegold and Lawler et al. 1998, Core, Holthausen and Larker 1999; Duleweiz and Herbert 2004). As a mechanism for the management of risk it is also responsible for the conduct of audits and other similar activities. It also debates the value of diverse participants in the auditing function as it does the composition of the board itself. There are various debates about the independence of directors, conflicts of interest, the number and status of the directors and how they should best be remunerated to undertake their duties diligently (Leblanc 2005). Their roles, abilities and contributions are often debated.

Further into the functioning of the organisation are the operational processes which impact CG (Bhasa 2004; Grant 2003; Bain and Band 1996). The level, depth and intensity of communication with all parties, the transparency of processes, and the varying degrees of employee satisfaction, as well as the appreciation and development of knowledge capital, are reflections of a corporate culture which dictates CG at the grass roots level. Technological responsiveness at this level for example, may be an indicator of an innovative and learning organisation in phase with economic, social and environmental trends. As an entrenched corporate reality CG factors now invite measurement (Sonnenfeld 2004), with attempts to even use scorecard metrology (Strenger 2004).

The final dimension that has come to the forefront in recent times is that of CSR (Maignan, Ferrell and Hult 1999; Hirschey 2003). In the socio-political and economic global environment that a corporation operates in, the CSR of the corporation is seen as its ability to fulfill its financial and legal responsibilities to all stakeholders (Evans 2007) and how well it manages the workplace, the environment and its supply chain relationships (Gettler 2005a, 2005b). There is a sound business case for acting in publicly socially-responsible ways (Arthur D Little 2003), just as there is for social cohesion amongst the stakeholders (Oketch 2004). Even though there are international differences ascribed to CSR in different countries, there is nonetheless an increasing interest in the firm’s social and environmental actions (Aguilera et al. 2006). There are also “socially responsible” investors who could enhance the stakeholder accountability of the firm by pressuring it to engage in stakeholder-oriented governance (Mclaren 2004). The reputation the organisation has for conducting business is integral to sustainable wealth creation (Pitelis 2004). CSR is often regarded as an indicator of competitiveness and firm performance (Brown and Caylor 2005; Bradley 2004; OECD 2006b). The reputation and performance of the organisation is often publicized (Larker, Richardson and Tuna 2005) through a number of independent indices (Sherman 2004). The St James Ethics Centre (2005) for example, publishes a yearly Corporate Responsibility Index (2004, 2005 and 2006) for Australian companies and the perennial winner of this award (Zonneveldt 2004) is the subject of this thesis. The British have an equivalent in the Business In The Community (2003) rating, as well as the FTSE (2005), while others include the Governance Metrics International (2005) index and the Dow Jones Sustainability Index (DJSI 2005).

As CSR is now widely accepted as an index of corporate performance, it is not unexpected that it has drawn academic attention (Batten and Fetherston 2003) and the attention of business consultancies (Arthur D Little 2003; Ernst and Young 2005).

2.4.3 Ethics and Morality in Business

The moral problems in business are complex and difficult to resolve because business actions can inherently hurt or harm individuals and groups associated with the firm. Managers faced with a course of action that can cause hurt, often rely on their view of what is 'right', 'just' and 'firm' but these moral standards are subjective and personal (Hosmer 2000). They are the way individuals intuitively feel about standards of behaviour and differ between people because the goals, norms, beliefs and values on which they are premised changes with variations in cultural and religious traditions as well as social and economic situations in the individual's environment. In business these are the ethical duties incumbent on all company employees, and displayed by the behaviour of managers (Ethics Digest 2006). As Hosmer (2006) would argue, it is leadership that is essential for ethics in business, and this is reflected in the following six universal conditions.

1) Personal virtues from Aristotle (384-322 BC), which can be expressed as "never take any action that is not honest, open and truthful, and that you would not be proud to see reported widely" (p. 14). These arise from normative philosophy (and prescribe how we think and should behave) and the incontrovertible principles of right and wrong, justness and fairness established since the time of Socrates.

2) Religious injunction, from St Augustine and St Thomas Aquinas, which can be expressed as "never take any action that is not kind, and that does not build a sense of community, a sense of all of us working together for a commonly accepted goal" (p. 14)

3) Unitarian benefits, where the action is right if it leads to greater net social benefits than social harms, also known as "the greatest good for the greatest number".

4) Universal rules (Kant 1723-1804), which state that net social benefit theory is elegant but should be 'universalized' by eliminating the self interest of the decision maker.

5) Distributive justice, Which states do not take any action which will harm the least of us. In economic theory this is often referred to as Pareto optimality, a condition in which scarce resources of production and the distribution of them is done so efficiently that it would be impossible to make any single person better off without making some other person worse off. With this concept the theory points to a means of achieving the social goal of the maximum benefit of most wanted goods and services produced at the minimum cost of least wanted resources.

6) Contributive liberty, which provides for the freedom to follow one's self interest within the constraints of the law and social contract and which does not interfere with others' rights to do the same.

First however, we must distinguish between morality and ethics. While morality refers to the standards of behaviour by which people are judged, particularly in relation to others, ethics encompasses the system of beliefs which supports a particular view of morality (Beauchamp and Bowie 1993). Since ethics is the basis for morality it follows that business ethics is the determinant of moral standards for business decisions.

Ethics is the system of interrelated beliefs that supports an acceptance of particular behaviours and should thus form part of a CG model (Ernst and Young 2005). Beliefs themselves are idiosyncratic to the time and place. Different groups in different countries and various locations, at different stages of social, economical and political development, and in different eras will have different beliefs. These will be reflected in their ethics and the behaviours they instigate. This 'ethical relativism' works against the quest for universal principles to construct a system of ethics applicable to all groups which, in turn, makes possible the unifying of competing moral standards. However, there is one principle that seems to exist across all situations mentioned above, and which forms part of every ethical system.

It is the belief that members of a group do bear some responsibility for the well-being of other members of that group. It is acknowledged across cultures and across time that cooperation is necessary for survival. This is no less applicable to the transactions between internal and external groups of the corporation and relationships with its stakeholders. There are established standards which attempt to achieve this such as SA8000 (SAI 2004). It therefore seems logical that a 'business ethics' aspect be included in the PM framework.

2.5 The SCM Approach to Organisation Performance

2.5.1 Introduction

SCM provides a framework for businesses and their suppliers to bring goods, services and information efficiently and effectively to customers, by firms collaborating to improve operational efficiencies and to leverage strategic positioning (Soonhong et al. 2005). For each SC member the B2B relationship represents a strategic choice of position in the supply channel, based on acknowledged dependency and the requirements of domestic and global customer accommodation (Gardner 2004). This SCM is heavily dependent on ICT/internet and the instantaneous and inexpensive transmittal of information which economizes the conduct of business (Frohlich and Westbrook 2002). Increasingly it is also having to deal with global CG differences (Neef 2004), as well as cultural and ethical issues that arise from global alliances (Kidd, Richter and Stumm 2003). In concept, SCM can be a highly efficient and effective network of business linkages which serve to improve efficiencies by eliminating duplication and non-productive, non value-adding work. It is seen by many senior managers as a strategic approach to competitive success (Keah, Lyman and Wisner 2002). In practice however, this is a challenge.

In the integrated supply chain model there are generally three related flow streams: Materials, information and finances. The first is usually the *material flow* stream is usually the first and involves the purchase of materials, components and services from external suppliers. This continues with the transformation of these supplies into manufactured and assembled finished goods. The last stage in this stream is the distribution of the finished product to customers. Note that it is not a major step in applying this description of supply chains to service industries where suppliers may provide data services as well as materials, and the transformation is the conversion of data to a form suitable for distribution. The supply network can be very complex with many suppliers and subcontractors, and even more customers. The SC network comprises the B2B links and the relationships that ensue.

The second flow stream is that of *information flow* which operates to a great extent in reverse to the physical flow. This B2B link is facilitated by electronic data interchange (EDI) and the internet (Sanders and Premus 2005). It has become increasingly important because advances in the necessary technologies have provided expediency and economy. Communication channels have become 'information superhighways'. The third flow stream in the SC is *financial flow*. The payment to suppliers and subcontractors and the receipts of payment from retailers and customers, as well as internal financial flows have equally been affected by advances in global information communication technologies. This whole integrated SC model requires management and leadership (Bowersox et al. 2007).

In the past SCM has not fully provided the benefits promised. Traditionally the B2B groups were linked loosely and independently by multiple arrangements with many different firms. The greater the independence of the operation the greater the possibility the group had a 'fragmented supply chain'. A common approach to handling these multiple arrangements and containing any fragmentation was to establish specialised functions with specific roles in the SC. Relationships were maintained by incumbents of these specialised positions and it was implicit in their duties that their primary objective was to 'get the best deal' for their employer (Carr and Pearson 1999). The adversarial nature of negotiations consequent to such an agenda, perverted the possibility of collaborative relationships and corrupted the structure that they operated in. Some firms were treated discriminately, based on the nature of the relationship and the power base (Cox 1999). Not uncommonly, issues that arose included questions of loyalty, confidentiality and conflicts of interest. Another approach was to outsource 'non core' functions.

Not only does this tend to insulate the buying company from poor supplier behaviour and from being held responsible for the latters egregious violations, it further fragments the supply chain eroding any competitive operational advantage this strategy held.

Difficulties in achieving efficiencies in the SC were recognised. One approach used to overcome them was to vertically integrate the organisation so that all SC members belonged to the same corporation. Benefits of this arrangement are intuitive: functional responsiveness and accountability was kept within the corporation, financial sophistication, transfer pricing and the ability to control and shift costs became available, and transfer of information could be conducted without loss of integrity. Additionally, the corporation was able to operate globally and employ improvement techniques such as Just-in-Time to achieve strategic advantage (Arnheiter and Maleyeff 2005; deWaal 2004; Crawford and Cox 1990). However, practices such as stockpiling inventory to insure against unpredictable markets were maintained, and remained unchallenged because no viable alternatives existed. As consumer affluence increased, this long standing passive acceptance of service changed to an expectation that there would be active involvement in design and delivery of products and services (Dornier, Fender and Kouvelis 1998). This too was facilitated by the expediency of communication facilitated by the internet. But, if the supply chain is seen as catering only for a particular product group, as in a single path through the supply network from suppliers to distributors, then pockets of inefficiencies and waste can still exist.

In terms of operational performance of the supply chain, the logic that prevailed assumed that, if the individual members of the SC were efficient, then the whole supply chain would benefit. Overall chain process efficiency was considered to be the sum of the individual efficiencies of members of the chain. Hence PM focused on the individual components of the SC (Grunberg 2004; Gunasekaran, Patel and Tirtiroglue 2001,). For example, cost per unit to manufacture and cost per unit to transport were analysed independently and not as part of the complete SC. Sometimes this invited an accounting game where spreading and sharing of costs through overhead allocations and burden rates were used to diffuse the true costs of non-viable operations. This is contraindicative of the objective which should be to achieve performances that provide the overall lowest cost for the total supply chain.

The quest for integrated SCM is to provide mechanisms where the cost of a product is reduced, the quality maintained or exceeded, and the expectation of ultimate consumers satisfied. This can only be achieved by collaboration of partners within the supply network, extending the enterprise beyond traditional organisational boundaries, and integrating the services of all providers by the facilitation of ICT (Sanders and Premus 2005). It is this ICT that has manifested paradigm shifts in thinking about the possibilities – the move from a supply chain to a value chain to a network (VN) has significant strategic advantages (Towill 1997). It is more pragmatic to regard these chains as networks because of the myriad of complex structures that describe the direct and indirect elements of transactions in the interdependent relationships between firms. There is technical and social content in these relationships. The technical ones are the mechanisms that control supply functions while the social ones involve trust, commitment, collaboration and power. Good relationships may be an asset (Kanter 1994) because the time spent on activities of both parties can be optimized by minimizing pre-qualification and credential checking and process auditing, while accessing the pooled the need to allocate resources of both parties to allow a division of tasks and a reduction in duplication. On the other hand, the disadvantage of this closeness is a restriction on company autonomy, resources to maintain the relationship and coordinate ongoing processes, and the real possibility of future indebtedness to the other. There is also the cost of termination of the relationship should it be unmanageable. However, the relationships between firms that interconnect to form networks display common characteristics which feature in collaboration as outlined below:

1) Reciprocity – each partner is expected to contribute some balanced share to the specific transactions. This may include different proportions at different periods of time and at different stages in the supply process.

2) Interdependence – the parties are knowledgeable of each others' capabilities and operations and may draw on these to help solve process problems.

3) Loose coupling – while maintaining rudimentary legal formal obligations there is a reasonably stable framework for interaction and communication.

4) Power – a supply chain has inherent power relations which can be exploited positively or negatively, usually to the whim of an 'orchestrating' key partner.

5) Boundedness – boundaries of the network are defined by the demarcation of operations of individual partners within the common supply chain.

These characteristics highlight the necessity for communication and collaboration in these relationships with a commitment to trust, shared values and aligned goals.

> The fundamental rationale behind collaboration is that a single company cannot successfully compete by itself. Customers are more demanding; competition is escalating. Thus many firms seek to coordinate cross-firm activities and work reciprocally over time to produce superior performance. (Min, et al. 2005, p. 238)

The importance of collaboration is such that along with the other variables it has been studied by various researchers (Simatupang and Sridharan 2002). These researchers for instance (Simatupang and Sridharan 2005), have developed a collaboration index (CI) which has the three dimensions of information sharing (10 items), decision synchronization (9 items), and incentive alignment (6 items). They structure the quantitatively validated relationship as:

$$CI = f(IS, DS, IA) \tag{2.2}$$

Traditional 'anticipatory-based' business practices can now be surpassed by 'response-based' business models. The anticipatory model required a forecast to initiate material purchases, program manufacturing, and plan warehousing and distribution, at high cost, in the expectation of those forecast sales. It was based on a 'push' strategy. The alternative response–based model works on a 'pull' strategy. In this approach customer requirements are not misjudged by questionable forecasts because the orders are confirmed. The response-based business model is the fruit of low cost information. Managers can share information rapidly to improve forecasts or eliminate them in an effort to minimize inventories (Basu 2001). By reducing the reliance on forecasts because of speedy accurate information, the response-based model mimics the traditional 'build-to-order' manufacturing without its disadvantages (Holweg 2005). The contemporary response-based system operates faster than build-to-order and gives meaning to the oxymoron 'mass customisation'. Direct connectivity with end users via web-based communications allows such customisation with the added benefit that the customer is no longer simply a passive participant (Fundin and Bergman 2003).

While these in themselves are noteworthy achievements, the benefits expand. Manufacturing postponement, delayed logistical fulfillment, the financial sophistications of cash-to-cash conversion, dwell time minimization and cash spin are at the heart of response-time based capabilities. A manufacturing postponement strategy reduces the anticipatory risk in traditional SCs because the working arrangements available through response-based orders allow the postponement of final manufacture or shipment of the product until receipt of the customer order. The operational tactic allowed by this strategy is to maintain the product in a non-committed or neutral state as long as possible, thus allowing economies of scale while accommodating a variety of product configurations to satisfy individual customisation. The result is a reduction in the number of stock-keeping units in logistics inventory while supporting broad product variety. Delayed logistical fulfilment through logistics postponement works contrary to manufacturing postponement in that the full line of inventory is built but stocked at one or few strategic locations and available for accelerated delivery upon receipt of customer order. This is also known as geographical postponement and often suited to products such as service and replacement parts. This approach reduces overall inventory investment yet achieves reliable customer service (Beamon 1998).

What are the financial benefits of time-based strategies for SC operations? The financial benefits are straightforward; speedy delivery means less inventory and reduced distribution facilities, and quicker to customer means less working capital in the supply chain. These are expressed in the financial sophistications of cash-to-cash, dwell time minimisation, and cash spin. Cash-to-cash conversion is the time taken for the conversion of raw material to sales and relates to inventory turn. The higher the ‘inventory turn’ the faster the cash conversion.

This can be achieved by designing the SC so that the cycle time from receipt of customer order to the delivery of goods is reduced. Reducing cycle time can be achieved by minimizing dwell time. Dwell time is the ratio of time that an asset waits idly to the time required to complete the cycle or parts of the cycle being measured. Reducing the assets across the SC also provides a benefit referred to as cash spin.

If some asset in the SC is eliminated or reduced by re-engineering existing processes, the capital freed by their absence becomes available for other investment. Such changes are reflective of trends in the new operating environment (Bamford and Forrester 2003).

An alternative to ‘anticipatory-based’ and ‘response-based’ business models is the ‘process-oriented’ framework. Lambert, Garcia-Dastugue and Croxton (2005) evaluate the framework of the Global Supply Chain Forum (GSCF) against that provided by the Supply-Chain Council (SCC). The GSCF classifies SC processes as: customer relationship management, customer service management, demand management, order fulfilment, manufacturing flow management, supplier relationship management, product development and commercialization, and returns management. The SCC has five supply chain operations references: plan, source, make, deliver and return, which can be analysed on four levels with each level based on the three components of process reengineering, benchmarking and best practice. Lambert Garcia-Dastugue and Croxton conclude that the differences are merely a distinction between a strategic approach to SCM versus a tactical approach, and both are applicable to any firm depending on its requirements at a particular time.

The financial attractiveness of strategic and tactical changes to SC operations should be sufficient to stimulate collaboration between member firms and an impetus to challenge tradition (Duffy and Fearne 2004; Basu 2001). The arguments for collaboration as a mutually beneficial strategy in network relationships are often presented as compelling (Manzoni and Islam, 2006a, 2006b, 2006c). However, the obstacles to cross organisational collaboration are many. The issues include management and leadership, confidentiality, trust and loyalty, reward and risk sharing, and measuring the performance of the supply chain.

A collaborative framework requires good management, integrative leadership and an acceptance that the framework is unique to that particular supply chain (Lambert, Knemeyer and Gardiner 2004). Since the primal issues are ones of power and risk, the integrative leader will be the supply chain partner that has significant power through its role in the SC or delegated power from other members that are willing to allow this firm to act as the collaborative leader.

One challenge for the collaborative leader is to distribute equitably the rewards and risks. If process innovation is successful what is a fair share of benefits? If a venture fails, what is a fair apportionment of risk absorption? In traditional modes, one method of sharing risk and rewards is transfer pricing. It is guided by market forces and works for transaction-driven business relationships. The collaborative SC works at a higher level of commitment and on a different basis to transaction driven business. Confidentiality, trust and loyalty are higher parameters, as is joint strategic planning to achieve future goals of survival, growth and profit. The collaborative SC will have participant firms that are simultaneously engaged in other networks and commonly with direct competitors. There is genuine overlap and potential for conflict and breaches of confidentiality. The conceptual simplicity of neat linear supply chains quickly dissolves into a quagmire of competitive complexity and a maze of operational interactions. It is in these relationships that integrative leadership can launch, nurture and sustain collaborative initiatives. Management of the relationships in multiple supply chains with these potentials for damage can be achieved by 'partitioning' organisational structures to specifically focus on particular collaborative relationships (Doran 2003). The cross functional integration and optimising of the supply chain is an evolution which needs to be 'orchestrated' (Schmitz and Platts 2003). Orchestration is the role of the partner in the dyad that makes the key decisions but not on the basis of a power game (O'Reagan and Ghobadian 2004), rather on the basis of mutual benefit to the whole SC. Whereas integration was once discussed as an inter-departmental and intra-firm objective it is now openly accepted that it extends beyond the firm itself (Daugherty, Ellinger and Gustin 1996). Once integration is under way, the common interest in measuring performance may commence with choosing information reporting capabilities which align with the needs of the SC partners (Griffis et al. 2004).

Once issues of jurisdiction are resolved there remains the question of how to measure the performance of the supply chain. Accepting that the performance of the SC is not simply the summation of individual firms' performances, and that it operates in a globalised knowledge economy, negates conventional measurement devices for supply chains. There are however, concepts of functional integration which approach SCM from a systems perspective, not dissimilar to this thesis. Min and Mentzer (2004) propose a system where 'supply chain orientation', expressed through trust, commitment, cooperative norms, organisation compatibility and top management support, is a precursor to the upstream and downstream performance of the SC, where the customer focus is perceived as equally important in the long-term relationships of partners. The measurement metrics must assess performance as the collective synthesis of the synchronised SC while being able to isolate and identify individual contributions. Min and Mintzer suggest metrics such as growth, profitability, timeliness, availability and product/service offerings. Other approaches to measurement may be quantitative. Li, Kumar and Lim (2002) build a 'scenario model' which defines organisational entities as supply chain nodes, distinguished from each other by the attributes of product/service, organisation specialization and location, that are engaged in a complex set of multi-layered interdependencies, represented by numerous equations of mathematical integration. Alternatively, Chan and Qi (2003) use fuzzy logic to build a PM hierarchy of judgments in the supply chain with inputs such as time, labour and capital costs, and outputs such as value of finished and semi-finished product, as a quantitative approach to SC measurement.

Most companies realize that in order to evolve an efficient and effective supply chain, they need to assess its performance (Beach and Muhleman 2000), but it is notable that the development of meaningful performance metrics for supply chains is in its infancy (Cigolini, Cozzi and Perona 2004).

2.6 The Measurement of Organisation Performance

2.6.1 Introduction

Performance management is a diverse and debatable subject which crosses disciplines and offers perspectives from various specializations. Traditionally the accounting framework has been the mainstay of quantitative PM with financial planning and control maintaining its central role so that managers can deliver returns to shareholders and other stakeholders. However in recent times this approach has been severely criticized for being inadequate.

Financial control requires monitoring and corrective action and is thus ‘backward-looking’. The major criticism of this traditional approach is paraphrased in the question “How can the firm go forward if it is always looking backwards?” In fact, as commentary on the accounting approach Otley (2002) states that:

> There is no definitive set of financial ratios that can be said to measure the performance of a business. Rather, a set of measures can be devised to assess different aspects of financial performance from different perspectives. (p. 8)

He maintains that there is still a need for these financial measures since they provide tools for the efficient use of resources, provide measures against organisational objectives, act as motivation and control mechanisms in the organisation, and assist in achieving the needs of outsiders (to the organisation) such as shareholders, bankers, etc. Through audited financial statements there is also the opportunity to comply with CG requirements as encapsulated in agency theory. And, while financial specialists are aware of the criticisms they are actively trying to introduce new means of economic PM. The EVA model and ‘triple bottom line’ are examples of this, just as ABC was earlier.

If the task is simply to provide measures then the objective is obscured. Meyer (2002) identifies a total of 117 top level measures comprising 17 financial, 17 customer related, 19 internal processes, 35 renewal and development, and 26 human resources. This may be symptomatic of what Neely and Austin (2002) note as “we measure everything that walks and moves, but nothing that matters” (p. 48).

In addressing SC performance from customers to suppliers, customer satisfaction attracts a large and continuing academic interest (Hill and Alexander 2000). The underlying notion is that customer satisfaction is about meeting expectations for services and products, and performance is how well these expectations have been met. This paradigm of ‘disconfirmation-of-expectations’ has had mixed results and this may be a distraction from a true measure of performance of the SC, with the consequence that the quest is to find what really affects cash flow and what really matters to performance.

While there is a richness of sophisticated measures of market performance,

> … this richness brings with it confusion as researchers and managers struggle to find a set of measures that is comprehensive enough to be accurate, yet simple enough to be usable. (Clark 2002, p. 36)

In the analysis of supply chain performance, the literature abounds with measures that apply to the central orchestrating firm, the main player. Measures for the operations of individual firms, viewed in isolation of the supply chain, have congregated around the concept of the balanced scorecard applications (Kaplan and Norton 1993) because it is credited with structuring a functional array of performance measures (Amaratunga, Baldry ans Sarshar 2001). These include: the explicit link between espoused strategies and the performance measures for these, the four major areas of measurement which match stakeholder concerns, the main drivers for future performance (unlike simple financial measures), and the key success factors being limited to only four performance areas rather than the prolific KPIs of other measurement systems. It is even possible that the EVA metric could be used as one of the financial measures in a BSC formulation. This interest in a BSC as a PM metric is emphasized by the increasing availability of enterprise resource planning (ERP) software with the capability of reporting on these scores (Curran and Lald 2000). For example, SAP, Oracle, Peoplesoft and Baan have such software modules. Programs such as these should simplify the process of designing an optimal PM system. Such a system would have relatively few measures, three financial and three non-financial for example, with the financial ones as backward performance indicators and the non-financial ones as forward performance indicators.

These measures should pervade the supply network uniformly to permit comparison across organisational units, and should be stable enough to reveal true performances at focal points in time yet responsive enough to evolve as the integrated network of firms does. The intuitive reasoning for a minimum of three of each financial and non-financial indicators is that the supply chain can be broadly viewed as the three parties: suppliers, orchestrating firm, and customers, with each segment having a financial and non-financial metric. Non-financial measures have often been shied away from because they were considered intangibles (Eskildsen, Westlund and Kristensen 2003).

The financial and non-financial dyad can be further supported by viewing the progress through the SC as a generic three-stage causal model with foundations (suppliers), processes (orchestrating firm), and outcomes (consumer product), as represented by the 'performance tree' of Lebas (1995). The tree analogy was chosen to illustrate process complexity entwined with growth and change. The generic model incorporates traditional conceptualizations from the economic and financial requirements of shareholders and company stewards, as well as other conceptualizations from the perspective of non-fiduciary stakeholders such as social, environmental and political or regulatory organisations.

Modeling performance as a tree offers the scope to visualize performance as a complex concept which both defines and legitimizes it as a social construct. This allows the articulation of performance as a set of propositions pronounced by various researchers in recent times and enunciated by Lebas and Euske (2002). One proposition is that performance can only be expressed as indicators of processes through which various outcomes are achieved. The next proposition is that performance exhibits a causal relationship. Actions today influence results in the future. The third proposition is that performance is user-defined because as a social construct its application depends on the user's objective. For example, the acceptability of an organisation's performance could be assessed antithetically by shareholders and environmental groups. This suggests that another proposition supposes performance is different when evaluated from inside and outside the firm. The fifth proposition is that performance is always connected to a domain of responsibility. The domains in an organisation are the teams, functional specializations, or departments, and other sub-models within the greater structural hierarchy.

The Taylorist view, still widely held, is that these sub-models are additive while the contemporary view is that they overlap in networks of cross-functional processes represented by 'domains of responsibility'. Similar to Lord Kelvin's statement: "if you cannot measure it, it does not exist", Lebas and Euske's proposition six states that performance only exists if it can be described or measured (2002, p. 74). Proposition seven requires that the model needs to be continuously validated to remain relevant and proposition eight states that these metrics should be accepted as being only partially descriptive of performance. Their final proposition is that:

> …performance is a relative concept requiring judgment and interpretation…[and]… contradictions among temporal measures and other indicators are inevitable. (p. 77)

An acceptance of these performance propositions can be productive in establishing a set of basic principles for PM. Austin and Gittell (2002) list three.

1) Performance should be clearly defined in advance and to agreed criteria.

2) Performance should be accurately measured, in a way to convey maximum information.

3) Rewards should be contingent on measured performance.

These principles can be perfunctorily applied in balanced PM systems so that decisions made and actions taken in the past are quantifiably expressed as efficiencies and effectiveness of the results in the present. These organisational results would be the aggregation of PM for the individual domains of responsibility and reflect the ability of the ICT infrastructure to enable data acquisition, collation, analysis, interpretation and dissemination to be exploited. In an economic fashion this has been achieved by models such as Dupont's pyramid of financial ratios.

How can existing knowledge of PM help in attaining practical metrics in supply networks? Surprisingly, a comparison of the popular measurement frameworks reveals a congruence among models which can be drawn on. Deficiencies in the Dupont pyramid, particularly the focus on historical financial performance and its prodigy 'short-termism', has led to models which pronounce a more balanced approach with the inclusion of non-financial indicators.

The Matrix Model (MM) of Keegan, Eiler and Jones (1989) provided a simple framework with cost, non-cost, and external and internal dimensions to give greater balance. Lynch and Cross (1991) similarly provide for internal and external measures with ‘cascading’ measures down the organisation to departmental and work centre levels, similar to the domains of responsibility mention earlier. The balanced scorecard of Kaplan and Norton (1992, Appendix 11), widely adopted since the early 1990’s, has a similarity to and a development from the Tableau de Bord (Epstein and Manzoni 1997) established in France earlier last century and still widely applied.

But, contemporary thinking (Kennerley and Neely 2002, 2003) has criticized these models on a number of shortcomings (Krause 2003), in particular the need to address the increasing demands of stakeholder satisfaction. The Cranfield University model (Appendix 12) that adopts the stakeholder-centric view is the Performance Prism (Neely, Bourne and Adams 2003; Adams and Neely 2000). It recognizes the growing power and importance of regulators and significant pressure groups by attributing two of the five facets of performance to stakeholder issues.

An in-depth analysis of the above models allowed Bitici et al. (1997) to identify common features and study the dynamics of PM systems (Bititci, Turner and Begemann 2000). From a review of over 260 publications across many disciplines Bititci, Carrie and Turner (2002) uncovered numerous fragmented concepts and principles of PM but

> …very few publications provided a complete and structured view for an integrated PM system…[and]…none of the existing models or approaches completely addresses the requirements identified (p. 177).

This then, provides an opportunity to develop a framework which addresses these deficiencies. This is the aim of this thesis.

2.7 DEA and the Measurement of Efficiency

2.7.1 Introduction: Background and Brief History of the Model

The term data envelopment analysis (DEA) was first used and reported in the *European Journal of Operations Research* by Charnes, Cooper and Rhodes (1978) based on Rhodes' PhD dissertation research "A DEA Approach to Evaluation of the Program Follow Through Experiment in U.S. Public School Education". It was the failure of all the statistical-econometric approaches tried previously that led Rhodes to suggest Farrell's (1957) work 'The Measurement of Productive Efficiency" as an alternative to analyzing efficiency as a measure of performance expressed in a ratio of single output to single input. Farrell identified two components of efficiency: a *technical efficiency* (TE) which showed the ability to maximize output from a given input, and a price efficiency which reflects the use of inputs allocated in optimal proportions (and hence also referred to as *allocative efficiency*) (see Chapter 4). Considered together these measures provide an overall (or economic) efficiency. These ideas were developed further in later DEA models and explained well in texts by Cooper, Seiford and Tone (2000, 2006), and Zhu (2003), as well as the milestone text by Charnes, Cooper, Lewin and Seiford (1994). The Australian contributions include Coelli et al. (2005), and Avkiran (2006). These are reviewed later in this section.

At this time the concept of efficiency as a ratio of the output goods and services to input resources, to be termed productivity, was gaining credence. It was the work of the Organisation for European Economic Cooperation (OEEC) to promote productivity in the 1950s that led many European and Asian nations to establish Productivity Centres and Councils (Sumanth 1984). As a concept it became an economic tool for the measurement and comparisons of productivity at international, national and industrial levels, but only to a minor degree was it used at the company level.

The obstacle to general acceptance was the difficulty in arriving at a productivity ratio which could include all the different input resources and the various outputs, and be universally accepted or have comparability (Nyhan and Martin 1999). The productivity ratio takes the form of three different types: *partial productivity* (PP) which is the ratio of output to a single selected input, e.g. units per labour hour, units per tonne, etc.; *total-factor productivity* (TFP) which is the net output to the aggregated labour and capital inputs; and *total productivity* (TP) which is the ratio of all outputs to the sum of all inputs (Sumanth 1984).

The partial productivity ratio has become the most widely used because of its ease to calculate, understand and obtain data, especially since it relates output to a single input. However it may mislead and fail to give a true picture of the situation. Total factor productivity, as defined in the early literature, is less meaningful to operational managers because only labour and capital inputs are represented. This may not always be appropriate, for example when there is a large materials input. This meaning of TFP seems to have waned and has been replaced by what was originally total productivity, a measure representative of the organisation's true economic position.

The measurement of total factor productivity (or total productivity) is quite difficult to achieve because of the quantity and availability of the information required and also because TFP is not able to quantify important intangible factors of input or output. Nevertheless the concept that efficiency can be expressed as a ratio of all output goods and services to the sum of the total inputs (beyond only tangible resources) is widely accepted and rarely challenged. In commercial spheres for example, the financial index of the aggregated dollar value of sales to the aggregated dollar value of inputs is often calculated and used in some fashion, but global measures such as this provide little insight into the firm's efficiency at the operational level and a better diagnosis of the output/input relationship would be helpful. The contemporary, generally agreed measures of productivity are PP and TPF, noting that the latter is now regarded as inclusive of all inputs and all outputs. These distinctions become important in later research because they are tied to efficiency and performance.

Charnes, Cooper and Rhoder (1978) were able to by-pass the shackles of financially focused metrics and partial productivity measures by optimizing individual ratios, as defined by the researcher, to generalize from single outputs/inputs to multiple outputs/inputs by the use of 'virtual' surrogate units that represented multiple outputs and multiple inputs. The discrete units to be measured are those decision making units

(DMUs) that are defined by the researcher according to the output-input relationship that warrants investigation (Gass and Harris 2001). In fact all DMUs in DEA are the discretionary inputs and outputs as assigned by the researcher.

By 1992, 14 years later, 472 publications on DEA reflected a growing interest in this tool. Its rapid acceptance was attributed to the development of extensions to the original model, and variations to it, when problems in its application were encountered (Charnes et al. 1994). By 1999, over 800 citations were recorded, and by 2001 the publication list stood at more than 3200 (Tavares 2003, cited in Avkiran 2006; and Cooper, Seiford and Tone 2006). These publications have addressed a great variety of research interests by over 1600 authors in 42 countries. Yet this field is barely tapped. Emrouznejad and Podinovski (2004) for example, report that at the 4th International Symposium of DEA there were more than 190 papers submitted, spanning the boundaries of academic disciplines. Sixty of these are published in their proceedings.

This author (2006a, 2006b, 2006c; Manzoni and Sadler, 2005) has added to this by presenting DEA applications of PM, SCM, and CG to a number of international and national conferences (). The volume of work reflected in the above figures and the diversity in applications reported suggests strong support for the technique as a diagnostic instrument and one with broad applicability. Additional bibliographic listings are available at DEAzone (2005) and Emrouznejad and Thanassoulis (2005).

2.7.2 Recent Research and Model Development

Some recent studies show the potential for future research. Sarkis (1999) applies DEA in the study of environmentally friendly manufacturing, while Tone (2001) shows how to deal with undesirable outputs in DEA, other than treating them as negative inputs. Eilat, Golany and Shtub (2006) show how an extended DEA can be used to quantify some qualitative concepts embedded in R&D project portfolios. Quantification of qualitative concepts was earlier discussed in the generalized multiple criteria model of Greenberg and Nunamaker (1987).

Efficiencies in the Australian finance sector are studied by Brown (2001) while the Industry Commission (1997) shows how DEA can be applied to measure

Commonwealth/State government service provision. Rickards (2003) used DEA to evaluate benchmarks and balanced scorecards

The DEA literature is diverse because of all the disciplines it transcends, being a quantitative diagnostic instrument. In very broad terms however, DEA research may be categorized as: learning and technical development of the mathematical model, joining it with complementary mathematical techniques, traditional widespread and popular applications, and emerging novel applications. Some themes naturally, become more popular as new research is published and applicability established, and many overlap categories.

The technical development has seen many versions and new variations to the Charnes Cooper Rhodes (CCR) model (Charnes et al. 1985; Seiford and Lewin 1997; Zhang and Bartels 1998; Frei and Harker 1999; Pastor and Sirvent 1999; Ahmad, Berg and Simons 2006). Those that have passed academic scrutiny have usually been expanded in specialized texts.

For example, the recent text of Zhu (2003) develops DEA so that managers can conduct performance evaluation and analyze decision alternatives by the easy use of spreadsheets. DEA Excel Solver is supplied to calculate 150 different model versions providing various contexts to allow benchmarking. The Cooper, Seiford and Tone (2000, 2006) texts are similar in that they provide instruction and software but also build on the earlier work of Charnes et al. (1994) which provided a multitude of examples of application in very diverse fields, including a valuable DEA bibliography from 1978 to 1992. The included software in the recent text is for limited use by its reader to test the DEA application, while the advanced professional version for purchase, is provided for real-world larger applications. This is the DEA Solver Pro used in this thesis. The text also explores some developments in theory and methodology including sensitivity analysis, statistical approaches such as OLS regressions, stochastic frontier regressions and window analysis, to name a few. Cooper, Seiford and Tone (2000) adds to the earlier version by providing additional material from more recent developments. The concept of 'super-efficiency' where E>1 for example, makes it possible to ascertain the consequences of eliminating a complete DMU – especially an efficient one.

Avkiran (2006) provides an Australian text with DEA as the productivity analysis technique which captures the complex interplay between multiple inputs and outputs. It is designed as an introductory text, suitable for the classroom, with case studies from the services sector. It presents the areas of banking, education and research centres, hospitality and tourism, public transport, police stations, telecommunications, Olympics, public libraries and others. This list draws on work in journals, monographs, conference proceedings and other sources, identified by Avkiran, other researchers and by this researcher. It is not a comprehensive list but it does illustrate the diversity of the DEA applicability. Another Australian text by Coelli et al. (2005) is the second edition of a book written for people wishing to study efficiency and productivity analysis by four different methods: econometric estimation of average response models, index numbers, DEA and stochastic frontiers. It starts with the basic concept, gives simple examples, then extends the method with a number of detailed empirical applications using real-world data.

The Sengupta (2003) monograph integrates the theory of firm efficiency and industry equilibrium, emphasizing a dynamic setting, and incorporating uncertainty of market demand and prices. It also discusses the implications for shared investments; all of these with the parametric and semi-parametric methods of estimating production and cost frontiers using DEA. The Ramanathan (2003) text, on the other hand, is a tool for practitioners who need to know the merits and pitfalls of the technique but must first gain an understanding of the algorithm. Another basic explanation for practitioners is provided by Anderson (2005).

Many facets of DEA have been debated but a recurring one is how to allocate the correct weighting to the DMU's input and output factors. While there is general acceptance that the algorithm performs satisfactorily with its self assignment of weights thus providing a conservative result, there has been ongoing attention to the best approach. Golany and Roll's (1989) procedure for DEA discusses this and introduces the idea of using the Analytical Hierarchy Process (AHP) for assigning weights. Cheng and Li (2001), Yurdakul and Tc (2005), and Sarkis (1999) for example, use AHP to assign weights. Entani and Tanaka (2006) however, demonstrate how the bounds of efficiency can be changed by adjusting weights on non-efficient DMUs, in particular by adjustments to inputs and outputs, while Troutt, Ehie and Brandyberry (2007) propose a ‘winner take all’ optimization for determining the most productive unit. They simultaneously assign input and output factor weights along with optimal intensity values for the virtual composite unit to achieve the ‘maximally productive input-output units’.

2.8 Conclusion

This chapter presented a review of the contemporary literature on the various topics encompassing this thesis. It reviewed the emergence of a global knowledge economy as the foundation for new management theory and PM practices. In particular, it studied the impact of the global knowledge economy on Australia in recent times and the emergence of a new system of OB through OSTS. This system was presented as a development from established contemporary theories of management with ideas from more recent schools of thought. General systems theory and its developments were incorporated with STS to present OSTS as a theory for the management of a whole supply network in the 21^{st} century. The SN was described in terms of the over-riding system in which the organisation operates, and therefore its performance is contingent on the performance of this bigger system.

This was followed by a review of previous and recent methods of measuring performance, with an analysis of their successes and limitations, thus providing a basis for the positivistic methodology of DEA. DEA is an established technique for making efficiency comparisons and was reviewed from its origins in 1957 to the present time. This review covered the historical development of the technique with some specific issues relevant to that period. The next chapter presents the conceptual framework and research methodology for the model developed in this research.

Chapter 3

Conceptual Framework and Research Methodology: A New Approach to PM

As far as the laws of mathematics refer to reality,
they are not certain, and as far as they are not certain,
they do not refer to reality.

Albert Einstein 1879-1955

3.1 Introduction

This chapter describes the research methodology used in this thesis to test and justify the conceptual framework of the performance pyramid as a valid metric for measuring organisational performance. Based on positivistic foundations and research data available from other work, a quantitative analysis using mathematical modeling is undertaken. Operations research techniques are assessed for their suitability and an optimization algorithm available through the linear programming approach of DEA is used. This is a new approach to the measurement of performance in a framework which is integral to an OSTS.

The chapter is structured on the basis that a new conceptual framework for the performance of a firm can be defined and that certain postulates of PM can be tested by the use of an operations research methodology. These postulates are discussed in Section 3.3.1 below after the development of the conceptual framework. An optimization model of business is then developed through a number of stages, amplified in later chapters, to show how linear programming can be used to apply DEA. It is then further refined by demonstrating how mathematical programming is now simplified by the advent of spreadsheet software.

The detailed illustration of how DEA can be applied using a spreadsheet application, is demonstrated in Appendix 2a but the task is made more efficient by the availability of commercial software designed specifically for DEA-type studies. Alternative methodologies for measuring efficiency and other related mathematical models are then discussed to support the choice of DEA for this study.

The chapter concludes by discussing and supporting the data to be used in this study, as applied in Chapter 5. It also discusses the need for model validation as a precursor to later chapters where this is done.

3.2 Conceptual Framework for PM

An integrated performance measurement system(IPMS) model as proposed by Bititci, Carrie and McDevitt (1997), Bititci, Turner and Begemann (2000) and Bititci, Carrie and Turner (2002) tested in over 30 organisations, suggests that an auditable reference model can be developed. Drawing on total systems intervention theory they conclude that an IPMS should include all the following.

- Reflect stakeholder requirements to maximize their satisfaction.
- Reflect the firm’s existing competitive position.
- Facilitate an input to company strategy.
- Align strategic objectives with business processes.
- Distinguish between control and improvement.
- Focus on critical areas.
- Encourage wide understanding to maximize ownership.
- Facilitate the provision or resources to activities critical to performance.
- Facilitate performance planning based on constraint management.
- Promote proactive management.
- Accommodate qualitative with quantitative measurement.
- Measure capability and organisational learning.
- Ensure measures are used at the appropriate levels.
- Promote an understanding of the causal relationships between measures.

- Facilitate simple reporting.
- Be dynamic and responsive to changes in the internal and external environment.

Organisational performance is indisputably the consequence of combining of a means of addressing the requirements of an IPMS type model together with the features of those others discussed earlier, i.e. the balanced scorecard, performance prism, Tableau de Bord, measurement matrix, etc., into one that can be applied to the supply network. The structure of a conceptual framework that can do this is presented in Figure 3.1, where the performance pyramid presents a baseline scorecard of all stakeholder needs. This novel concept, presented for the first time in this thesis, is able to successfully address each of Bititci's requisites for a system that will work. In this figure the process for measuring performance commences with knowledgeable stakeholders pressing the organisation for outcomes that satisfy their diverse needs. To achieve this, the firm must develop a sound strategy and adopt effective operational plans. It also needs measures of performance to gauge its achievement against set objectives. The critical success factors shown to the left of the figure indicate what needs to be measured, namely financial and non-financial factors, and CG of the firm. The right of the figure demonstrates the integrative roles of human factors and computerization (Bititci, Nudurupati, Turner and Creighton, 2002). Central to the figure and concept is: the recognized need to measure performance, an understanding of what needs to be measured – CSFs shown as PM content, and the means by which PM can be facilitated, shown as process. This results in a system which addresses the requirements of a PM model, as stated by Bititci et al. (1997) and others (Bititci et al. 2000; Bourne et al. 2000). This is illustrated as the performance scorecard. The Performance Pyramid represents the application of the PMS to all affected members of the complete supply chain (Franco and Bourne 2003).

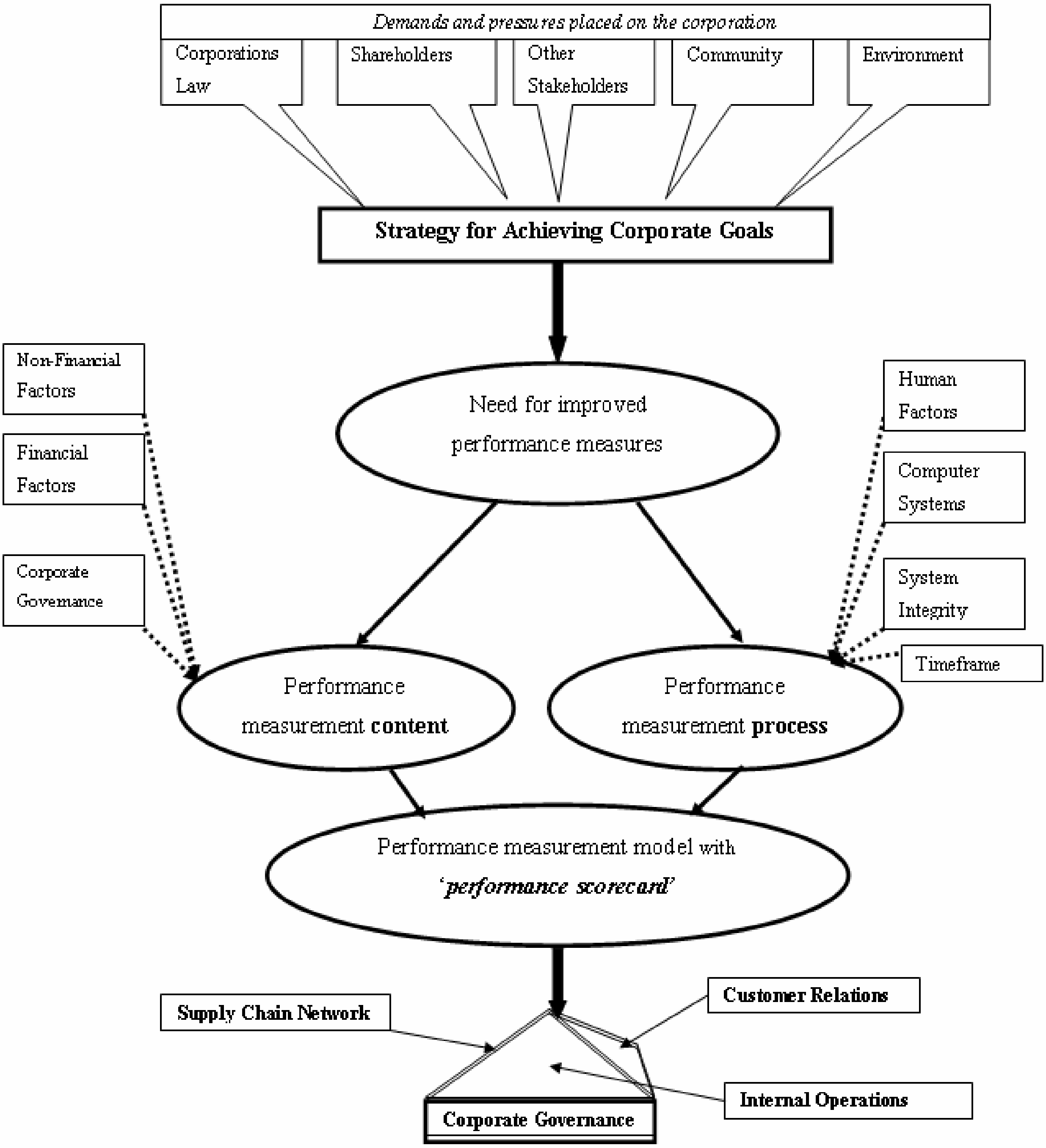


Figure 3.1 PM Conceptual Framework

The tetrahedral pyramid representing the baseline performance scorecard for the organisation is chosen so that the sides represent the performance metrics of the immediate supply network of direct and indirect suppliers, and their own suppliers, internal company operations and customers, while the base represents the foundations of

CG footings. Good CG is pivotal to the performance of all organisations. The analogy in engineering parlance is that if the foundations are weak or unstable the rest of the structure becomes the same, while in commerce, businesses with seemingly good operations, supplier and customer relations, have failed because of CG shortcomings. Figure 3.1 further illustrates that the metrics of performance are the processes established to capture the pertinent KPIs, for example information communication technologies, and the choice of KPIs themselves such as financial and non-financial ones. These in turn, could be chosen as a means of achieving the corporate goals through a strategy of 'satisficing' various stakeholder demands. The requirements of these diverse groups do are not identical in the formulation of strategy. Some stakeholders, shareholders and regulatory authorities for example, will have their needs as high priorities on the strategy agenda, while others may receive only scant attention. Nevertheless, they can contribute to the success or failure of the measurement system (Bourne et al. 2002; Barratt 2004)

This conceptual framework is manifested as an idiosyncratic application of the sixteen factors of the Bititci et al. model above, amongst the supply chain partners. Since business is continually evolving and firms exist in various states of maturity and sophistication, it is expected that firms will display differing levels of attainment in achieving performance measures in an integrated socio-technical system. The integrated OSTS extends across the whole supply chain and subjects all partners to a variety of influences from the external environment as presented in a simplified fashion in Figure 3.2 below. It can be amplified by including those precursors to the performance pyramid in Figure 3.1 and then by iterating the model for each of the supply chain partners in the supply network. Inclusive of this would be the description of how the Bititci factors are incorporated into the IPMS for each particular member firm. This is then developed into the integrated model as presented in Figure 3.2. Note that the pyramid would be replicated in each portion of the SC, as well as for all members of the network. In other words, every participating organisation in the supply chain would have its own pyramid mimicking that of the 'orchestrating' partner.

Such an integration of performance factors, with OB theory and its practice through CG across the whole supply chain and within members of the supply network, is a novel concept and a contribution to the discipline. Previous studies have investigated restricted portions of the concept presented here.

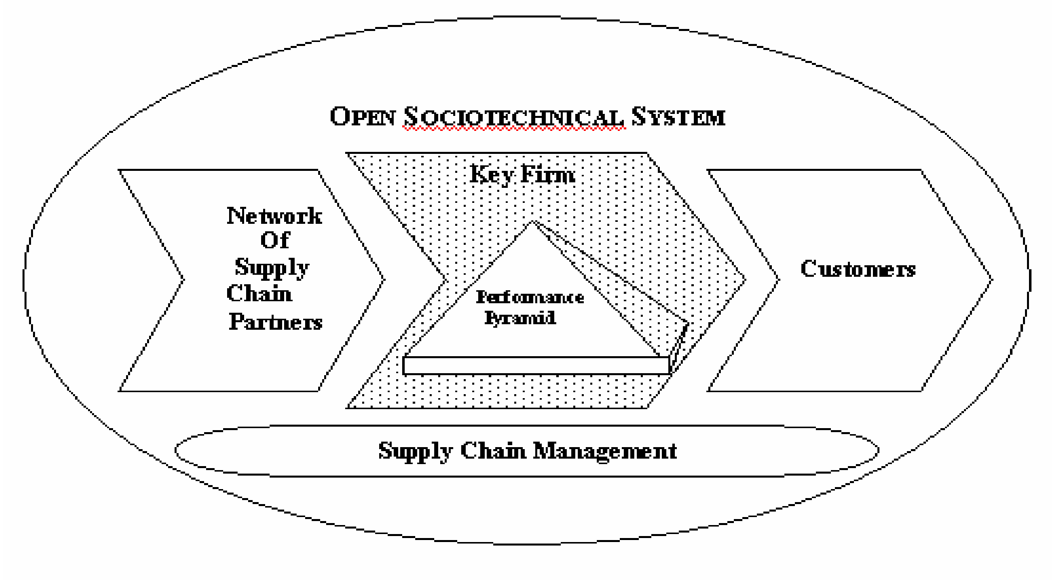


Figure 3.2 The Integrated OSTS for the OBPM model

3.3 The OBPM Model

The OSTS as a theory of organisation has many proponents. Its strength lies in an acceptance that the firm does not exist in isolation but is affected by a myriad of external factors. These influential factors range from those that are malleable to pressures from the firm to those that are impervious. The sociotechnical system of the firm, as a subset of OSTS, also has proponents who support the concept of the two subsystems, technical and social, that operate inter dependently in the organisation and allow it to function idiosyncratically. The STS view also accommodates the human relations approach, especially that of the Tavistock Institute of Human Relations, which elevates the importance of people working collaboratively under humanistic leadership to align and attain economic and social goals and extends this beyond the organisation itself (deWaal 2003).

SCM is the managerial function of those processes which span functional areas within individual firms and link trading partners and customers across organisational boundaries to elicit improved operational efficiencies.

Working collaboratively, each of the firms in the supply chain can leverage its strategic position by working within a framework where key resources are shared and the operational alignment of customers, and distributive and supply networks provide competitive advantage through enhanced value. Value in the supply chain results from the synergies of the critical flows; information, product, service, finance and knowledge (Neely and Powell 2004). This is facilitated by the emergence in recent times of powerful information communication technologies which have empowered an integrative management able to respond speedily across the globe and to adopt digital business transformation where possible (Lau et al. 2001). Sophisticated financial transactions and economies of scale are also enhanced by digitization in the supply chain. This 'extended enterprise' paradigm of the supply network can be interpreted as a specialized stream within the context of the OSTS theoretical explanation of organisations, and is consistent with that theory.

The primary determinants of SC performance are those established by the integrated procurement, manufacturing and marketing strategies which interlock capabilities across the network within a framework of total cost minimization through joint optimization of all resources. In this fashion core competencies can be exploited (Mills et al. 2002). A total cost analysis across functional groups can be achieved by deploying performance measures at key stages of flows within the supply chain. Typically the key points are those that, according to the theory of constraints, are the significant bottlenecks. However, since all firms are users of resources whose scarcity dictates that they be effectively utilized, the measures of performance needed suggest a role for operations research techniques. Linear programming, mixed integer programming, simulation, network optimization, as well as heuristic techniques are already applied to measure the performance of the technical subsystems of the OSTS, so they can be extended into the supply network. Similarly, the social subsystems within the SC should be assessed. This thesis contends that OR techniques such as the DEA application of linear programming can be used to evaluate DMUs which in the social subset can be defined as functional work groups (MacBryde and Mendibil 2003), or preferably in accord with STS nomenclature, 'self directed work teams' (SDWT). The capacity to use psychometric measures of human resources and work relationships is only limited to the extent of their importance as characteristics common across SC partners. Once these characteristics are enumerated, conventional benchmarking techniques and 'best practice' comparisons can be employed to provide performance measures (Franco and Bourne 2003; Maleyeff 2003; Malina and Selto 2004).

In this fashion one is able to recognize the benefactions of integrating organisation theory, SCM and PM into a coherent perspective of a PM model for a productive unit of an enterprise in Australia using DEA.

This section has argued that an OSTS approach to organisation design enables humanistic management, in concert with modern technological advances, to pursue performance efficiencies available in the integrated supply network. The effective integration of such a network requires a management philosophy which views collaboration as a vehicle of ethics, trust, business morality and strategic alignment as foundation stones for enhanced corporate performance. It further proposes that, in accord with the methodologies cited in the earlier chapters these features, and the dynamics they present, are measurable using operations research techniques. The principles of good CG are precursors rather than consequences of leading performance in business. Support for this contention is provided in the following chapters together with the analyses and discussions of the results of the empirical research presented.

3.3.1 Research Study Postulates

There are multitudes of factors which affect performance (Figure 3.1), and some means of identifying salient factors is required – thus the quest for a framework upon which the concept of PM can be structured. This structure is the performance pyramid, a tetrahedron with CG as the foundations and the sides representing company operations, customer relations and supplier networks.

The base of the key firm also supports the supply network in which the firm operates. This study attempts to validate the claim that organisational performance has its roots in

CG above all else, and therefore measurement of this dimension is required before proceeding to other critical success factors. It follows that if DEA is able to measure efficiency on this criteria, which has been argued to be qualitative and thus intangible, then it can be more stoichiometrically applied to tangible dimensions of performance higher on the performance pyramid, and ultimately to the supply network in which the organisation operates.

The objective of validating the PM construct for supply networks is predicated on the following postulates.

Postulate 1: Organisational performance is founded on a base of CG.

Postulate 2: Performance is measurable.

Postulate 3: Organisational performance is measured by productivity.

Postulate 4: Productivity is the ratio of all outputs to all inputs, i.e. all goods and services to all resources used in achieving these.

Postulate 5: Improvements in productivity lead to improvements in performance.

It is these postulates that are tested in this study. The first postulate is tested on the basis that CG, as the means by which corporate values are communicated throughout the organisation and displayed in policies, procedures and responsibilities, is the foundation of performance. One of the factors of CG is CSR, and this is measured in this study. The second postulate is supported through the measures that show a score for corporation social responsiveness. Because CSR is an output result contingent on the inputs of various factors, it supports a productivity-based measure of organisational performance. Only CSR will be tested, in part because not all CG factors are self-evident nor are they conveniently available. The methodology to test these postulates is described in the remainder of this chapter.

3.4 The Optimization Model of Business using DEA

Operations research can be described as the scientific approach to decision making in an attempt to determine how best to design and operate a system under conditions which usually require an allocation of finite resources. It is characterized by the use of mathematical models which are chosen to best represent the decision environment. In this thesis the decision environment is the commercial business system as it exists in a market-centric economy in Australia. In today's competitive environment, businesses have limited resources available to them so it becomes increasingly important that these resources are used as effectively as possible. Linear programming is the operations research approach to making business decisions which will result in the optimal or best use of limited resources in achieving the organisational objective. The measurement of business performance through the optimization model of LP using DEA will be developed below.

3.4.1 Stages of an Applied Operations Research Study

There are five stages in the generalized mathematical programming approach. The optimization process for DEA conforms with the established operations research steps as shown in Figure 3.3 (Winston 1991).

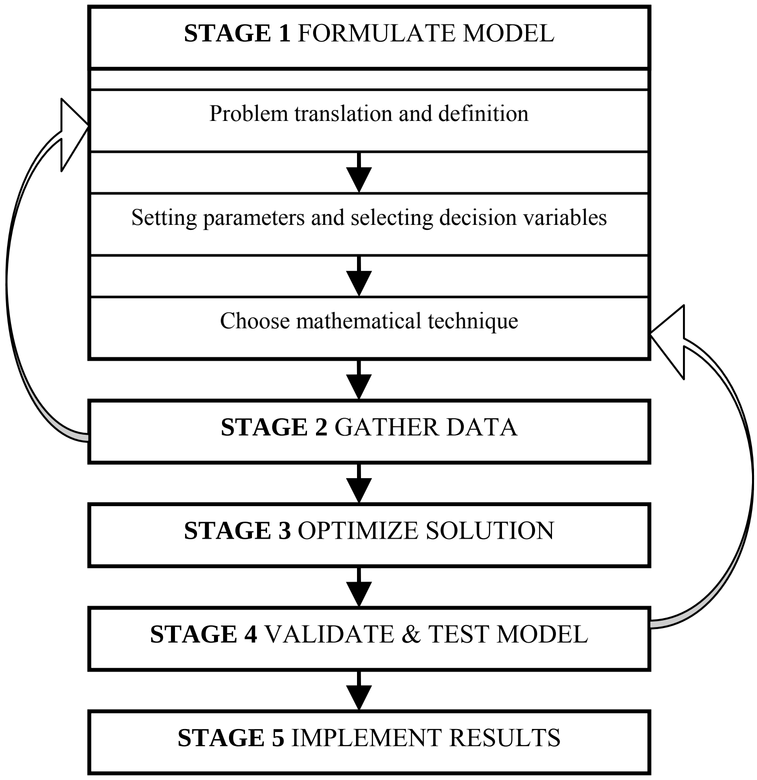


Figure 3.3 Generalized steps in modeling optimization for DEA

Stage one comprises model formulation and requires several steps. The business problem needs to be translated from managerial jargon and broad statements of objectives and specifications into terms that can be mathematically operationalised. These can then be defined and refined by establishing the important parameters and identifying the key decision variables. While the decision variables are those factors that the decision-maker is seeking answers to and are generally controllable, the parameters are those factors that affect the decision, imposed by the external environment and therefore are not usually controllable. In some instances this may require some ingenuity in selecting those variables that best describe the problem being investigated. The relationship between the decision variables and the parameters are the constraints imposed by the characteristics of the problem. These constraints are very important to formulating the mathematical model because they determine the selection of the mathematical technique. The goal of the model's computation is an optimum solution for achieving the best possible value of the objective function or decision criterion.

This stage is developed in Section 3.4.2 using the Golany and Roll (1989) procedure and in Section 3.5 for the linear programming formulation of DEA.

Stage two is the gathering of data as defined by the problem parameters. This involves the constraints or matrix coefficients, the coefficients for the objective function, and the values for the right-hand side of the mathematical programming model. Data collection is usually time consuming and can be costly, so if secondary data is readily available and can be suitably adapted, it should be considered. This is described in Section 3.9.

Stage three is obtaining an optimal solution. After dutiful scrutiny and careful selection, data can now be entered into the model so that the optimum solution is computed. This is shown in Chapter 5.

Stage four is validation and testing of the model through an assessment of how well the recommended course of action provided by the computed solution relates to the real situation and provides an answer applicable to the problem as originally specified. Model validation is an important step in OR because it justifies the mathematical interpretation of reality. According to Hazell and Norton (1986), validation of a model leads to a numerical report of its fidelity to historical data, a potential for improvement if initial validation fails, and a qualitative judgment of how reliably the model achieves its designed purpose. The theoretical validation of DEA for this study is done in Chapter 4 and testing of the DEA through trial experiments is shown in Chapter 5 prior to running the program for the optimal solution. A review of other OR models leading to the choice of DEA as the most suitable for this study is discussed in Section 3.7.

As shown in Figure 3.3 some of these steps are iterative, so adjustments required are made as new information becomes evident. For example, the specifications of the original problem may have changed as a consequence of trying to formulate reality in mathematical terms, or because the operational reality itself has changed.

Also, new parameters may be necessary for better problem definition, or budgetary constraints may curtail the project. Some allowances may also be made for ‘point in time’ calculations giving static answers to a dynamic system. A sensitivity analysis of the optimum solution may gauge this influence.

When testing is complete and the model has been validated, the implementation stage can commence. Implementation may be ‘once-off’ or continual upon repeated use of the model. The outcome of business decisions made on the basis of modeled solutions will determine the model’s efficacy and future use. However, on going monitoring of results and incorporating changes as required should follow in pursuit of keeping the model current.

3.4.2 The Procedure for DEA Application

When the generalized approach to model formulation is systematized for the specific applications of DEA, the stages become a pragmatic rehearsal of three phases of carrying out an efficiency study as espoused by Golany and Roll (1989). Their flow chart of the entire procedure is presented in Figure 3.4 and their validation of this protocol is shown in Section 3.5.

The three phases comprise a number of steps which include heuristic, rule of thumb, selections of the appropriate number of DMUs, physical organisational boundaries, and the time horizon for the application. They also caution that an initial selection may not be ‘correct’ and that the proposed procedure is iterative, as mentioned for the generalized model earlier.

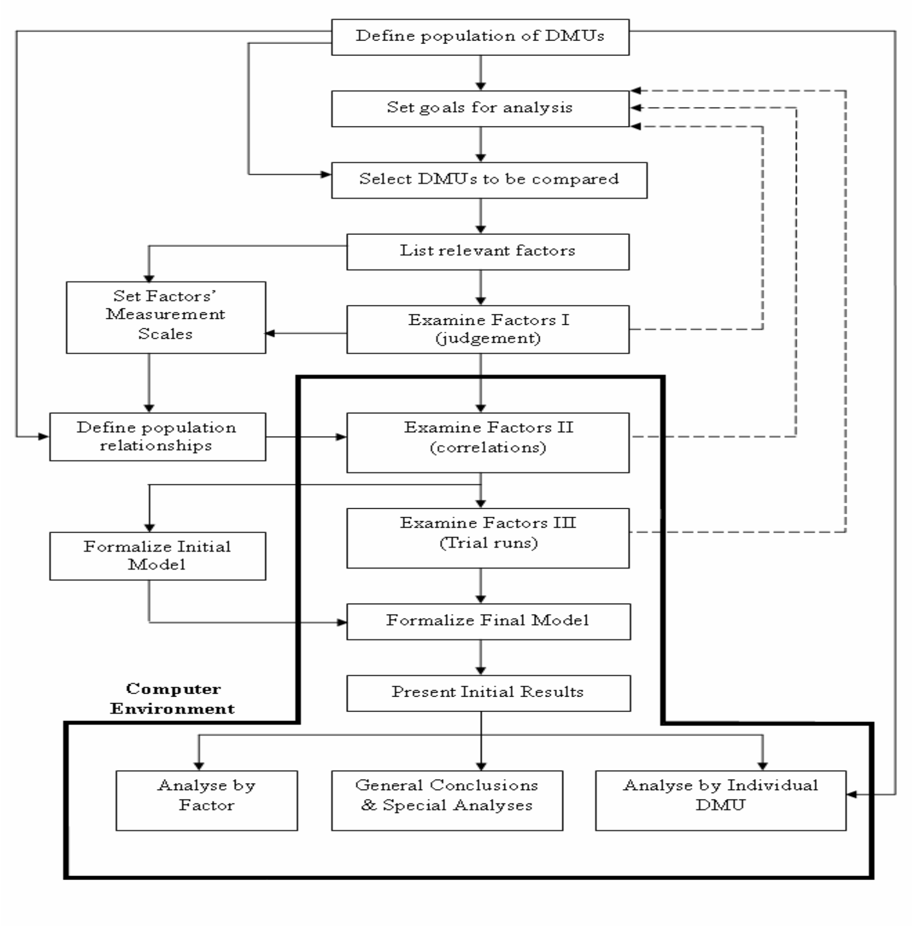


Figure 3.4 The DEA application flow chart

3.5 Linear Programming and DEA

3.5.1 Linear Programming

Linear programming[1] (LP) is a mathematical optimization technique which attempts to maximize or minimize a linear function of decision variables. The function that is to be maximized or minimized is the *objective function* and the values of the decision variables must satisfy a set of *constraints* which are linear equations or linear inequalities. There is also a non-negative restriction associated with each variable.

[1]Named by George Danzig in 1948 on the recommendation of Tjalling Koopmans after Dantzig presented a paper "Linear Programming in Production Scheduling".

Specifically, the linear programming problem can be described as finding the values of n decision variables, $x_1, x_2, \ldots\ldots x_n$ such that they maximize (or minimize) the objective function z where:

$$z = c_1x_1 + c_2x_2 + \ldots + c_nx_n \tag{3.1}$$

subject to the following constraints:

$$\begin{aligned} &a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n \leq b_1 \\ &a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n \leq b_2 \\ &.. \qquad\qquad\qquad .. \\ &a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn} \leq b_m \end{aligned} \tag{3.2}$$

and usually:

$$x_1 \geq 0, \qquad x_2 \geq 0, \quad \ldots\ldots x_n \geq 0 \tag{3.3}$$

where c_j, a_{ij}, and b_i are given constants representing the objective function coefficients, constraint coefficients and right-hand side coefficients respectively.

Let:

$$\mathbf{x} = \begin{pmatrix} x_1 \\ \vdots \\ \vdots \\ x_n \end{pmatrix}, \qquad \mathbf{c} = \begin{pmatrix} c_1 \\ \vdots \\ \vdots \\ c_n \end{pmatrix}, \qquad \text{and} \qquad \boldsymbol{b} = \begin{pmatrix} b_1 \\ \vdots \\ \vdots \\ b_n \end{pmatrix} \tag{3.4}$$

be column vectors of sizes n, and m, respectively, and:

$$\mathbf{A} = \begin{pmatrix} a_{11} \cdots a_{1n} \\ \vdots \cdots\cdots \vdots \\ \vdots \cdots\cdots \vdots \\ \vdots \cdots\cdots \vdots \\ a_{m1} \cdots a_{1n} \end{pmatrix} \tag{3.5}$$

be the m x n constraint matrix.

The above linear program can be written in matrix-vector form, with superscript T representing the transpose of vector or matrix and **0** the column vector.

$$
\begin{array}{lll}
\text{Maximize} & \mathrm{I}z = c^T\mathrm{x} & \\
\text{subject to} & \mathrm{Ax} = \mathrm{b} & (3.6) \\
& \mathrm{x} \geq 0 &
\end{array}
$$

The values of the decision variables $x_1, x_2, \ldots .x_n$ that satisfy all the constraints of equations (3.2) and (3.3) simultaneously are said to form the *feasible solution* to the linear programming problem while the set of *all* values of the decision variables characterized by the constraints (3.2) and (3.3) form the *feasible region*.

Solving the linear program can result in four possible situations:

1) The linear program could be infeasible. There are no values of the decision variables $x_1, x_2, \ldots .x_n$ that simultaneously satisfy all the constraints of (3.2) and (3.3).
2) There could be an unbounded solution. The value of the objective function (if maximizing) can be increased indefinitely without violating any of the constraints.
3) Usually it will have at least one finite optimal solution.
4) It may have multiple optimal solutions.

3.5.2 Linear Programming for DEA

In DEA, the study unit is a 'decision making unit' and is an assigned entity responsible for converting inputs into outputs. DEA computes the performances of DMUs relative to one another with the most efficient being ascribed the benchmark value of unity.

Suppose there are n DMUs and for each there are $j=1\ldots\ldots m$ inputs and outputs, where the input data for DMU$_j$, $(x_{1j}, x_{2j},\ldots\ldots\ldots.x_{mj})$, are represented by the **X (**m x n) matrix and the output data, $(y_{1j}, y_{2j}, \ldots\ldots\ldots y_{sj})$, are represented by the **Y** (s x n) matrix as follows:

$$\mathbf{X} = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{pmatrix} \tag{3.7}$$

$$\mathbf{Y} = \begin{pmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ y_{s1} & y_{s2} & \cdots & y_{sn} \end{pmatrix} \tag{3.8}$$

The efficiency of each DMU is measured as the 'virtual output' divided by the 'virtual input' once, so there needs to be n optimizations for the whole DMU set. The following fractional programming problem is solved to obtain values for the input "weights" (v_i) $(i = 1,\ldots,m)$ and the output "weights" (u_r) $(r = 1,\ldots,s)$ as variables.

$$(FP_O) \quad \max \quad \theta = \frac{u_1 y_{1o} + u_2 y_{2o} + \ldots + u_s y_{so}}{v_1 x_{1o} + v_2 x_{2o} + \ldots + v_m x_{mo}} \tag{3.9}$$

$$\text{subject to:} \quad \frac{\mu_1 y_{1j} + \mu_2 y_{2j} + \ldots + \mu_s y_{sj}}{v_1 x_{1j} + v_2 x_{2j} + \ldots + v_m x_{mj}} \le 1 \; (j = 1,\ldots,n) \tag{3.10}$$

$$v_1, v_2, \ldots, v_m \ge 0 \tag{3.11}$$

$$\mu_1, \mu_2, \ldots, \mu_s \ge 0 \tag{3.12}$$

The above fractional program (FP_o) can now be replaced by a linear program (LP_o) as follows:

$$(LP_O) \quad \max_{\mu,v} \quad \theta = \mu_1 y_{1o} + \ldots + \mu_s y_{so} \tag{3.13}$$

$$\text{subject to:} \quad v_1 x_{1o} + \ldots + v_m x_{mo} = 1 \tag{3.14}$$

$$\mu_1 y_{1j} + \ldots + \mu_s y_{sj} \leq v_1 x_{1j} + \ldots + v_m x_{mj} \quad (j = 1, \ldots, n) \tag{3.15}$$

$$v_1, v_2, \ldots, v_m \geq 0 \tag{3.16}$$

$$\mu_1, \mu_2, \ldots, \mu_s \geq 0 \tag{3.17}$$

The conventional mathematical approach to solving this linear program is a task that is not necessary because these types of problems are more easily solved with the user-friendly spreadsheet models which are readily available.

3.5.3 Mathematical Programming with Spreadsheets

The computational power and efficiency provided by modern information technology and personal computing has made mathematical programming practical and more widely available. In particular, this has been facilitated by modeling language systems and spreadsheet optimizers.

The widespread use and availability of applications with personal computers has triggered an avalanche in the availability and practicality of mathematical programming models. As hardware and software prices have decreased, the availability of mathematical model applications through spreadsheet optimizers has increased. What was previously restricted to academics with access to mainframe computing has quickly become available to managerial practitioners at their personal computer workstations. Similarly the mathematical modeling for real-world problems has been translated into software applications which are user-friendly. This approach is demonstrated with illustrated steps in Appendices 2a and 2b.

3.6 Alternative Methodologies for Measuring Efficiency

There are a variety of approaches available in microeconomic theory and management sciences to measure efficiency as defined by multiple inputs and multiple outputs. Those evaluated here as alternatives to DEA include ratio analysis, pure and modified programming, statistical regression, and deterministic statistical frontier and stochastic frontier approaches.

3.6.1 Ratio Analysis and Efficiency Evaluation with Multiple Input and Multiple Output

Ratio analysis is a relevant alternative to DEA because it is an ex post evaluation tool able to analyse multiple input and multiple output relations.

Unlike DEA however, ratio analysis does not involve mathematical programming to organize the ratios into aggregate measures of efficiency, nor does it take into account interactions over the full range of inputs and outputs. Consequently, if a DMU ranks highly on some measures and low on others the comparative assessments of performance become increasingly difficult (Lewin, Morey and Cook 1982). A simple example with only two DMUs demonstrates the difficulties is presented in Table 3.1.

DMU	DMU_1	DMU_2
Output	1	1
Input A	1	2.5
Input B	3	2
Ratio 1 (Output/Input A)	1	0.4
Ratio 2 (Output/Input B)	0.33	0.5

Table 3.1 Ratio Analysis for Two DMUs

Ratio 1 of DMU_1 is larger than DMU_2 while the situation reverses itself for Ratio 2. The performance of DMU_1 relative to DMU_2 cannot be determined by examination of these ratios unless a relative importance weighting is assigned to each one. In applications of multiple performance ratios of many DMUs, such as in this study, the weighting of the ratios would require the formulation of complex decision rules and their justification, as well as a much greater computation workload. In a similar situation, Lewin, Morey and Cook (p. 401) compared the ratio analysis approach with the CCR model and found DEA to be superior on a number of fronts. DEA found the best combination of all ratios, and with slack analysis (a feature of DEA) they found it to be insightful of the sources of inefficiencies. DEA also performed better in utilizing the data resources. Additionally, comparisons of single ratios will often lead to misclassifications and incorrect judgments simply because simple ratios usually provide only partial measures of the multiple input-output relations. Despite these significant shortcomings however, ratios do have the advantage that they are commonly used because of their ease of use ordinarily and their simplicity.

3.6.2 The Pure Programming Approach

Based on the technique proposed by Farrell (1957) and developed further by Charnes, Cooper and Rhodes (1978), this approach uses a sequence of linear programs to construct a transformation frontier and to compute primal and dual efficiency relative to the frontier. It represents an earlier approach to the commonly described version in Section 3.5.

Consider a sample of *n* production units, each with variable inputs $x=(x_1..x_m) \in R_+^m$ in the production of outputs $y= (y_1....y_s) \in R_+^s$. For notation let x_{ij} represent the amount of input i used by unit j (j=1,…n), and let y_{rj} represent the amount of output r produced by j. We assume technology is known and may be modeled by an input correspondence $y \rightarrow L(y) \subseteq R_+^m$ or inversely by an output correspondence $x \rightarrow p(x) \subseteq R_+^s$. L(y) is the subset of all input vectors capable of producing at least output vector y, and p(x) is the subset of all output vectors obtainable from input vector *x*.

The relationship between the input correspondence and the output correspondence of each production unit can be written as $L(y) = \{x \in R_+^m : y \in p(x)\}$ and inversely as $p(x) = \{y \in R_+^s : x \in L(y)\}$.

Two subsets of L(y) of interest are: the isoquant and the efficient subset. These can be defined as:

$$IsoqL(y) = \{x : x \in L(y), \lambda x \notin L(y), 0 \leq \lambda < 1\} \tag{3.18}$$

$$EffL(y) = \{x : x \in L(y), u \leq x \Rightarrow u \notin L(y)\} \quad y \geq 0 \tag{3.19}$$

From (3.18) and (3.19), $EffL(y) \subseteq IsoqL(y)$ and so $x \in IsoqL(y) \not\Rightarrow x \in EffL(y)$. This property is important for the measurement of primal efficiency because the input vector *x* is said to be technically efficient in the production of output vector *y* if $x \in EffL(y)$. Similarly, the output *y* is said to be technically efficient for input vector *x* if $y \in Effp(x)$.

The pure programming approach to efficiency measurement starts by constructing the input set *L(y)* for any *y*. The sample data are bounded, or 'enveloped' by a convex weak-disposal hull consisting of a series of facets. The input set constructed is the smallest set that includes all *n* observations in the sample, and which satisfies properties of any well behaved input set.

Technology is well behaved in the sense that the input correspondence is assumed to satisfy (3.20).

* $0 \in$ L(y), $y \geq 0$, and L(0)= R_{+}^{n}

* $\| u^{1} \| \rightarrow +\infty$ as $l \rightarrow +\infty \Rightarrow \bigcap_{l=1}^{+\infty} L(y^{1})$ is empty (3.20)

* $x \in L(y) \Rightarrow \mu x L(y), \ \mu \geq 1$

* *L* is a closed correspondence

*L(θy)$\subseteq$L(y), $\theta \geq 1$

Because this method constructs the smallest possible input set containing all the data (consistent with regularity conditions in 3.20), the pure programming approach generates upper bounds to the true but unknown efficiencies. The resulting input set is piecewise linear, and the construction process achieves considerable flexibility because the breaks among the pieces are determined endogenously so as to fit the data as closely as possible.

The Farrell technical efficiency measure is computed for each production unit by solving the programming problem :

$T_e(x,y)$=min{$\mu : \mu x \in$ L(y)}, $\mu \geq 0$ where for the sample of *n* units,

$$L(y)=\{x: y_{rj} \leq \sum_{j} \lambda_{j} y_{rj}, \ \sum_{j} \lambda_{j} x_{ij} \leq x_{ij}, \ \sum_{j} \lambda_{j}=1\} \quad (3.21)$$

$$\lambda \in R_{+}^{n}, r=1,\ldots\ldots s; \ i=1\ldots\ldots m; \ j=1\ldots\ldots n \quad (3.22)$$

The construction process guarantees that *EffL(y)* $\subseteq$ *IsoqL(y)* but that *EffL(y)* $\neq$ *IsoqL(y)*. This being the case, it is possible to obtain $T_e(x,y)=1$ though $x^k \in$ *EffL*(y^k) for some k.

This can happen if the minimum value of μ is one and there are non-zero slacks in the linear programming problem equivalent to (3.21).

One of the problems with the pure programming approach results from the fact that the sample data are enveloped by a maximum production possibility frontier. Consequently, the entire deviation of an observation from the frontier is attributed to inefficiency.

Since the frontier is non-stochastic, no accommodation is made for issues such as random external shocks, measurement error, omitted variables or noise in data. Every possible influence beyond the control of the production unit is incorporated into inefficiency and referred to as inefficiency. This may lead to under or over statements of true inefficiency. An alternative to the pure programming approach is a development called the modified programming approach. This approach is similar to that above except that the frontier constructed in this approach is parametric. It was first suggested by Farrell and extended in later studies (Aigner and Chu 1968; Forsund and Jansen 1977; Forsund and Hjalmarsson 1979). This approach is again purely deterministic and makes no allowance for noise, measurement error, etc., as earlier. The main concern with this approach however, is that it is unable to easily deal with multiple outputs.

3.6.3 Regression Analysis with Multi-Inputs and Outputs

Significant work has been done using ordinary least squares to assess comparative performances of DMUs which use a single input or produce a single output. In the single input case, the output levels may be regressed on input levels and with the appropriate model, the output level of each DMU can be estimated from its input. Research reports however, that the biggest problem in regression based studies comes from the need to collapse multiple outputs into a single output measure, and if there are interactions among the outcomes in production then the estimation for single outcomes makes interpretation difficult. Bessent et al. (1982) indicate that major difficulties arise when OLS is used in multiple output cases because of the implicit impact on outputs having the same input resources. Where OLS techniques can be modified to accommodate multiple inputs and multiple outputs, there may result a similarity to a DEA result, except that OLS allows for random noise while DEA assumes it reflects inefficiency. Where OLS results have agreed with the DEA study, it has been observed that DEA, being non-parametric, requires less severe assumptions as do OLS techniques and the results are usually more informative.

3.6.4 The Deterministic Statistical Frontier Approach

This approach uses statistical techniques to estimate a transformation frontier and to estimate primal and dual efficiency relative to the estimated frontier (Afriat 1972; Richmond 1974; Greene 1980). Consider the same sample as in Section 3.6.2 but producing a single output $y \in R_+$. The input set *L(y)* is defined as $L(y) = \left\{ x : y \leq \prod_i x_i^{a_i} \right\}$} where the Cobb-Douglas specification for $\phi(x)$ is arbitrary. Next, the actual output obtained from the input vector x is expressed as $y = A\prod_i x_i^{a_1} \exp(\varepsilon)$ where $\varepsilon \leq 0$ is a disturbance term having some specified one-sided distribution, such as a truncated normal or exponential. Here ε represents technical efficiency relative to the deterministic (full) production frontier $\phi(x)$. The data are enveloped by a parametric deterministic frontier which is estimated. $\phi(x)$ and $f(\varepsilon)$ (the density of ε) may be estimated by corrected ordinary least squares or maximum likelihood (Lovell and Schmidt 1988).

The way that the deterministic statistical frontier approach differs from the other approaches earlier is that the primal and dual frontier and related efficiencies are estimated by statistical techniques rather than computed by programming techniques. For statistical reasons the sample size should be large. This is a distinct disadvantage, as is the attempt to specify a distribution for technical efficiency (a form for $f(\varepsilon)$) if a production frontier is estimated. Specification of such would have to be based on knowledge of the factors that generate inefficiency but this knowledge is rarely available. No *a priori* consideration is made for choice of a particular distribution; choice typically being based on analytical tractability. Estimates of the parameters of $\phi(x)$ and of the magnitude of efficiency are not invariant with respect to the specification of a distribution for the efficiency term. The deterministic statistical frontier approach shares the same weakness of the modified programming approach, that is, it assumes a deterministic frontier, and all deviations from the frontier are attributed to technical inefficiency. No allowance is made for noise or measurement error.

3.6.5 The Stochastic Frontier Approach

As with the previous approach, the stochastic frontier approach uses statistical techniques to estimate a transformation frontier and to estimate efficiency relative to the estimated stochastic frontier. This technique was a development from those studies mentioned earlier (Aigner Lovell and Schmidt 1977; Meeusen and Van den Broeck 1977; Jondrow et al. 1982, Huang 1984). Considering the same sample explained earlier, but producing a single output $y \in R_{+}$, the input set *L(y)* is defined as $L(y)=\left\{x : y \leq A\prod_{i} x_i^{a_1} \exp\left\{\varepsilon_1\right\}\right\}$ where the Cobb-Douglas specification for $\phi(x)$ is arbitrary. Here the symmetric disturbance term ε_1 permits random variation for the production frontier across observations, and captures the effects of noise, measurement error and exogenous shocks beyond the control of the production unit. The actual output obtained from input vector *x* is defined as

$$y = A\prod_{i} x_i^{a_1} \exp\left\{\varepsilon_1 + \varepsilon_2\right\} \tag{3.23}$$

where $\varepsilon_2 \leq 0$ is a one-sided disturbance term that captures the effects of technical inefficiency relative to the stochastic production frontier. The data generated in this approach is bounded by a stochastic frontier. The deviation of an observation from the deterministic kernel of the stochastic frontier may be observed from two sources: a) random variation of the deterministic kernel across observations captured by the component ε_1; and b) technical inefficiency captured by the component ε_2. It may be observed that the deterministic statistical frontier model is a special case of the stochastic frontier model for which ε_1=0.

A valuable characteristic of this approach is the introduction of a disturbance term representing noise, measurement error and exogenous shocks beyond the control of the production unit. This phenomenon permits decomposition of the deviation of an observation from the deterministic kernel of the frontier into two components, inefficiency and noise. Without this accommodation the statistical noise would be counted as inefficiency.

Disadvantages of this approach are that it requires a large sample, and structures are imposed on technology as well as the distribution of technical inefficiency. This approach also has that same difficulty of dealing with multiple outputs.

3.7 Other Related Mathematical Models

Models are simplified representations of the world and model-building is an attempt to capture the most significant decision variables by way of mathematical abstraction. Typically an iterative process, model-building allows a mathematical solution to the problem and attempts to achieve as complete and realistic representation of essential characteristics of the decision environment as possible. A model is also a less expensive way of analyzing decision problems and can deliver needed information on a timely basis. More importantly, models are often helpful in examining situations which may be difficult in the real world and thus provide an insight and understanding about the decision problem being investigated. This section reviews other OR models to judge their suitability.

Models can be broadly categorized according to the extent that they portray realism in the representation of a problem. They range from operational exercises, to gaming, simulation, and analytical models. In the operational exercise the modeling effort involves undertaking a series of experiments in the decision environment and measuring and interpreting the results, for example the blending of various grains to meet a market requirement. It is an inductive learning process embedded in the empirical research approach of the natural sciences which allows for a generalization to be drawn from observations of a particular phenomenon. The high degree of realism however, comes at a high cost, inviting simplification of the external abstractions and possibly resulting in sub-optimizing decisions being made. It would not be suitable for PM because of its high cost and lack of 'generalizability'.

Gaming, as the second type of model, involves the abstraction and simplification of the real environment to evaluate the effectiveness of alternative proposals.

It loses some degree of realism by simplification but the speed of measuring alternative performances is increased and the cost of processing is decreased. It is not suited to measuring performance since these models do not require a comparison of alternative strategies but rather the best use of resources.

Simulation models resemble gaming models in the simplification of reality but they differ in that there are no human decision-making interventions in the process. As with the previous two, simulation does not provide optimum solutions nor empirical alternatives. The results of these models need human decision-making for the final judgment of suitable strategy and may find applications in system dynamics as discussed in Chapter 6.

Analytical models on the other hand, present reality in completely mathematical terms. Usually an objective or criterion is to be maximized or minimized, subject to a set of constraints that are there to portray the conditions which have to be satisfied so that decisions can be made. This model computes the optimal solution, that is, a solution which satisfies all of the given constraints, to provide the best objective function. Linear programming has been one of the most popular of these analytical models in recent times. The analytical model of operations research suits the present study because the thesis objective 'to develop a model that will measure performances achieved under given business conditions so as to optimize resources in attaining operational efficiencies' meets all the conditions necessary for this style of mathematical analysis.

The pragmatic approach to business modeling is to adopt some aspect of optimization theory where the scientific solution to a real world problem is attempted through an analysis utilising the most suitable mathematical techniques available from a number of alternatives.

The mathematical programming models that can be employed are pervasive in that they are now accepted in a diversity of industries as valid ways of interpreting business operations, enhancing efficiencies and hence improving productivity.

> The value of the conceptual model lies in the frame of reference it offers for analyzing and testing rules, methods and procedures in the prototype system in relation to their efficiency in achieving optimal managerial decisions. (Avriel and Golany 1996, p. 2)

Typically the task is one where the problem is quite complex because of the number of variables which are significantly influential in the outcome, and also because the systems being studied are themselves evolving and dynamic, changing from day to day.

At the application level, mathematical programming deals with the problem of maximizing or minimizing a real valued function such as profit or loss, in the light of constraints from real-life operating environments.

A method of classifying analytical and simulation models may commence with a matrix that segregates certainty and uncertainty on one dimension versus strategy generation and strategy assessment on the other, as shown in Table 3.2. Uncertainty usually makes a significant difference to the type and complexity of techniques used since problems involving uncertainty are inherently more difficult to formulate well and to solve efficiently. Strategy assessment models are those where the user chooses and constructs the alternatives and evaluates them with the model, whereas in strategy generation the class of alternatives is established by the constraints imposed and by the algorithm used. The procedure generates the 'best' alternative in that class. Mathematical programming generally includes those models under strategy generation (except for decision theory and control theory as shown in Table 3.2).

	Certainty	***Uncertainty***
Strategy Generation	Linear Programming Integer/mixed-integer Programming Non-linear Programming Network Models Control Theory	Decision Theory Dynamic Programming Inventory Theory Stochastic programming Stochastic Control Theory
Strategy Assessment	Deterministic Simulation Econometric Models Simultaneous Equations Input-output Models	Monte Carlo Simulation Econometric Models Stochastic Processes Queuing Theory Reliability Theory

Table 3.2 Classification of Analytical and Simulation Models

For some real-world problems it may be difficult to find an optimal solution using the conventional linear program approach because the characterization of reality cannot be represented by a linear function, non-negativity or other certainty requirements of the linear programming algorithm. In cases such as these there are other models which are better suited to the optimization task. These are described in the following paragraphs to show their suited applications but more importantly to show why they were not chosen for the present PM (which uses the DEA form of linear programming).

The models include integer programming, dynamic programming, non-linear programming, multi-objective programming, stochastic programming, heuristic models, graph theory and networks.

Integer programming (IP) is the extension to LP that admits an additional class of variables which are restricted to integers. The requirement for discreteness pervades many classes of problems and provides wide application across scientific and commercial disciplines. However, unlike LP, the IP problems are practically and theoretically more difficult to optimize and no single methodology is appropriate for all problems. DEA is not bound by an integer restriction.

Mixed integer programming (MIP) is a form of integer programming where some of the variables are integers and others are the more conventional continuous variables. Since the variables for PM do not have the integer limitation, the DEA linear programming is sufficient.

Dynammic programming (DP)[2] is the name given to those mathematical techniques which require sequential decision processes. The stage-wise optimization of the problem is required to describe the governed transition of stage to stage under which the system operates. There are two classes of DP, one where uncertainty is crucial and the other where uncertainty is incidental. The 'functional equation' which describes the DP process is a specific 'recursion', where "a set of one or more equations in which the unknown quantity or qualities appear just to the left of the equal sign and also to the right-hand side" (Denardo 1996, p. 308).

---

[2] "Richard Bellman is credited with creating the field of dynamic programming and coining the language that describes it." (Denardo, 1996, p. 322).

The characteristics of DP applications include the following.

1) The problem can be divided into stages with a decision required at each stage.

2) Each stage has a number of states associated with it.

3) The decision chosen at any stage describes how the state at the current stage is transformed into the state of the next stage.

4) Given the current state, the optimal decision for each of the remaining stages must not depend on previously reached states or previously chosen decisions.

Performance measures for study in this thesis will be taken at an instant in time and without recursive decision processes, so a dynamic programming approach is not relevant.

Non-linear programming (NLP) differs to LP in the requirement that the problem to be solved has a non-linear objective function and one or more non-linear constraints, consequently, while LP solutions occur at the corner points of the feasible region, the NLP feasible region may be curvilinear with optimal solutions possibly occurring within this region. The general form of the NLP is not applicable to DEA which has the assumption of linearity as shown in the 'production frontiers' of DEA development in Chapter 4.

Multiobjective programming (MOP) comes from the scientific discipline in management better known as multiple-criteria decision making where an action or course of actions is selected from a set of alternatives so that a satisfactory result for some criteria of optimization is achieved. The 'satisficing'[3] result may be the compromise between criteria which are in conflict. There are a number of techniques in this class and goal programming (GP) is one of the more popular because of its similarity to linear programming. GP extends the LP formulation to accommodate mathematical programming with multiple objectives.

> It minimizes the deviations of the compromise solution from target goals, weighted and prioritized by the decision maker. There are two categories of constraints, namely structural/system constraints (strict and rigid as in traditional LP) and the so-called goal

[3] Satisficing is a notion of satisfaction based on fair sacrifice.

> constraints, which are expressions of the original objective functions with target goals set a priori and negative and positive deviational variables built into them to accommodate possible over or underachievement. (Tabucanon 1996, p. 494)

If the measures of organisational performance were expanded to include goals in addition to efficiency then MOP could be considered as an alternative to DEA. Presently this is not the case.

Stochastic programming (SP) explicitly considers uncertainty in the optimization procedure as a means of accommodating the fundamental random characteristics of the problem being solved. Unlike deterministic programs, SP does not anticipate future outcomes so the quality of the results depends on the successful portrayal of the random variables over time. PM does not generally accommodate randomness in the allocation of resources but may do so if part of the study objective is any of the approaches below.

There are generally four approaches to dynamic modeling of the stochastic parameters:

1) econometrics and related time series methods which rely heavily on historical data;
2) diffusion and stochastic processes using historical and expert information to calibrate the system;
3) stochastic simulation models; and
4) expert opinion relies on judgment by experts regarding the possible realizations of random variables.

It is assumed that performance is not significantly affected by random factors so a stochastic approach is not suitable in this study.

Heuristic models are those that are best suited when it is unlikely that an algorithm which provides optimal solutions can be developed quickly. They are generally 'rule of thumb' methods which aim at finding reasonably good solutions in a relatively short time. There are many of these techniques with the following three clusters as examples of this approach.

The myopic rules cluster describes those styles where the solution to the problem is constructed in a progressive manner with each iteration producing a part of the solution.

This is then extended by selecting one of a number of options available. In scheduling activities, for example the myopic rules are often called dispatching rules where the overall objective of minimum completion time is achieved by the best sequence of set-up and processing times. The heuristics used may be; ‘shortest set-up time first’, or ‘longest processing time first’, or ‘most important order first’.

Another cluster of heuristics is based on local search which attempts to find a solution better than the current one through a search in the ‘neighbourhood’. The best journey for the traveling salesman, or the best schedule for a single machine, are examples of this approach which is also known in the literature as the 2-opt, 3-opt or k-opt procedures.

The branch and bound heuristics are widely used methods for obtaining solutions to scheduling type problems where all jobs not yet scheduled are scheduled using some composite dispatching rule. An heuristic approach to PM could be a possible methodology in situations where performance-seeking behaviours may be displayed as ‘rule-of-thumb’ strategies by managers.

Graph theory and network optimization has wide practical applications. On a graph the circles which represent sources, destinations and intermediate points of a network are called nodes and numerically identified. These nodes are connected by arrows and called arcs. The resultant graph provides a network which can be the characterization of many flow problems. Examples of this approach include: minimum-cost flow problem, the transportation problem, the maximal flow problem, the assignment problem, the shortest path problem and the critical path method. Such an approach has little relevance to PM of a single commercial entity, as focused and investigated in this paper, but is of possible value when considering the performance of the supply chain in which the organisation exists.

3.8 Research Data for this Study

3.8.1 The Data Source

The research method employing mathematical models relies heavily on the value of the data used. If there are legitimate concerns about the quality of data being used the whole model becomes questionable and the research findings untenable. It was for these reasons that the secondary data available from the recently completed doctoral thesis of a fellow researcher was meticulously scrutinized. The research methodology adopted by Black (Black 2004) to produce the empirical data required for theory formulation and validation follows. There were a number of epistemological assumptions that founded her thesis and led to the critical realist approach of theory formulation known as adaptive theory. Adaptive theory uses an iterative cycle of qualitative and quantitative investigation to develop and test embryonic theory. It builds on existing frameworks and adjusts interpretations of data to test against the emerging theory. It employs ongoing data collection and development through multiple research strategies that use qualitative and quantitative methods. In this instance there were a number of studies. The first study was exploratory and used in-depth interviews to develop grounded theory 'sensitizing' concepts of the construct. After Q sort analysis to refine the categories identified in transcripts, a total of five detailed models had been constructed. These were synthesized with research literature to establish constructs which could be tested psychometrically.

Psychometric testing was developed because of its suitability for measuring abstract attitudinal and behavioural constructs. Psychometric surveys rely on respondents to answer multiple statements to indicate their level of agreement to a concept. A multi-item seven-point Likert scale was the instrument used for this purpose. Varimax rotation, which reduces cross-loading of items across multiple factors to clarify the factor structure, and factor analysis, with a threshold of 0.7 coefficient alpha, were used to identify patterns of relationships in the data set. The final scale comprised 24 items.

A pilot self-report mail survey of 602 produced a response rate of 34%. Results were used to refine the constructs and make improvements. The researcher was now able to develop the testable hypotheses. Two large well-known Australian organisations were used as case studies. They were tested comparatively, and together with in-depth interviews, they provided a richness and understanding of the phenomena being investigated. In addition, good case research design requires construct, internal and external validity which is enhanced by multiple sources of evidence and careful attention to case study protocol. This should allow 'theoretical generalizability'.

In this instance a multiple case study design using psychometric instruments and interviews provided triangulation of data sources within each case and across cases. A survey instrument was prepared and with discriminant and predictive validity established, the variables were operationalised. A test-retest procedure was conducted at two week intervals and across seven groups and provided additional precision for estimating measurement error.

The final web-enabled survey distributed by a hotlink embedded in company email was sent to 767 participants who represented four levels of management. The 245 usable replies (later trimmed to 231), representing a response rate of 32%, were used to finalize that research and support the theory by conventional hypothesis testing.

3.8.2 The DEA Data

The raw data from the Black (2004) thesis was provided to this researcher on a SPSS spreadsheet and transferred untarnished to an Excel™ spreadsheet as required by DEA-Solver™. This data was the basis for establishing DEA as a valid algorithm in the assessment of PM. The availability of the secondary data from the Black source was opportune because this thesis argues that PM commences on a foundation of CG, as the base of the performance pyramid described in the previous chapter. While Black used the data to establish a construct of corporate social responsiveness and a measure of corporate social responsiveness management capacity (CSRMC™) (Black 2004), the statistical support for her construct came from a tradition of hypothesis testing and factor analysis.

This study shows that a quantitative methodology through the operations research tool of DEA can provide support for a PM construct, known widely as productivity and axiomatic in the relationship between inputs and outputs. The computations are shown in Chapter 5.

3.8.3 Validating the DEA Model

Implicit in assessing the validity of OR models is the conclusion of where models are not suitable. The last section demonstrated choice of model, i.e. others against the chosen DEA linear programming model for this thesis. This section describes the validation for the DEA approach used in this thesis.

Validation criteria for all models can include descriptive, analytical and experimental validation (Gass and Harris 2001). Descriptive validation addresses the attainment of the model's objectives and the plausibility of the results, as well as the suitability of the model structure. Analytical validation again tests the plausibility of results but also their robustness and characteristics. Experimental validation assesses accuracy and efficiency of implementation, costs, data transfer and storage and methodological tests of model documentation.

These validations are done for DEA: in Chapter 4 for structural robustness, Chapter 5 for experimental application, and Chapter 6 for plausibility of results against indicators obtained elsewhere. Such a validation is in agreement with the Golany and Roll (1989) refinement which stipulates judgmental screening, non-DEA quantitative analysis, and a DEA based analysis. The judgmental analysis may be exercised *inter alia* along the following lines,

a) Is the factor related to, or contributing to, one or more of the objectives set for the application?

b) Is the factor conveying pertinent information not included in other factors?

c) Does the factor contain elements (e.g. price) which interfere with the notion of technical efficiency?

d) Are data on the factor readily available and generally reliable?

The non-DEA quantitative methods can include simple regression analysis to indicate the strength of factors in the relationship being investigated, as was done when comparing the DEA results against the regressions of Black (2004).

The DEA based analyses can test the discriminating power of different factors by grouping them in a series of combinations which identify the candidates eligible for elimination. This was done, and is explained in Chapter 5, where the factors were subjected to trials which would elicit the antecedent and consequence factors of corporate social responsiveness management capacity as defined by Black.

All the validations that have been conducted on the DEA model are described in its procedural application in Chapter 5.

3.9 Conclusion

This chapter has approached the task of applying a methodology to the research in this thesis. The methodology is traditionally supported, contemporarily based, but academically rare. It has shown a new approach to measuring performance in a novel conceptual setting. By using a model of the business environment in an optimization setting, it has expanded the virtues of adopting an operations research methodology which has substantive support of theory quantification through mathematical dogma. A number of operations research techniques were investigated to arrive at the mathematical programming model most suited to the task of this thesis. Linear programming through its particular specialization of DEA was chosen. DEA was judged as the most suitable means of measuring performance, as defined by the productivity paradigm, because of its strength of mathematical sophistication and the maturity demonstrated by its commercial availability, DEA was seen as the most adept at achieving the measurement requirements stipulated by this study. It is not incidental that its commercial availability, through 'user-friendly' spreadsheet applications software, has led to its choice for this particular investigation, and others of the same ilk. The development of DEA as the diagnostic tool, through its theoretical foundations to its technical robustness, is discussed in Chapter 4, and its validation testing and practical application for this thesis, as conducted for the CSR subset of CG, is reported in Chapter 5.

Chapter 4

DEA: Theory, Methods and Applications

Whenever you can, count.

Sir Francis Galton 1822-1911

4.1 Introduction

This chapter describes the mathematical foundations for performance expressed as an efficiency computation. The latter is based on the underlying relationship between inputs and outputs, and is often described as productivity. The chapter also shows an increasing use of the mathematical application known as DEA, that was developed initially as a measurement tool for application in organisations which do not have a profit-driven mission yet need to operate according to principles of business efficiency. The distinction of these organisations from the more conventional commercial ventures is not only the absence of profit-driven strategies but the explicit enunciation of other less tangible objectives, often conveyed in the corporate vision statement. The tenet of this thesis is that if performance can be sucessfully measured under the conditions of not-for-profit, how much better would such a measure be for those organisations that have the added luxury of financial and other tangible metrics.

The Total factor productivity considers all inputs and output's and presents a ratio allows an investigation of a multitude of combinations of these factors, as viewed from vantages which are often bounded by external constraints. To understand these different perspectives it is necessary to know how the factors interact and what are the key determinants of particular outcomes. This can be done by extrapolating from a basic model and incrementally changing the parameters. For example, there is much value in simplifying the decision variables to two dimensions so that the various outcomes can be visualized graphically.

While there are a number of strengths in mathematically based models such as DEA, there are also some weaknesses. It is necessary to address these and other issues which may compromise the model, before it can be applied in a non-tangible arena such as CG (in particular the aspect of CSR), which is significant in its tangible outcome of economic performance. This is done later in the chapter after a preliminary explanation of how DEA works.

4.2 The Basic Model

The first DEA model that successfully optimized each individual observation (the decision making unit), with the objective of calculating a discrete piecewise frontier was proposed by Charnes, Cooper and Rhodes (1978) and was based on the previous work of Farrell (1957), as mentioned earlier. To construct the 'efficient production function' Farrell commenced with an acknowledgement of the difficulty in achieving "a postulated standard of perfect efficiency (p. 255)" that represented the best theoretically attainable efficiency, and then proceeded to describe how an observed standard of efficiency could be achieved pragmatically and be sufficient in place of an unobtainable absolute. He illustrated technical and price efficiency, the basis for all later DEA models in a simple isoquant diagram, Figure 4.1, showing the factors of production needed to produce a single product i.e. output of one with input of two factors (under constant returns to scale, see 4.3.3).

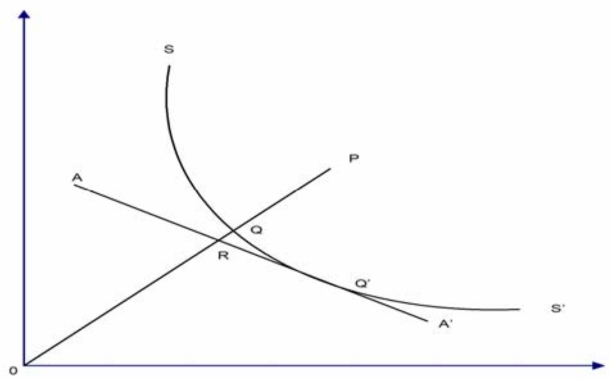


Figure 4.1 Farrell's Isoquant Diagram

In Figure 4.1, point P (2 input factors, 1 output unit) represents the values at which a firm is operating while the S-S[1] isoquant represents the various combinations of these factors that a perfectly efficient firm could use to produce unit output.

If Q is operating similar to P, but is fully efficient, it achieves equal output at the fraction of P which could be expressed as OQ/OP. Alternatively, it can produce OP/OQ times more output for the same input as P. 'Technical efficiency' (TE) of P is defined by this OQ/OP ratio. An efficiency issue this ratio generates is the question of what is the best proportion for inputs when their prices are included in the consideration. If in Figure 4.1 the A-A[1] slope represents the ratio of the input (production) factors, then Q^1 is the optimal production because while Q and Q^1 are equal in technical efficiency, the price of inputs at Q^1 are only $\frac{OR}{OQ}$ the fraction of Q. Farrell described this as 'price efficiency' (PE) but later it became better known as 'allocative efficiency' (AE). Re-visiting point P: if it were both technically and price efficient it would be at the OR/OP fraction of what it currently is. This is the optimal efficiency and Farrell called it 'overall efficiency' (OE), and is sometimes referred to as cost or economic efficiency. It is worth noting that this OE is the product of technical and price efficiency:

$$\frac{OQ}{OP} \times \frac{OR}{OQ} = \frac{OR}{OP} \tag{4.1}$$

Charnes et al. (1978) designed a model (known as the CCR Model) that:

> …generalized the single-output/input ratio measure of efficiency for a single DMU in terms of a fractional linear-programming formulation transforming the multiple output/input characterization of each DMU to that of a single "virtual" output and virtual input. (Charnes et al. 1994, p. 6)

They defined the efficiency of an arbitrary unit i as:

$$Efficiency \quad of \quad unit \quad i = \frac{\sum_{j=1}^{n_O} O_{ij} w_j}{\sum_{j=1}^{n_I} I_{ij} v_j} \tag{4.2}$$

Where: $Efficiency \ of \ unit \ i = \dfrac{Weighted \ \ sum \ of \ unit \ i's \ outputs}{Weighted \ \ sum \ of \ unit \ i's \ inputs}$

and: O_{ij} represents the value of unit i on output j;

I_{ij} represents the value of unit i on input j;

w_j is the non-negative weight assigned to output j;

v_j is the non-negative weight assigned to input j;

n_I is the number of input variables; and

n_O is the number of output variables.

A linear programming solution is iterated for each DMU in the sample, under a set of pre-defined constraints. One of these is the value of the weighting factors. In arriving at the solution, no unit is allowed to select weights that would cause that unit to obtain an efficiency greater than 100%. Thus, the weighted sum of the units' outputs must be less than or equal to the weighted sum of the units' inputs.

$$\sum_{j=1}^{n_O} O_{kj} w_j \leq \sum_{j=1}^{n_I} I_{kj} v_j \quad \text{for k=1 to n units} \tag{4.3}$$

Also, to prevent unbounded solutions we need the sum of the weighted inputs for each unit to equal one.

$$\sum_{j=1}^{n_I} I_{ij} v_j = 1 \tag{4.4}$$

Note that since DEA also assumes that for input variables 'less is better' and for output variables 'more is better', the variables chosen should conform to this logic[4].

The arbitrary unit for which the efficiency is calculated (DMU) is typically any productive entity that is chosen by the researcher contingent on which aspects of the output and input factors is of interest. Researchers sometimes refer to this unit as the 'firm' or other such descriptors but the DMU allows for the broadest application in all DEA models. This allows the researcher to investigate efficiency relationships beyond traditional views, an important feature noticeable in later and more recent research.

Needless to say, there are a number (usually many) of DMUs in the study cohort as it is implicit in the DEA technique that these are assessed and ranked relative to one another. The number of DMUs can be as few as 15 or 20 and as many as 10 000 (Beasley 1990), but is important because it impacts on the model's ability to discriminate between them. There are some rules of thumb to suggest the optimum quantity of DMUs (sample size), along with their input and output factors. The sample size should be greater than the sum of inputs times outputs. The sample size should also be equal to or greater than three times the sum of inputs and outputs. Finally, the one third rule states that the sample size is acceptable if the number of fully efficient DMUs is no greater than one third of the total number of DMUs in the sample (Cooper, Seiford and Tone 2006; Avkiran 2006; Ramanathan 2003).

Each DMU is characterized by output and input factors which are of differing importance to the best operational efficiency of the unit given that DEA automatically assigns weights to each factor to optimize the overall efficiency of the unit (in the CCR model). How weights are assigned and their importance has generated vigorous debate and is discussed later in Section 4.3.4.

If we return to Farrell's original diagram in Figure 4.2 we see the inclusion of data points for other DMUs and notice how they are 'enveloped' by the isoquant $S\text{-}S^1$ which is the efficiency frontier at which they aspire to operate. Hence, Charnes, Seiford and Tone's (1978) choice of DEA is an apt name for this approach.

---

[4] This has been addressed in the most recent models so that 'more is worse' can be an output factor. For example, pollution generated in a production process fits this reality.

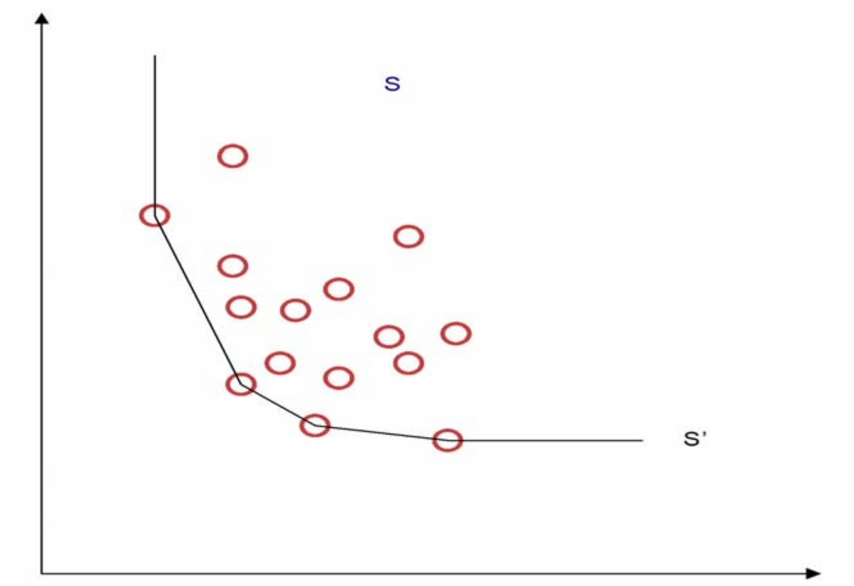


Figure 4.2 Data Enveloped by the Efficiency Frontier

To develop the DEA model from basics but beyond the simple efficiency comparisons of Farrell's ratios of single output and input measures we start with examples of the analysis provided when multiple outputs and inputs exist. These are limited to multiples of two to illustrate the concept graphically. Section 4.2.1 develops DEA for one output and two inputs, while Section 4.2.2 develops the model for two outputs and one input.

4.2.1 DEA for One Output and Two Inputs

The following example based on a common application of DEA to banks, illustrates the relative performances of DMUs given a single output and multiple (two) inputs.

Here:

Efficiency of DMU = Output/Two Input (4.5)

Consider the performance of 6 bank branches (A-F), which each have the following inputs and output: number of employees x_1 (direct customer contact), customer service space x_2 (floor space in $10m^2$), and output of revenue y_1 (units \$100 000). The original data would show a variety of values reflecting different configurations of these factors for number of employees x_1 (which provides the resource of direct customer contact), and service space x_2 (which provides the floor space available to customers for all branches).

To start computation it is necessary to establish a baseline against which comparisons can be made. The inputs can be adjusted pro rata to a unitized output value of 1 for the y_1 revenue. These values are now presented in Table 4.1 below.

Table 4.1 Two Inputs and One Output

Branch		**A**	**B**	**C**	**D**	**E**	**F**
Employees	x_1	4	7	8	4	2	6
Service Space	x_2	3	3	1	2	4	2
Revenue	y_1	1	1	1	1	1	1

The values in Table 4.1 can be plotted on the following graph (Figure 4.3) with the x axis representing the x_1/y_1 (employee/revenue) scale and x_2/y_1 (service area/revenue) on the y axis.

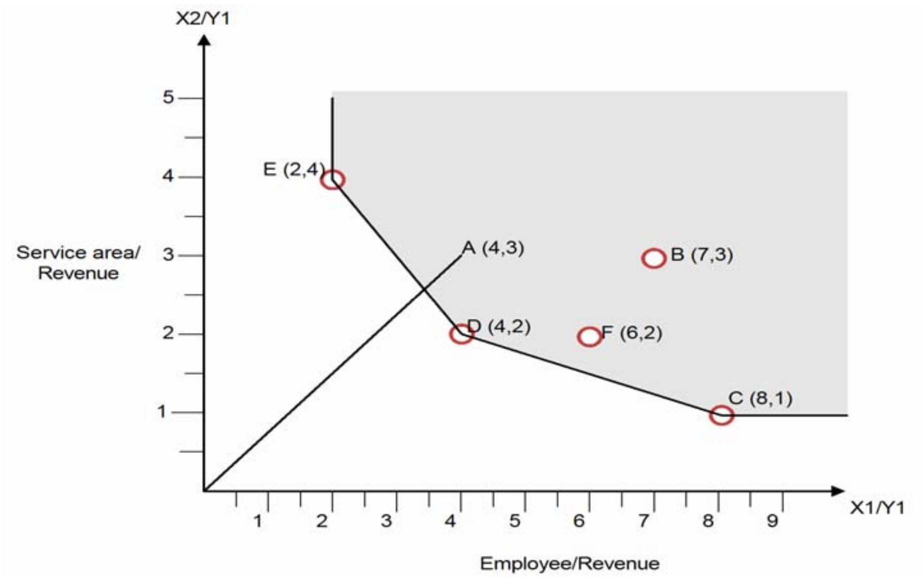


Figure 4.3 Efficiency Frontier for Six DMUs with One Output and Two Inputs

We note on the graph that branches C, D and E use less inputs, albeit in differing arrangements of the variables, to get 1 unit of revenue. They thus form the *efficiency frontier*. If we 'envelop' all the data within the region delineated by this frontier we are defining the area where operations are feasible. This is called the *piecewise linear* production possibility and is shaded on the graph. Those branches operating in this area and not on the frontier are inefficient by this criteria. Branch A (in Figure 4.4) for example, is inefficient to the extent that it needs to move to A^1 to become efficient. By projecting a ray from the origin 0 through A^1 to A we can obtain A's efficiency as: $0A^1/0A = 0.86$, or 86%. Similar calculations will show the efficiencies of other non-efficient branches. While a move to A^1 will make A an efficient Branch, it is also possible to become efficient by moving to any point on the frontier, to A^2 or A^3 for example. The values for A^1, A^2 and A^3 as represented by the x_1/y_1, x_2/y_1 coordinates, which are (3.4, 2.6), (4,2) and (3,3), respectively.

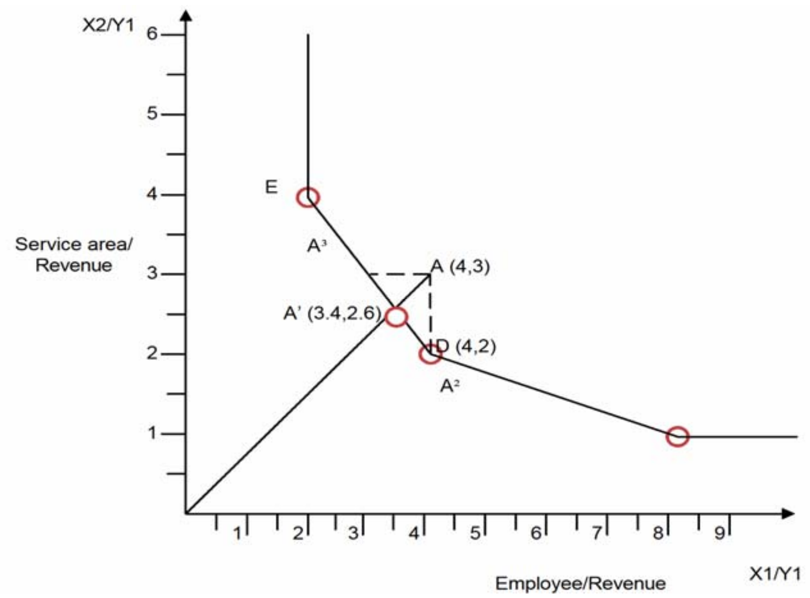


Figure 4.4 Efficiency Improvement possible for one DMU

In its current inefficient state, Branch A uses inputs of 4 employees in 3 service area units. It can become efficient by maintaining revenue output with 4 employees but reducing service area to 2 units, the same as Branch D or reducing to 3 the employees and maintaining 3 service area units, as shown by A^3. Both these strategies achieve efficient outcomes but at greater effort than moving to the frontier point A^1 which only requires a reduction in staff to 3.4 and a reduction in service area to 2.6. That is, moving from (4,3) to (3.4, 2.6) is less distance than moving to D(4,2) or A^3(3,3), thus providing a technically better option. Graphically this lesser effort is shown by the shorter distance needed to arrive at the efficient frontier.

4.2.2 DEA for Two Outputs and One Input

Consider 7 DMUs (for example, 7 corporate banking regions represented by the 7 Australian states, labeled as A, B, C, D, E, F and G) that have varying levels of achievement (outputs) on 2 different CG criteria, say employee satisfaction y_1 and community reputation y_2 where each banking region tries to maximize achievement on each criterion. All state branches are subject to the same organisational policies, procedures and mechanisms implemented as part of the corporate strategy. Corporate governance is the input. (There would most likely be other CG factors for inclusion, but as these would preclude a graphical visualization, they are discussed later in the thesis.) Data for this example is presented in Table 4.2.

Table 4.2 Two Outputs and One Input Data

STATES	**A**	**B**	**C**	**D**	**E**	**F**	**G**
CG CG (Input)	1	1	1	1	1	1	1
Employee Satisfaction (Output y_1)	2	3	4	2	2	1	2
Community Reputation (Output y_2)	4	3	1	3	2	2	1

Here:

Efficiency of DMU=Two Output/One Input …………………(4.6)

In Figure 4.5 we provide a 2-dimensional representation, of how each of the states (A-G) performs on the y_1 and y_2 criteria by the coordinates reflecting the scores for these categories. For example, A may represent the Victorian region which achieves a score of 2,4. Note that 4 is the highest score achievable on this y_2 parameter for all states and a score of 4 is also the highest value on the other y_1 parameter (axis), but for a different State C. This reflects the comparative nature of DEA where relative rather than absolute values are displayed. In this situation these are the highest scores and may be regarded as the best in the comparison even though higher scores may be theoretically possible. The goal in this exercise is to find the state/s with the Pareto[5] optimal combination of the two outputs and one input factors that display the highest scores on the (y_1,y_2) output criteria, and then to compare the other states' performances against this benchmark.

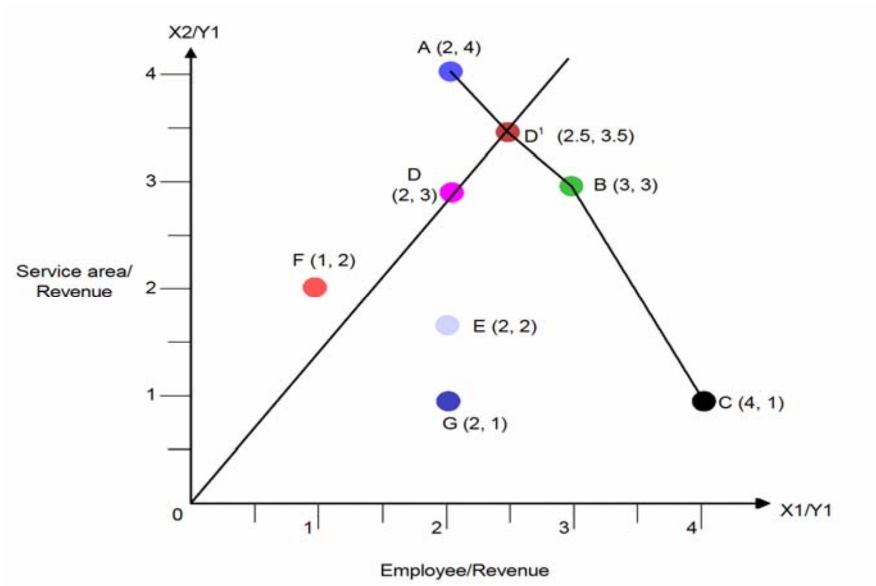


Figure 4.5 Efficiency Frontier for Seven DMUs with Two Outputs and One Input

The DEA efficiency (production) frontier delineated by the A-B-C boundary shows that these states are Pareto optimal for the various combinations of the 2 decision criteria, while the others are not. For an illustration of this optimality, A has a score of 2 and 4 for y_1 and y_2 respectively and no other state can achieve a better score on one of the criteria without the expense of lessening the value of its other criterion. For example, if C wishes to improve its performance on y_2 (to raise it from a value of 1 to 2 within the assumed data envelope), it will do so at the expense of y_1 dropping in value from 4 to 3.5. A similar analysis will reveal the same compromise for the others under Pareto optimal conditions. However, D is Pareto suboptimal from the outset as indicated by its distance from the efficiency frontier segment AB.

[5] Pareto optimality is a measure of efficiency from game theory where each player's outcome is optimal with at least one player better, and the outcomes cannot be improved without at least one player becoming worse off.

D could achieve optimality by mimicking A's values (2,4) or B's values (3,3) but the movement to these positions requires more effort than to achieve optimality by moving to D^1 which is at the intersect of the extrapolation of OD and the segment AB. Measuring this vector shows that D is located at $5/6^{th}$ of the distance from 0 to D^1 (through the vector equation of 2,4 for A and 3,3 for B). Alternatively, it can be surmised that D is operating at 83.3% ($5/6^{th}$) of its Pareto optimal performance suggesting a scope for improvement of 16.7% on these CG criteria. Furthermore, the extrapolation shows that D would attain 100% efficiency at y_1y_2 values of 2.5 and 3.5 pointing the way for an improvement strategy.

There is no difference in the strategy for both examples in sections 4.2.1 and 4.2.2, of achieving efficiency by movement to the production frontier, simply a difference in direction. While the first example shows that efficiency can be obtained by movement toward the origin on the graph, the second example shows that a movement away from the origin achieves the same objective. These objectives reflect the type of improvement imperative and are referred to as *technical* and *allocative efficiency,* as discussed earlier.

The calculations illustrated thus far and the Pareto optimal endpoints for each of the DMUs are not known *a priori* and would not be evident until all the linear programming computations conducted by the DEA algorithm are completed. The DEA formulation itself assigns weights in the computation of the Pareto optimal reference points (by solving vector equations as shown earlier) and reveals the optimal surface which houses the most efficient DMUs. The assigning of weights is also discussed later in Section 4.3.4.

The result of a typical DEA computation is multi-dimensional, representing the multiple inputs and outputs that have been analysed, not the two dimensions as illustrated in these graphical examples. The full DEA matrix can only be shown in a tabular form, as presented in the spreadsheet output of various computer programs, and while it is not possible to visualize the output in a graphical form, it nonetheless presents an ability to make countless comparisons.

4.3 Extensions to the Base Model

4.3.1 Technical and Allocative Efficiencies: Input and Output Orientations

One important reason for doing a DEA study is to find inefficient DMUs so that they can be projected onto the *efficient frontier.* Fully efficient DMUs all lie on this *frontier* so all others are inefficient. The amount by which these are inefficient is represented by their distance from the frontier. To reach the frontier, movement must be origin-seeking, i.e. input focused, or origin-leaving, i.e. output focused. Both distances can be computed. If a DMU is closer to the origin, and needs to travel outwards to achieve efficiency, it is seeking to better use existing resources. More output can be achieved from the same inputs so that this *technical efficiency* represents a score of under-achievement. For example, a technical efficiency of 80% suggests that 20% more output is possible from the existing inputs.

When the output quantities are acceptable and need to be maintained, the inefficiency displayed by a DMU is interpreted as the achievement of this output at a cost of inputs higher than efficient DMUs. *Allocative (price) efficiency* therefore shows how much reduction in inputs is necessary for the DMU to become efficient. For example, an allocative efficiency of 70% suggests that inputs can be reduced by 30% for the DMU to achieve full efficiency compared to other DMUs. This ‘price efficiency’ usually shows how the DMU falls short of achieving efficiency due to a failure to make input substitutions or reallocations, in other words, to find better priced equivalent alternatives. The third efficiency (after technical and allocative efficiencies) is the overall efficiency discussed earlier.

These examples have all measured efficiency along the ray from the origin to the data point of the DMU. In doing so, the measures along the ray maintain proportionality depending on their position along that ray. This occurs because the origin of all rays is fixed at the intersect of the two axes. These *radial* efficiency measures have a significant advantage; the measures are *units invariant*. That is, the changing of measurement units does not change the value of the efficiency metric. This is in contrast to the difficulty experienced when a *non-radial* measure is chosen, as when the shortest distance from the DMU to the production surface is sought, and is not origin directed.

There are three possible directions that can occur in achieving the efficiencies mentioned; inwardly focused, outwardly focused or both, reflecting the goals of reducing inputs to achieve the same outputs, achieving more outputs from given inputs, or doing both.

The *input-oriented (IO)* projection as shown in Figure 4.6, aims to reduce the amounts of the inputs by the ratio QP/OP to achieve technical efficiency. The allocative efficiency is shown by the ratio OR/OQ. This was illustrated in the first example (Section 4.2.1) where revenues were to be maintained and resources curtailed. The IO notation usually follows the name of the DEA model used to indicate this orientation. For example, the model that was widely applied in early studies was the CCR-IO.

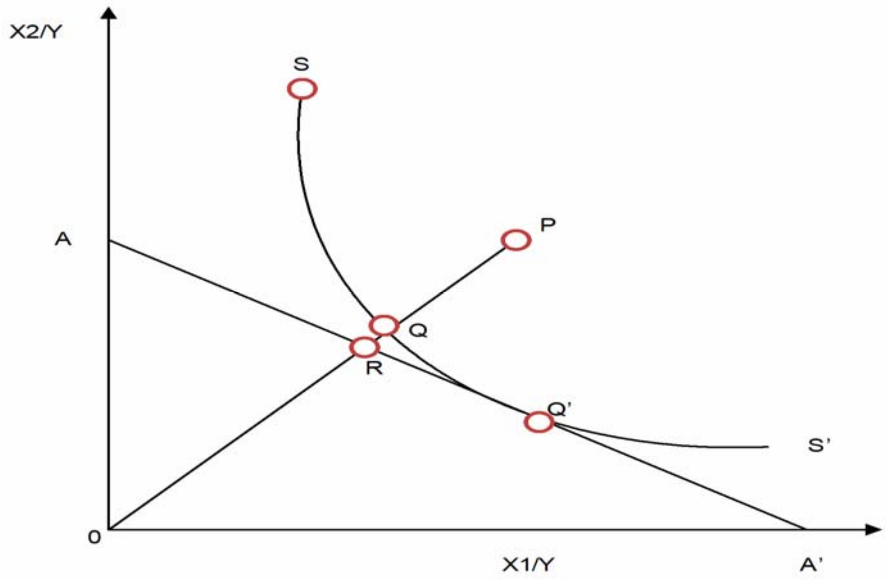


Figure 4.6

Technical and Allocative Efficiency for Input Orientation

The *output-oriented (OO)* projection is shown in Figure 4.7. The aim is to maximize output levels under conditions where the input consumption remains constant. A is the inefficient DMU because it lies below the efficient frontier so the distance AB represents technical inefficiency while TE is shown as OA/OB. Allocative efficiency is OB/OC. The second example (Section 4.2.2) illustrated this type.Note that the OO notation after the model name is used to indicate this orientation.

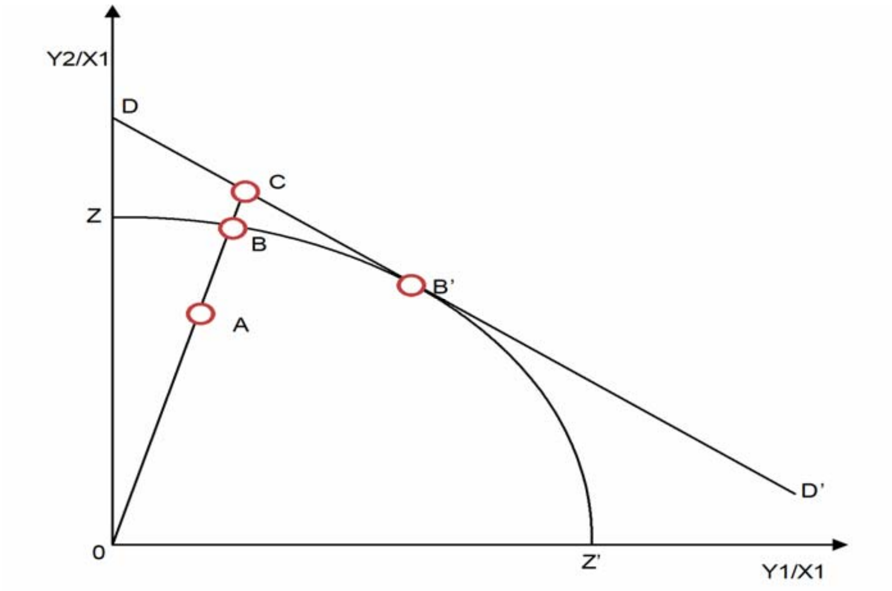


Figure 4.7 Technical and Allocative Efficiency for Output Orientation

The third possible strategy is to attempt to achieve the *input-oriented* and *output-oriented* objectives simultaneously. That is, try to address input excesses and curb these while at the same time trying to obtain more output; minimize inputs and maximize outputs. This is represented by the additive (AM)[6] and slack-based (SBM)[7] models. The slack-based measure of efficiency addresses the output shortfalls and input excesses by using the additive model to give invariant scalar measures (ranging from 0 to 1) to encompass all the inefficiencies that can be identified. Slack is discussed in Section 4.3.2.

When the main purpose of the DEA is the computation of general efficiency levels rather than an analysis of the DMU factors responsible for those performances these orientations will all produce the same results. Furthermore, input and output-oriented measures are equivalent only when constant returns to scale exist (which is the only scale assumed for the models discussed so far).

[6] The additive model (Charnes et al. 1985) extends the basic CCR model to take into account Pareto-Koopmans efficiency which states that a DMU is fully efficient only if it is not possible to improve any input or output at the expense of some other.

[7] Slack-based measures augment the additive model to make measures 'invariant', i.e. dimension-free, so that the unit of measurement becomes a single scalar.

4.3.2 Slack

Those DMUs that are efficient allow us to empirically estimate the efficiency frontier and to approximate it piecewise linearly. By definition these DMUs are 100% efficient and conversely those not on this frontier are inefficient. *Slack* is the amount of inefficiency exhibited by these non-efficient DMUs and may be a consequence of poor performance of inputs, outputs or both. If inputs are being used ineffectively, then we have *input slack,* and conversely we can have *output slack.*

Figure 4.8 below shows two efficient DMUs, namely C and D, and two inefficient ones in A and B. The technical efficiency of A could be improved by moving to A^1.

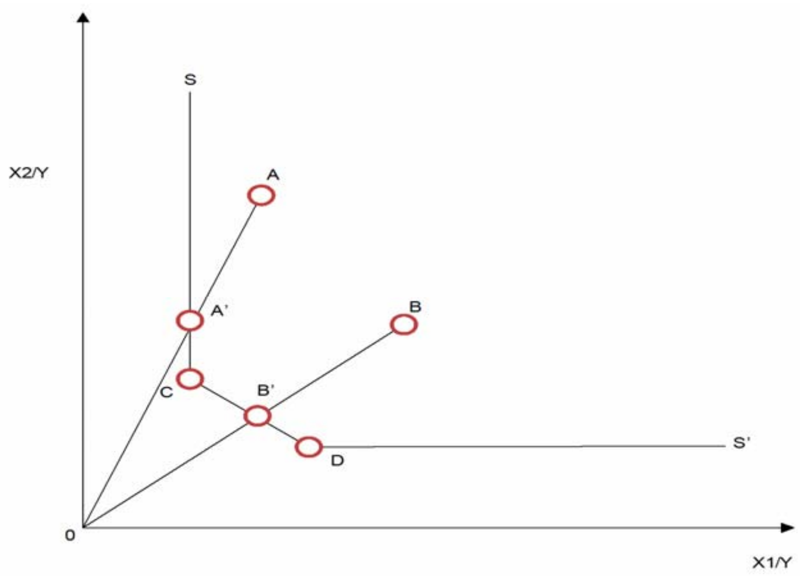


Figure 4.8 Slack

The efficiency of A is expressed by the ratio A^1O/AO so the slack is a value obtained from the $(1-A^1O/AO)$ subtraction. Since A needs to move to A^1 on the graph, its ratio of inputs and outputs must be altered to achieve this, but alternatives exist. These are shown in Figure 4.9 below, where a may achieve efficiency by moving only toward the vertical (x_2/y) axis, alternative 1, or toward the horizontal (x_1/y) axis, alternative 2. In these cases the slack values will differ, and their acceptability will depend on the optimizing strategy chosen.

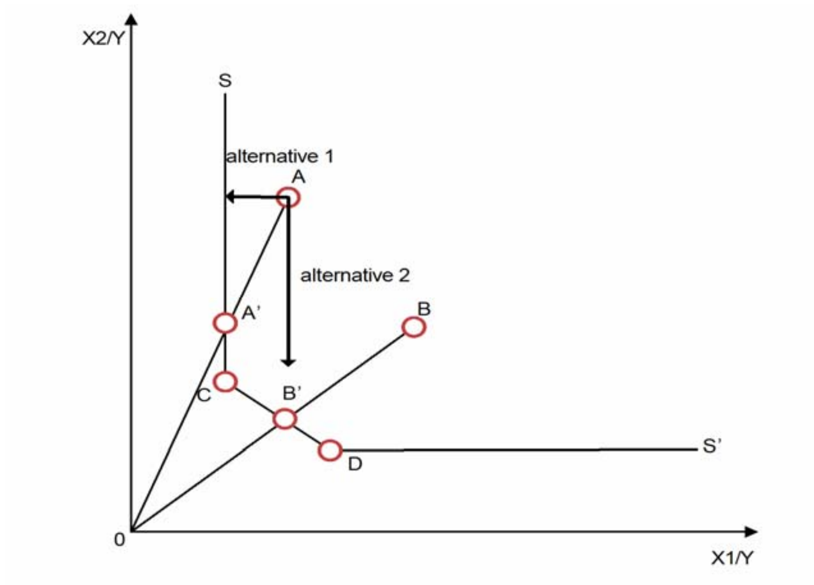


Figure 4.9 Slack Identification of Improvement Potential

4.3.3 Returns to Scale

The *returns to scale (RTS)* concept represents the relationship between inputs and outputs when one or the other is changed. It primarily refers to increasing or decreasing efficiencies based on size of change. In economics this is called 'elasticity'.

The possibilities for efficiency are the following.

- A change in input or output results in a directly proportional change in the other. For example, a doubling of labour hours worked results in a doubling of output. This is a *constant RTS* and often abbreviated *CRS.*
- An increase in inputs may result in an increase in outputs in greater proportion than the input increase. This is known as an *increasing RTS,* or *IRS.*
- An increase in inputs may lead to a proportionally lower increase in output. For example, a doubling of miners in the mine results in less than double

output because of congestion at the workplace. This is known as *decreasing RTS* or *DRS.*

The RTS properties that an organisation possesses may reflect the nature of the industry, the size of the company, its mode of operation, and a variety of other attributes which constrain efficiency-seeking strategies. The CRS assumption for example, is only appropriate when firms are operating at optimal scale with no imperfect competition, no constraints on supplies, labour or finance, etc. If constraints do exist, then a *variable RTS* DEA model that Banker, Charnes and Cooper (1984) (BCC) developed after the CCR model avoids the difficulties of scale efficiency and confounding measures that could otherwise arise. It is no wonder the *VRS* model was the most commonly used during the 1990s.

A classification of the models that assume a piecewise linear envelopment surface, as presented by RTS and I-O orientations can be represented diagrammatically as follows in Figure 4.10.

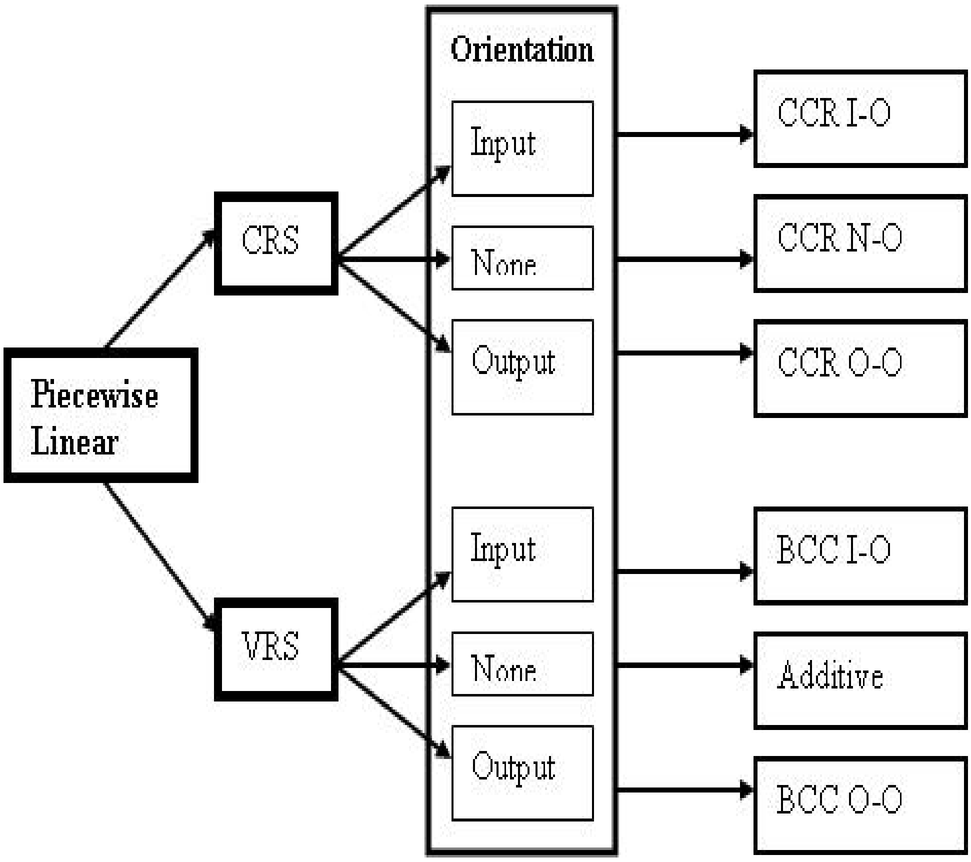


Figure 4.10 Models that Assume a Piecewise Linear Envelopment Surface

4.3.4 Weighting the DMUs

How much of the efficiency rating of a DMU is due to the data and how much is due to the weights? The typical DEA model (CCR) uses variable weights derived directly from the data. Apart from obviating the need to set weights *a priori,* this allows DEA to choose weights so that the optimum outcome is possible for each DMU. This means that the input:output ratio is maximized relative to other DMUs under the conditions: that all data and weights are non-negative: the values lie between zero and unity: and the same weights are applied to all. To illustrate the process we use the widely applied input-oriented CRS model.

For the i^{th} DMU in a population of *n:*

$$\text{Efficiency DMU}_i = wO_i/vI_i \qquad (4.7)$$

where: O_i is the output for the DMU, and w a vector of output weights; and

I_i is the input for the DMU, and v a vector of input weights.

The optimal weights are obtained by solving the problem:

$$\begin{aligned} &\max_{wv}(wO_i/vI_i) \\ \text{s.t.} \quad & wO_i/vI_i \leq 1 \\ & w,\ v \geq 1 \end{aligned} \tag{4.8}$$

To avoid an infinite number of solutions a further constraint $vI_i = 1$ can be imposed. This leads to a different linear programming problem (known as the *multiplier* form):

$$\begin{aligned} &\max_{wv}(wO_{i)} \\ \text{s.t.} \quad & vI_i = 1 \\ & wO_i - vI_i \leq 0 \\ & w.v \geq 0 \end{aligned} \tag{4.9}$$

Thus the efficiency measure for the i^{th} DMU is maximized subject to the constraints that all efficiency measures must be less than or equal to one.

4.3.5 Setting the DMU weights

A major stream of DEA literature revolves around concerns about allowing the basic CCR model to assign the weights to input/output data. Since the model is knowledge-free of the actual transformation processes, it is claimed that it may underestimate the relative efficiency of some DMUs and possibly even reduce the feasible solution space (Tracy and Chen 2005). While this feature may be an advantage in situations where there is no managerial process knowledge or judgment available, the reality is that some process knowledge is the norm rather than the exception. The exclusion of this information could significantly disadvantage the results. Consequently studies have partly addressed this problem by adding to the blend of models that allow for weight restrictions. The Greenberg and Nunamaker (1987) transformation for example allows for the articulation of those indicators that managers think constitute good performance or are considered to have a greater impact on performance by accepting surrogate factors expressed in a quantified form. In other words enumerated rankings reflecting the importance of subjectively rated factors are allowed.

This is important because:

> Ignoring the interrelationships among performance measures and limitations on their possible combination may result in specification of weights vastly different from those which would have been specified had these aspects been considered. (Greenberg and Nunameker 1987, p. 333)

Although this flaw has been evident for some time, the application of modified models remains relatively unrealized. Tracy and Chen (2005) propose a parametric DEA (PDEA) which addresses this problem with a 'generalized linear weight restriction'. They design a weight restriction in the form:

$$\Omega = \{(u,v) : \alpha \leq a^{T}u + b^{T}v \leq \beta\} \quad (4.10)$$

where a and b are vectors (T) of appropriate dimensions and α and β are scalars. The restriction above is of a general form which can be divided into two categories:

> Type 1 constraints are those where the input weights are not related to the output weights (u,v separable). Type 2 constraints are those where the input and output weights are related (u,v linked). (p. 391)

Type 1 are presented in the form:

$$a^{T}u \leq \alpha, \quad b^{T}v \leq \beta \quad (4.11)$$

Type 2 constraints are typically:

$$au_r \geq bv_l \quad (4.12)$$

They maintain however, that as weight restrictions can contribute to significant problems in DEA formulation further research is warranted. Alternatively, other mathematical techniques not specifically designed to overcome DEA difficulties may be tested in this situation. The analytical hierarchy process (AHP) (Zahir 2006) is possibly one way of quantifying the Greenberg and Nunamaker (1987) transformation and validating its application, while a broader approach could be to use uncertainty principles from the physical sciences (Palmer and Parker 2001). Ragsdale (2004), a mathematician rather than a proponent of DEA *per se,* recommends AHP for "the decision maker who finds it hard to subjectively determine the criterion scores and weights needed in the multicriteria scoring model" (p 809), and while it primarily targets the criteria scores it can apply exactly the same structured approach to determining criteria weights.

The AHP approach has the following steps:

1) create a pairwise comparison matrix for each of the alternative weight values on a scale of 1 to 9 (1 = equally preferred, 5 = strongly preferred, 9 = extremely preferred);

2) normalize comparisons;

3) check for consistency using; Consistency Index (CI) and Consistency Ratio (CR);

4) repeat for each of the alternative weights; and

5) calculate the weighted average scores for the alternatives and select the best.

This thesis acknowledges the importance of weight restrictions in the determination of relative efficiencies. However, it is prepared to take the conservative stance that comes from the DEA algorithm assigning DMU weights because the computational output is claimed to present a conservative 'worse case scenario' which adds robustness to the results.

4.4 DEA: Assumptions, Strengths and Limitations

The unique feature of DEA is that it has a reported usefulness in cases where other tools have failed because of the complexity and often unknown nature of the relationship between multiple input and output variables. In fact this robustness is demonstrated in the ability of DEA to use data of imperfect knowledge to the extent that such data may be expressed in ordinal relations such as 'more than' or 'less than' for some DMUs and more conventional tangible data for others. The levels of measurement, i.e. nominal, ordinal interval and ratio for DMUs, may differ but the ability to include them in the data set ensures that the efficiency calculation for each DMU occurs with the contributions of all factors weighted according to their individual influence.

> DEA was designed to measure the relative efficiency where market prices are not available [but] by its ability to model multiple-input and multiple-output relationships without a priori underlying functional form assumption, DEA has also been widely applied to other areas. (Zhu 2003, p 4)

4.4.1 Assumptions and Precautions of DEA

The fundamental assumption underlying DEA is that as an 'extreme point' method if one DMU is capable of achieving 100% efficiency through the correct ratio of output and input factors optimally weighted, then other inefficient DMUs should be capable of doing the same if they operate efficiently. Implicit in this assumption is that the inputs and outputs are homogeneous, when in fact there may be differing amounts of heterogeneity not in only the factors of the DMUs but within the DMUs themselves.

Other considerations that warrant attention when applying DEA include the following.

- The exclusion or poor selection of input and output data, by design or omission, may produce a bias in the results.
- Measurement error in the data can produce biased results.
- Extraneous environmental (e.g. regulatory or physical) factors may impact on operational performances of different DMUs.
- Efficiencies of DMUs are cohort dependent and could be quite different if the wider population were included.
- The DEA computation does not necessarily account for operational decisions regarding management's risk aversion or longitudinal optimization strategies.

4.4.2 Strengths and Advantages of DEA

DEA is a powerful non-parametric tool for analyzing efficiencies of DMUs in the same cohort by allowing direct peer and peer to grouped-peers comparisons, on the basis of a multitude of input and output factors through a now diverse range of models.

An *a priori* knowledge or assignment of weights is not necessary (although sometimes preferable) for the model as results are still legitimate, albeit arguably conservative. This may be particularly valuable when inputs and outputs are of different measurement units.

There is no need to make assumptions about the functional form of the inputs or outputs and their relational analysis provides different perspectives of efficiency (TE, AE and EE), revealing opportunities for improvement.

Charnes et al. (1994, p. 8) provide twelve strengths of DEA as listed below.

1) The focus is on individual DMUs in contrast to population averages.
2) Each DMU has a single aggregate measure for the utilization of input factors (independent variables) to produce desired outputs (dependent variables).
3) DEA can simultaneously utilize multiple outputs and multiple inputs with each being stated in different units of measurement.
4) Adjustments can be made for extraneous variables.
5) Categorical (dummy) variables can be included.
6) Computations are value-free and do not require specification or knowledge of *a priori* weights of prices for the inputs or outputs.
7) There is no restriction on the functional form of the production relationship.
8) DEA can accommodate judgment when desired.
9) DEA can produce specific estimates for desired changes in inputs and/or outputs for projecting DMUs below the efficient frontier onto the efficient frontier.

10) Results are Pareto optimal.

11) Focus is on revealed best-practice frontiers rather than on central-tendency properties of frontiers.

12) It satisfies strict equity criteria in the relative evaluation of each DMU.

4.4.3 Weaknesses and Limitations of DEA

The non-parametric nature of DEA means it does not allow the application of inferential statistics and traditional mechanisms such as hypothesis testing, etc. As an extreme point technique it can be significantly influenced by outliers and is susceptible to the ‘noise’ (even symmetrical noise with zero mean) such as measurement error. DEA is good at estimating relative efficiencies but poor with absolute values. It converges slowly to ’absolute efficiency’ not allowing a comparison to the ‘theoretical maximum’ and DEA requires that each DMU has a separate linear programming formulation, thus resulting in many LP iterations. For large problems with many DMUs this can be computationally intensive and demanding, and sometimes beyond the capabilities of some programs. Another concern is the lack of definitive operational parameters. While there are rules-of-thumb that give guidance to the application of DEA there appears to be a lack of a definitive boundary.

For example, Cooper, Seiford and Tone (2000) say that:

> If the number of DMUs (n) is less than the combined number of inputs plus outputs (m+s), a large portion of the DMUs will be identified as efficient and efficiency discrimination among DMUs is lost. (p. 103)

Their answer is ‘trial and error’. Try a small set of input and output items and gradually increase the number, observing the effects. While these weaknesses and limitations may be inimical to the successful application of DEA, it should be noted that an understanding of their threat and possible impact also means that they can be ameliorated for the betterment of the investigation. There is also the option of overcoming some weaknesses by applying DEA in concert with other optimization techniques.

4.5 Other Models and Issues

4.5.1 Other Models

DEA can be regarded as a body of concepts and methodologies that has evolved since the seminal work of Charnes, Cooper and Rhodes (1978). The CCR ratio model has been the focus of this dissertation to highlight the fundamental mechanisms that have propelled the application of DEA. It has yielded objective evaluations of efficiencies and thus inefficiencies of decision making units. By revealing the inadequacies of the non-performing units it provides a path for improvement. The flaw in the original model however, was the assumption that movements (toward efficiency) were at constant returns to scale. The CCR yields a piecewise linear constant RTS surface. CCR type models, under radial efficiency, do not take into account input excesses and output shortfalls, i.e. non-zero slacks. The slacks-based measure (SMB) addressed this by using the additive model "to give scalar measures from 0 to 1 that identify all of the inefficiencies that the model can identify" (Cooper, Seiford and Tone 2006, p. 104).

The Banker-Charnes-Cooper (BCC) model (1984) distinguished between technical and scale inefficiencies. It estimated TE at given scales of operations by evaluating the benefits of using decreasing, increasing or constant returns-to-scale to enhance efficiency. The BCC yields a piecewise linear variable RTS envelopment surface.

The multiplicative models use piecewise log-linear or piecewise Cobb-Douglas envelopment instead of the traditional linear piecewise surface.

The additive and extended additive model relates to the CCR model but incorporates Pareto's economic concept and Koopman's earlier work.

An evolution of the DEA concept and methodologies in the first 15 years of this approach is detailed in Charnes et al. (1994, p.12), with other authors mentioned earlier (Emrouznejad and Thanassoulis 2005; DEAzone 2005) adding to this list in later years.

4.5.2 Other Issues

The body of knowledge surrounding DEA and its applications is growing steadily and becoming diverse. It is not expected that this paper can fully explore all the issues but some additional commentary may give a perspective of DEA's applicability. The earlier models were implicit in the notion that more outputs and less inputs were positive achievements, and consequently were designed around this axiom with no provision for alternatives. In recent times the focus on operational efficiencies has broadened to include the impact of these efficiencies beyond the organisation. For example, increased productive output may be seen positively by stockholders, economists, and government and company staff, yet be frowned upon by the community. Increased output may mean increased waste, pollution or environmental damage consequent opun acheiving the perceived affordability of a decrease in the purchase cost per unit. Traditional DEA models could not accommodate such negative outputs. Consequently, strategies such as loading the inputs or inversing outputs to become inputs, e.g. pollution becomes an input cost to compensate, were adopted. Undesirable inputs/outputs in variable returns to scale (VRS) envelopment models have now been developed (Zhu 2003).

DEA purposely identifies the best-practice frontier and performance is measured against this. It is usual to have more than one DMU on the efficient frontier. If all the efficient DMUs define the frontier and occupy different positions on it, which is the best of the efficient DMUs? Fortunately a way of ranking efficient DMUs through a context-dependent analysis allows a form of first tier, second tier and so on, elimination until the 'best of the best' is left.

Congestion in economics refers to situations where reductions in inputs can actually increase outputs. For example, an oversupply of fertilizer may actually reduce output. The VRS model can be re-written to account for this and to include the impact of (input) slack on (input) congestion.

Supply chain efficiencies, in particular those value-adding processes that are available through an analysis of the total supply chain, have been elusive due to the existence of multiple and different measures that members of the chain use, and the adversarial nature of contractual negotiations. Zhu (2003) contends that traditional DEA fails to correctly characterize the performance of the supply chain because the efficient performance of individual components of the chain may not be correctly identified. He presents models that can address this.

Non-discretionary inputs and outputs are those situations where exogenously fixed or non-management-controlled environments impact on possible efficiencies of the DMUs. Traditional DEA models assume that all inputs and outputs can be varied at the discretion of management or others, but 'non-discretionary variables' not subject to management control may be significant enough to be included in consideration. These variables may be as diverse as weather conditions for flying aircraft, the demographics of a regional customer bases, the age of storage facilities, etc. A mathematical treatment of the data to minimize the influence of non-discretionary input excesses or output slacks is possible and has been formulated for CCR and BCC models (Charnes et al. 1994).

4.6 Conclusion

This chapter has demonstrated that DEA is founded on a statistical base which defines productivity as a measure of efficiency represented by the ratio of inputs to outputs. The history and development of DEA shows a strong grounding in the study of the efficiencies represented by these ratios, in organisations which are traditionally not regarded as profit driven commercial enterprises and so a limited choice of suitable PM processes. The commercial organisations on the other hand, through their profit motivated missions, have had a plethora of PM instruments at their disposal.

Nevertheless, the growth in DEA has demonstrated its acceptance as not only an effective diagnostic tool for non-commercial organizations, but more recently as a valuable addition to measuring efficiencies and efficiency-like relationships in a variety of commercial environments.

The production or efficiency frontier displayed by DEA, in so far as it can be displayed in simple two-dimensional graphical models, shows that there are conditions where the achievable efficiencies under existing conditions are as good as can be expected, while maintaining a Pareto optimality.

Technical and allocative efficiencies with input and output orientations show how efficiencies are calculated, and subsequently how inefficiencies can be improved in non-performing units.

The weighting of factors and its significance was discussed, together with suggestions as to how this could be addressed in the future. It was also highlighted that this study would not pursue the course of formulating a strategy for calculating weights since the DEA algorithm's assignment of values for these weightings provides a solution that is regarded as conservative.

DEA is not without weaknesses. These were delineated with suggestions that could help ameliorate the difficulties they present. Alternatively the strengths of DEA were highlighted to show why such an optimization technique is appropriate and ideal for any analysis of efficiencies which represent performance. And, while DEA is not the only model that is capable of these revelations, it is one that is finding support in areas as diverse as SCM and CG.

Finally, the DEA application is linked to the study of CG through one of its dimensions – that of CSR. The CSR study is presented in the next chapter, along with how it was applied using the successful procedural steps advanced by Golany and Roll in 1989.

Chapter 5

DEA of Corporate Governance: The Model and its Application

Thus, the task is not so much to see what no one has yet seen, but to think what nobody has yet thought, about that which everybody sees.

Edwin Schrodinger 1887-1961

5.1 Introduction

This chapter shows how the DEA model can be applied to that facet of CG known as CSR through the application of specialized proprietary software used to circumvent arduous in-depth mathematical computations. The initial discussion focuses on CSR as a pillar of CG through the stance of ethics and morality in business. The model that is adopted for CSR is that the company-wide capability for people, processes, and resources to meet its social obligations to all stakeholders, can be judged as a measure of corporate citizenship. CSRMC™ (Black 2004) is the framework on which DEA is tested as a suitable instrument for measuring CSR. This is the 'DEACSR' model unique to this thesis. A series of tests are conducted using the DEA-Solver LV program (Cooper, Seiford and Tone 2006) to assess its suitability, and once its applicability is justified the final trials are conducted with the professional program DEA-Solver Pro 4.1 (Appendix 2b). The data used in the final trials are the sanitized scores of the empirical results from the full cohort of an Australian bank study. The final results are presented for analysis and discussion in Chapter 6.

CG is a topical subject about organisational stewardship that is vigorously debated in current academic, business and government forums (Thomsen 2004). Its wide jurisdiction covering the institutions, laws, rules, policies and procedures governing the operations and running of the company, allows it to be analysed and discussed from numerous vantages.

CG is also multi-faceted thus allowing it to be studied at different strata and with restricted foci. It is much touted to underpin organisational competitiveness (Young 2003; Williamson 1988) and success, yet its dialogues are legal, financial, economic or social, and discussions are usually limited to these singular perspectives. And, while these dimensions are all contributors to corporate performance, not one of them alone is influential enough to be a significant gauge of corporate effectiveness, yet each has often been studied and promoted as if it were. It is intuitively attractive to regard each of these as indicators of particular aspects of a multi-factorial CG matrix where each factor is weighted according to its contribution to overall efficiency. To the author's knowledge this has not been done before. The potential for a mathematical model to achieve this is promoted in this thesis with the application of DEA for one dimension of CG, that of CSR. That is, this thesis investigates the efficiency of CG from the vantage of its CSR efficacy using DEA as the diagnostic tool. CSR, and its corollary corporate citizenship, is taken in this thesis as the extent to which the enterprise defines its ethical, legal, economic and stakeholder responsibilities, and how well it performs against these standards. The CSR model chosen for this purpose proposes that there are measurable 'antecedents' of CSR, displayed through identifiable 'indicators', which result in outputs displayed through 'consequences' of CSR. DEA is applied to a database of 231 decision making units across 39 variables in six business divisions. The procedure pursues five test runs to validate the model followed by three comprehensive trials to test the primary data. All trials succeeded in identifying efficient DMUs in each cohort.

5.2 Corporate Social Responsibility

Corporate social responsibility is one of the many dimensions of CG. It describes the way in which an organisation engages with stakeholders and the environment in which the firm operates. According to Robert Davies at the World Economic Forum (2004), CSR has migrated from the philanthropy arena to mainstream and strategic corporate practice for the most of the successful companies in the financial marketplace."

It is often personified in the label of corporate citizenship which Maignan and Ferrell (2001) define as "the extent to which businesses assume the economic, legal, ethical, and discretionary responsibilities imposed on them by their stakeholders" (p. 38).

Basically, the economic responsibilities are those obligations the organisation has to be productive and meet the expectations of shareholders and investors. The legal responsibilities are those which allow it to meet its economic mission within the legal framework that governs it. The ethical responsibility is society's expectation that it performs inside established moral standards. Discretionary responsibilities are those that extend beyond the ones mentioned above and are for the general betterment of society (Donaldson 2005). These can be seen as a continuum from reactive to proactive citizenship.

The proactive corporate citizen for example, is dedicated to fair treatment of employees (O'Sullivan 2003) in economic, ethical, legal and discretionary matters. Economically it may offer secure employment and competitive rates of pay as well as procedures that ensure it meets and exceeds contractual obligations (legal citizenship). It may have work-life-balance programs which encourage family centric initiatives and offer discretionary benefits such as employee share privileges and other benefits packages. It goes beyond the minimum expected by all stakeholders (Dean and Clarke 2004).

The reactive corporate citizen on the other hand, is one that would espouse the same values as above but only on the basis that they 'make a business case' and link directly to the bottom line. It sees citizenship as benevolence equated to profitability plus compliance plus philanthropy and possibly a piecemeal response to stakeholder demands. It may give lip service to the ethos of multiple social contracts: between the corporation and society, and government, and stakeholder groups (Quazi 2003).

The socially responsible corporation is one that displays high levels of social responsiveness to the demands of its stakeholders and an understanding of them. It experiences positive consequences as a result.

Lasting relationships with primary stakeholders has been shown to be a major source of competitive advantage in today's highly competitive environment (Oketch 2004). In studies of over 160 organisations with high social responsiveness capabilities, as mentioned earlier, Black (2004) found improvements in business performance, increases in employee commitment with a greater alignment between employer and employee values, and an improved perception of the employer by its employees. There was a reduced intent for employees to resign and a general reduction in conflict with stakeholders. In her particular study, managers identified benefits as tangible and intangible. They believed the company benefited tangibly by a greater financial literacy (for shareholders), improved shareholder value, increased involvement in company decision making, products developed to customer specifications, reduced conflict, and increased trust, as well as a likelihood of decreased government regulation and a general reduction in business risk. This is not in contradiction with features of an advanced knowledge economy, which would merit its own study. An inclusion in the Dow Jones Sustainability Index (DJSI) was also welcomed. The intangible benefits were better organisational identity and reputation, with employee pride and an employer of choice status, as well as an attractiveness to customers and a learning organisation. She proposed a model based on the organisation having a cultural mindset reflected in an antecedent platform which predisposed it to corporate social responsiveness and resulted in positive consequences. This is represented in Figure 5.1 below.

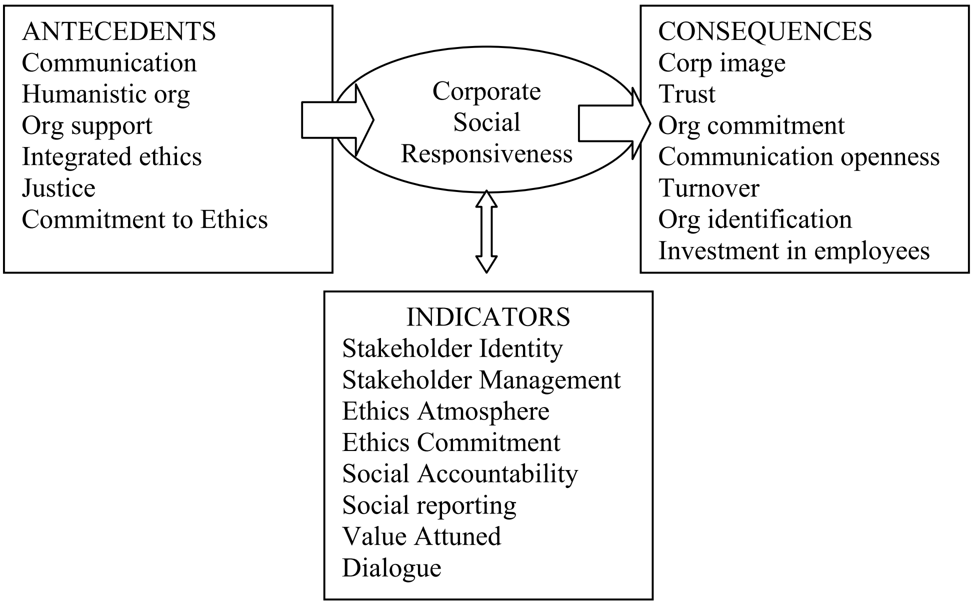


Figure 5.1 Model for CSR (from Black 2004)

The antecedents of CSR in Black's model emerged out of the perceptions of the culture within the firm held by internal organisational stakeholders. They viewed the firm as humanistic and supportive where communications flowed freely and the commitment to justice and business ethics was displayed by the integration of ethics in business practices and procedures. Employees felt that they were supported by the organisation. The consequences of such a culture were beneficial, as explained earlier, and included low staff turnover, an identification with the organisation which was trustworthy, had a good public image, and was willing to invest in employees and to communicate with them openly. In Black's model these consequences were the behavioural outcomes identified and measured across the organisational sample, noting that some of these were internal perceptions of how the organisation fared externally.

There is an organisation theory that explains Black's observations and aligns well with the firm she describes. It is OSTS theory, a development from the traditional sociotechnical systems advanced by the Tavistock Institute, with inclusion of parts of open systems theory as discussed earlier.

The sociotechnical view of the organisation is one where there are two independent sub-systems which operate interdependently and reciprocally. The social subsystem comprises the groupings of individuals in different roles, the knowledge, attitudes, relationships and authority structures that govern what people do in the organisation. The technical sub-system comprises the technical mechanisms, including tools, techniques and technology, which help people do their jobs. These subsystems do not operate in isolation, an aspect worth noting with regard to CSR.

When Mumford (2003) observes how firms operate she states that "every socio-technical system is embedded in an environment that affects the way it behaves…[which]…also includes the environment external to the firm" (p. 23).

This observation is akin to saying that there are stakeholders beyond the firm that have an interaction with it, and as such this tenet is in parallel with this thesis' ideas about CG and organisational performance.

Corporate social responsiveness can be described as the corporate strategy that enables the company to behave as a corporate citizen and meet its social obligations to all stakeholders. These capabilities can be measured by a psychometric tool developed and successfully tested by Black (2004) for this specific purpose. Known as 'CSR Management Capacity™' this system-based diagnostic tool measures 5 dimensions of social responsiveness embedded in the integrated structural and cultural kernel of the company. These dimensions are the capabilities displayed in Figure 5.2, represented below, abbreviated and labelled for the study in Table 5.1, and defined thereafter.

1) Stakeholder engagement:

- a. *stakeholder identity*
- b. *stakeholder management,*

2) Ethical business behaviour:

- a. *ethics atmosphere*
- b. *ethics commitment,*

3) Social accountability:

- a. *sense of accountability and*
- b. *accountability reporting*

4) Value attuned communication

5) Dialogue

Figure 5.2 Black's CSRMC Model (2004)

The stakeholder, ethical business and social accountability dimensions each have dual components providing the separate but important perspectives of the cultural and structural aspects of the same dimension. Thus, a total of eight indicative factors provide for a measure of social responsiveness, an indicator of CSR. This is summarised in Table 5.1, together with the labels used in the actual study and discussed later.

Table 5.1 Social Responsiveness Dimensions and Indicators

Dimensions of Social Responsiveness	Indicative Factors	Factor Label
Stakeholder Engagement	Stakeholder Identity	Stakid
	Stakeholder Management	Stakman
Ethical Business Behaviour	Ethics Atmosphere	Ethicatm
	Ethics Commitment	Ethiccom
Accountability	Sense of Social Accountability	Acctyid
	Reporting and Verification	Acctyrep
Value Attuned Public Relations	Value Attuned	Valuatt
Dialogue	Communication	Dialogue

The aggregation of the eight indicative factors of the five dimensional values has been used to assign a single CSRMC algorithm as an overall performance score.

However, the researcher Black notes that these factors have not been subjected[8] to any weightings accorded the importance of the eight different factors.

> It is not clear from the studies to date whether each of the capabilities should be weighted equally…[and]…future research needs to understand how they should be weighted and what conditions indicate variations in weighting. (Black, 2004 p. 255)

These hierarchical levels of measurement (dimensions converted to indicative factors) can provide deep levels of analysis of social responsiveness for the various DMUs of the business but not without some regard for the differences in importance of each factor. Fortunately, DEA arbitrarily assigns the optimum weighting for each factor if a researcher is unable or fails to assign such a weighting a priori. In this thesis the DMUs are individual managerial units across the organisation. The original 243 management units of Black's study provided a DEA usable sample of 208 DMUs across 6 business divisions once corrupt and incomplete data were rejected. An explanation of the dimensions and their factors follows.

Stakeholder Engagement

This dimension gauges the relationship of the firm with its stakeholders, through stakeholder identity and stakeholder management. One indicative factor is stakeholder identity which allows the firm to understand the needs of its stakeholders and incorporate these into the firm's business decisions, recognising that both their futures are linked. The firm needs to understand the stakeholder perspective in making decisions. Stakeholder management relates to how involved and empowered the stakeholders are in the decision-making process. For example good management skills may prevent stakeholder ignorance fostering unrealistic expectations.

Ethical Business Behaviour

This dimension also has two components, ethics compliance and ethics atmosphere. Compliance is the conformance to formal systems of reward and punishment used to reinforce ethical behaviour. Often it is the code of conduct prescribed in some corporate

---

[8] It may be noted that this non-assignment of weighted factors was influential in deciding to use an aggregated CSRMC score later in this research.

compliance handbook. Ethics atmosphere is the degree to which people sincerely care about the well being of others independent of what the rules say. It is possible that these two are de-coupled. A code for business ethics may be prescribed but observable behaviours reveal that interests are self-centred. Such a code of ethics without a supporting culture is generally ineffective.

Accountability

There are two elements to social accountability, the reporting of social impacts by the company and the sense of social accountability towards stakeholders held by management. Social reporting is how the firm substantively accounts for its performances truthfully even when the evidence is not good. Social accountability is the degree to which managers feel accountable to stakeholders for the firm's social impacts.

Value Attuned Public Relations

This dimension describes the ability of staff at the forefront of public affairs to detect and transmit value-pertinent information from stakeholders to organisational decision-makers. Well-developed environmental scanning and issues management skills can help senior managers recognise stakeholder aspirations and attune with these to achieve a congruence of corporate and stakeholder values. For example, a firm may symbolically and substantively authorise the entry of certain values into organisational decision-making by establishing a CSR committee that reports directly to the Board.

Dialogue

Dialogue is how a respectful attitude for stakeholders as equal partners is dealt with in communications about issues of mutual concern. It is the relationship between stakeholders and the firm's staff at the operational business level.

5.3 The DEA of Corporate Social Responsibility

5.3.1 The CSR Database

We take the opportunity presented by Black's (2004) doctoral research thesis of a large Australian commercial organisation to test the DEA model. The organisation she studied was a bank which consistently scored highly on an Australian national Social Responsibility Index, including several first 'gold star' performances. Her objective was to establish the existence of CSR which could be measured and attributable to certain antecedent factors. Black was able to develop an empirically supported construct for CSR from an investigation of 39 variables in six organisational business units with usable data from 231 managerial units from a sample of 243. All were given individual and aggregated CSR scores based on responses to psychometric testing of the variables. A breakdown of the variables is presented in Table 5.2. The first category provides demographic data such as: age, gender, managerial role, years of service, business division, etc. The next category has an overall performance score for CSRCM based on the results of two categories, dimensions and indicative factors. The following categories are the antecedents of CSRMC and the consequences of good CSR, and finally one for variables that were found unusable.

Table 5.2 Breakdown of CSRCM variables in the study

Category	Variables	Measure	Sample Size
Demographic Data	8	Nominal	243
CSR Management Capacity (Overall Score)	1	Scale (7)	228
Dimensions of CSRMC	5	Scale	227
Indicative Factors (of CSRMC)	8	Scale	227
Antecedents of CSRMC	7	Scale	231
Consequences of CSRMC	7	Scale	231
Other Miscellaneous	4	Scale	232

Black's model was supported by traditional hypothesis-testing methodology with correlations between the indicative factors for the CSRMC all significant at the 0.01 level (2-tailed tests). There was strong support for the hypothetical model of antecedents and outcomes of CSRCM as proposed, and significant ANOVA results for its eight sub-dimensions as related to the employee stakeholder group. Qualitative results through comprehensive interviews further attested to the significance of the CSRMC construct.

It was the positive results for a CSR model that invited an analysis of the data from the performance perspective of a DEA algorithm. No analysis of the type possible with DEA was attempted by Black.

5.3.2 The DEA Justification

Little seems to have been reported on studies of CG based on a diagnostic tool such as DEA. Perhaps this is because of the mathematical nature of the operations research based technique, as explained earlier, or because commercial firms have had CG traditionally examined from a non-quantifiable perspective. There also may have been little awareness of a need to use DEA because of its obscurity to researchers in the CG discipline, or because other established and research-rich investigative frameworks existed, e.g. board composition, independence and remuneration, stock holding participants, government, regulatory and other stakeholder influences.

This thesis, however, attempts to legitimize the use of DEA within the firm because of its attraction as a multi-criteria decision analysis technique with the benefit of weightings to assign a ranked position to the measured units. Adopting and applying the Golany and Roll (1989) procedure (see figures 3.3 and 3.4), DEA can perform well in the analysis of non-commensurate multiple inputs and outputs to give a measure of efficiency which reflects some aspect of organisational performance. The procedure for DEACSR is:

- establish the population of DMUs as managerial units within the organization;
- set the goals for analysis as efficiency;
- select the number DMUs for comparison (231 from a mail response pool of 245);
- define the input and output factors: the antecedent variables and the output the aggregated CSRMC variable;
- examine those factors:
    - by subjective judgment;
    - by correlations; and
    - by trial runs;
- formalise the final model;
- present initial results;
- analyse the factors and individual DMUs; and

- reach conclusions.

The output-input relationship that subsumes the DEA approach is grounded in the mathematical ratio form. This allows it to be generalized into a broader multiple criteria control model by using the Greenberg and Nunamaker (1987) transformation. Here the output-input factors themselves can be expressions of a ratio form as surrogates for the (difficult to obtain) exact measures of quantified tangible inputs and outputs. For example, scores from attitudinal surveys using instruments such as the popular Likert scale may be used by converting these scores into individual or aggregated ratios. In effect the supplanting of traditional metrics by surrogate factors expressed in a quantified form allows an articulation of those indicators that managers consider constitute good performance. Managers are often able to elicit what factors are contributors to overall good performance, and to rate these hierarchically but not absolutely. For example, two managers may score 'motivation' differently on some scale say 8/10 and 6/10, yet these scores are moot if both rate motivation ahead of 'punctuality'.

Managers also know that some factors have a greater impact on performance than others but often feel that they are unable to gauge the weightings of importance for these factors. But:

> …ignoring the interrelationships among performance measures and limitations on their possible combination may result in specification of weights vastly different from those which would have been specified had these aspects been considered. (Greenberg and Nunamaker 1987, p. 333)

Since the optimum set of weights can vary depending on a number of issues (even simple ones such as which measurement scales are used), managers may be unable, rather than unwilling, to assimilate the information in the specification of weights for different indicators.

The cognitive complexity of this task, together with managerial inexperience or lack of data may render it unassailable for these decision makers, and thus the task is not attempted or attempted rudimentarily.

DEA does not require the *a priori* assignment of relative weights to individual measures because the technique itself identifies the subset of performances that are Pareto optimal[9] and these can be regarded by managers as those performance benchmarks which are indicators of good performance. Should the current factors not be Pareto optimal, the model shows where improvement is needed to achieve this condition. The degree of sub-optimality is also the amount of improvement possible and is referred to as *slack*, discussed previously.

This slack is only displayed by a non-efficient DMU. Improvement is possible by various alternate strategies such as achieving more from the same resources or by maintaining a stable output and reducing the resources required, and thus removing slack.

DEA will be used to investigate the relationship between inputs and outputs for CSR where the eight indicative factors of the five dimensions would be considered in the aggregated CSRMC score as output and the antecedents as input factors. Black's results were all expressed as inferential statistics thus allowing the transformation possible by DEA.

Each of Black's sample managerial units is regarded as a DMU for the DEA computation.

5.4 Applying DEA

5.4.1 Pilot Tests and Variable Selection

The original database on an SPSS file was accessed and interpreted. It presented raw scores for 246 subjects across 39 variables. The variables as labelled on SPSS were pasted into an Excel spreadsheet and described in detail in Table 5.3.

Table 5.3 Parameters of the CSR variables

Note:. * (O) represents the indicative factors that comprise the CSRMC, **(I) the input factors.

Variable	Variable Label	Parametric Description
1	Id	Identity of sample unit

[9] Pareto optimality is a measure of efficiency from game theory where each player's outcome is optimal with at least one player better, and the outcomes cannot be improved without at least one player becoming worse off.

2	Busunit	Business division of subject residence
3	V5	Measurement scale (nominal-ordinal)
4	Gender	Male or Female
5	Age	Interval scale from 1-5
6	V8	Years of service
7	V9	Months of service
8	Role	Managerial role (team leader to senior executive, 1-7)
9	Stakid	Stakeholder identity (culture) (O)*
10	Stakman	Stakeholder management (structure) (O)
11	Valueatt	Value attuned communication (O)
12	Dialogue	Dialogue (O)
13	Ethiccom	Ethics compliance (structure) (O)
14	Ethicatm	Ethics atmosphere (culture) (O)
15	Acctyid	Social accountability (culture) (O)
16	Acctyrep	Social accountability (structure) (O)
17	Commopen	Communication openness
18	Commacc	Communication accuracy (I)**
19	Humanist	Humanistic orientation (I)
20	Employin	Employer investment in employees
21	Integeth	Integrated ethics (I)
22	Manageth	Management commitment to ethics (I)
23	Ethiccit	Ethical citizenship
24	Cspsensi	Sensitivity to corporate social performance
25	Orgcommi	Organisational commitment
26	Orgident	Organisational identification
27	Trust	Trust
28	Pos	Perceived organisational support (I)
29	Corpimag	Corporate image
30	Turnover	Turnover intention
31	Justice	Distributive justice (I)
32	Staking	Stakeholder engagement
33	Accounta	Social accountability
34	Tenure	Tenure
35	Socialde	Social desirability bias
36	Ethical	Ethical business behaviour
37	Manfin	Management commitment to finance
38	Csrmc	CSR management capacity (overall aggregated output)
39	Discitiz	Discretionary citizenship

Variable 2 'Busunit' identified the corporate division where the subject worked. There were 6 business units labelled A to F for confidentiality. The number of DMUs in each reflects the size of the unit and its organisational function. This is shown in Table 5.4 below and excludes corrupted data.

Table 5.4 Cohort Breakdown by Decision Making Unit

Unit Name	A	B	C	D	E	F
Number of DMUs	6	49	64	64	42	18

5.4.2 The DEA-Solver-LV Program

Software provided as supporting material for the Cooper, Seiford and Tone (2000) text was used in the pilot study. The DEA-Solver-LV program is spreadsheet based and designed to be used with the platform Microsoft Excel 1997/2000/2003 or later. Installation is menu driven requiring only to follow instructions. Once installed it includes the file DEA-Solver.xls and a folder for 'Samples', and places a shortcut on the desktop. It should be noted that as trial version software accompanying a text, the number of DMUs in a study is limited to a maximum of 50, and it only provides 7 basic models of the DEA algorithm.

DEA-Solver applies a notation which summarizes the DEA models. The format for this is: <Model Name>-<I or O>-<C or V>

Where I or O corresponds to 'Input' or 'Output' orientation and C or V to 'Constant' or 'Variable' returns to scale (which is omitted if not necessary). The 'Learning Version', limited to 50 DMUs as noted earlier, includes only the 7 models tabled below.

Table 5.5 DEA Models on DEA-Solver LV

Model Abbreviation	**Type of DEA Model**
CCR-I	Charnes-Cooper-Rhodes Input Oriented
CCR-O	Charnes-Cooper-Rhodes Output Oriented
BCC-I	Banker-Charnes-Cooper Input Oriented
BCC-O	Banker-Charnes-Cooper Ouput Oriented
AR-I-C	Assurance-Region Input Oriented Constant Returns to Scale
NCN-I-C	Uncontrollable (non-discretionary) variable Model
COST-C	Cost Efficiency Model

The data file should be prepared on the spreadsheet in a pre-set format prior to activating the program. Row 1 is for the problem name and other descriptors the user chooses.

Row 2 has headings for DMUs, and the input and output items distinguished by either (I) or (O) following the item name. Boundaries to the dataset are identified by a blank column and a blank row at the right and bottom respectively. There are also some restrictions on the names allowed for data sheets. A sample data file is shown in Figure 5.3.

ID of DMU	(I)Comopei	(I)Comacc	(I)Integeth	(I)Managet	(I)Pos	(I)Justice	(O)Csrmc
108	3.4	5.2	1.33	2.63	2	5	5.48
144	4.6	4	3.33	1.5	3.2	3	3.78
152	4	2	3	1.13	2	3.5	4.19
232	4	3	2.33	2.5	4.2	4	4.48
182	3.6	5	1	4.88	3	2	5.64
219	5.6	5.2	3	4.25	4	4.83	6.29

Figure 5.3 Sample Data Sheet for DEA Solver LV

The professional software DEA-Solver-Pro (Professional Version 4.1) allows for three types of analysis (with 130 models in 32 clusters, see Appendix 2b): radial, non-radial and oriented, non-radial and non-oriented

'Radial' models are those where efficiency calculations for the vectors are origin based (0,0 coordinates) and provide for a proportionate change in input/output values as their main concern. They neglect the existence of input excesses or output shortfalls (slacks) as freely disposable or secondary.

'Non-radial and oriented' on the other hand, includes slacks and does not treat input/output changes proportionately but rather, considers the input or output orientation in evaluating efficiency.

The target is either input reduction, i.e. to reduce input resources to the efficient frontier as much as possible, or output expansion, i.e. to enlarge output products as much as possible.

'Non-radial and non-oriented' models attempt to reduce inputs and expand outputs at the same time.

5.4.3 Test Trials of Data using DEA-Solver-LV

Test 1: Software Testing

Testing of the software and the data available verified that the program worked and that the variables chosen were correct. In the first test the data from business units A-F were used. This test had scores of all DMUs in each business unit averaged to represent a single score for each decision variable for each of the 6 business units tested. A summary of the results of this test from Appendix 3 is presented in Table 5.6 and shows that the test failed to discriminate because all DMUs were deemed to be equally efficient.

Table 5.6 Test 1 Summary for Business Units with Averaged Scores

DMUs	6	Business units A-F
Input Variables	8	Stakeid-soc reporting
Output Variables	7	Corp imag-emplInvest
Result	Test failed	

Test 2: All Business Units, Average Scores and Reversed Variables

The second test was a trial to gauge whether the reversal of the input and output factors would provide any additional information. The only change to Test 1 was the reversal of input and output variables. A summary of the results from Appendix 4 shows that this reversal also failed to discriminate the factors under investigation.

Table 5.7 Test 2 Summary for Business Units with Averaged Scores but Reversed Input and Output Factors

DMUs	6	Business units A-F
Input Variables	7	Corp image-emplInvest
Output variables	8	Stake Id-soc reportg
Result	Test failed	

Test 3: All DMUs in Cohort

The third attempt tried to elicit the factors that would be significant to the model, i.e. those factors that are determinants of efficiency. The segregation by business unit was abandoned and all DMUs (233) were presented for testing. Input factors were variables 17-39 in Table 5.3, and output factors were variables 9-16. The test failed to initiate. Solver LV is a sample learner program limitation to only 50 DMUs. When invoked it gave a message to indicate the limit was breached and the test could not proceed. This is shown in Table 5.8.

Table 5.8 Test 3 for all DMUs

DMUs	233	All managerial units
Input Variables	23	ComOpn-discitiz
Output variables	8	StakeId-soc reportg Y-AF
Result :	DMUs≥ 50 (program failed)	

Test 4: Reduced DMU Cohort

The fourth trial test overcame the 50 DMU limit by summarizing the data further and removing the DMUs which had the lowest level of employment service less than 5 years (variable 6 in Table 5.3), thus achieving a total DMU test sample of 48. The input factors of 23 variables and the 8 output variables were retained with the original intention of identifying the variables most relevant to the input and output factors. This test was able to run and computed a total of 1224 simplex iterations. However, the results were again inconclusive because all the DMUs displayed equal efficiencies of 1.00. These are summarized from Appendix 5 and shown in Table 5.9.

Table 5.9 Test 4 Sample of DMU Dataset to Overcome the 50 DMU limit

DMUs	48	Units A–F
Input Variables	23	ComOpn-discitiz
Output Variables	8	StakeId-soc reportg Y-AF
Result:	All DMUs 100% efficient.	

.

Tests 1-4 were all failures of the DEA application. Test failures require an analysis of the procedure, the data and the application. The Golany et al. (1989) procedure stipulates a careful selection of the variables in the first four steps: DMUs, input and output factors,, but an examination of the choices in the next step (5).

They suggest this evaluation of factors be done by subjective judgment, correlations and trial runs (see Section 3.7.1 validating the DEA Model). After four test failures this was the next step.

Test 5: One CSRMC Output Variable and Six Antecedent Variables

The analysis of the four trial-runs shown in tests 1-4 above and a reassessment of the data available suggests that the chosen DMUs are still appropriate but that input and output factors may have been mismatched. It was decided that the appropriate output factor should be the value expressed by Black's aggregated score for the CSRMC variable (shown as variable 38 in Table 5.1). The input factors should be those variables seen as precursors to CSR and later discussed as the 6 antecedents. Those selected were the two communication, two ethics and the organisational support and justice variables (shown as numbers 18, 19, 21, 22, 28, 31 in Table 5.1) and identified by the notation (I).

To overcome the limitation on the number of DMUs allowable under the DEA-Solver-LV program it was further decided that the DEA iterations would be conducted in two phases with two models as follows.

The whole cohort was to be tested but using the minimum, average and maximum scores for each decision variable of the DMUs in each business unit. This meant that every business unit (6) had three values, thus a total cohort of 18 DMUs were able to be run in the program (Appendix 6).

The whole cohort was to be tested iteratively by separate business units rather than the whole organisation. To ensure that the number of DMUs per business unit were acceptable at less than 50, units C and D which had 64 DMUs were trimmed to 49 and 48 by excluding DMUs which had a service history of less than five years (Appendix 7).

The two tests above were conducted for the CCR-I and CCR-O models of DEA-Solver.

Both models in both phases worked equally well in that input CCR-I or output CCR-O orientations made no difference. Phases one and two also revealed efficient and non-efficient DMUs. Test 5 was thus successful in showing the program worked and was able to discriminate between efficiencies of DMUs.

The summarized results of Phase 1 from Appendix 6 are shown in Table 5.10a and those for Phase 2 from Appendix 7 in Table 5.10b.

Table 5.10a Results of Test 5 for Minimum, Average and Maximum Scores in each Business Unit (from Appendix 6)

DMUs	18	Units A–F
Input Variables	6	Commacc-justice
Output Variables	1	CSRMC
Result:	4 DMUs 100% efficient.	

Table 5.10b Results of Test 5 using DEA-Solver LV for Less than 50 DMUs per Business Unit (from Appendix 7)

DMU Cohort	Number of DMUs	Input Variables	Output Variable	Number of Efficient DMUs
Unit A	6	6	CSRMC	3
Unit B	46	6	CSRMC	20
Unit C	49 (64)	6	CSRMC	9
Unit D	48 (64)	6	CSRMC	3
Unit E	41	6	CSRMC	16
Unit F	18	6	CSRMC	9
	Total 208			**Efficient 60**

Aggregating the values of the business units allowed a rudimentary computation of the overall efficiency. A total of 60 DMUs of a cohort of 208 were efficient. This could only be verified by testing all DMUs across the organisation without segregating by business units, and therefore requiring the commercially available software for DEA-Solver-Pro. The DEA Professional Program available from SAITECH-INC.com was purchased.

5.5 DEA of CSR using DEA-Solver-Pro 4.1

The tests using the 'Solver LV' program identified a number of issues associated with the application of an algorithm to solve a DEA structured problem. While limitations to data entry and sample size are merely technical obstacles (and overcome by use of the professional program) the questions of workable boundaries and thresholds of discrimination become obvious. When are there not enough decision making units in the computational sample? What indicates that the discrimination of efficient from inefficient units is delicate enough to segregate the cohort?

Cooper et al. (2006) suggest rules of thumb as guidelines for the DEA model to work successfully. There are three: R1, R2, and R3.

R1: The sample size should be greater than the product of inputs and outputs otherwise the model loses its discretionary power:

$S_s \geq I*O$

R2: The sample size should be greater than or equal to three times the sum of input and output factors:

$S_s \geq 3(I+O)$

R3: The one third rule suggests that the sample size is acceptable if the number of fully efficient DMUs is not greater than one-third the sample size:

$\text{Eff DMUs} \leq 1/3*S_s$

Ramanathan (2003) also supports the first two rules but is more lenient with R2 saying that the sample should be greater by 2 or 3 times the summation. These heuristics would be used in trials that were now possible with the professional program DEA–Solver-Pro 4.1.

Trial 1 presented the opportunity to test all 231 DMUs unhampered by learning program limits. It considered the inputs to be the 6 antecedents to CSRMC as defined by Black, and the outputs to be the aggregated value of the indicative factors that comprise the CSRMC.

The 6 antecedents were:

1) communication accuracy: honest, accurate and understandable communication;
2) humanistic orientation: where the organisation is managed in a participative manner and people support one another;
3) integrated ethics: by incorporating ethics into everyday practices and assessed in individual performances;
4) management commitment to ethics: talking and demonstrating ethics for the good of the company and society;

5) perceived organisational support: provides feelings of empowerment; and

6) perceived Justice; and ethical behaviour based on fair processes and fair outcomes.

Trial 1 Full Cohort Test with Six Inputs and One Output Across all Business Units

The structure of the trial and overall results from Appendix 8 are summarized in Table 5.11.

Table 5.11 Whole of Cohort Results of 6 Inputs (I) and 1 Output (O)

DMUs	n = 231	All business units
Input Variables	6	Antecedents to CSRMC
Output	1	Aggregated CSRMC score
Result	Success: 11 Efficient DMUs identified	

The 11 efficient DMUs identified in Table 5.11 could be traced back to their Business Units of origin. They were identified as efficient against peers across the whole cohort in the first instance and then labelled according to their location within the business unit structure of the organisation. Eleven efficient units from a sample 231 complies with the rules of thumb R1 (231>6*1), R2 (231>3*7), and R3 (11 <1/3*231) cited above. These are extrapolated from Trial 1 results in Appendix 8 and presented in summary in Table 5.12.

Table 5.12 Cohort-wide Efficiencies from Individual Business Units

DMU Cohort	Number of DMUs	Input Variables	Output Variable	Number of Efficient DMUs
Unit A	6	6	CSRMC	0
Unit B	46	6	CSRMC	0
Unit C	63	6	CSRMC	5
Unit D	57	6	CSRMC	4
Unit E	41	6	CSRMC	2
Unit F	18	6	CSRMC	0
TOTALS	231	6	CSRMC	11

Trial 2 Full cohort Test for All Business Units Tested Individually and Aggregated

To emulate the results of Trial 1, and to triangulate the test set of the complete cohort, DEA-Solver-Pro 4.1 ran the data across the separate business units individually. The total 2541 simplex iterations this produced compares with 1509 iterations required under Trial 1 conditions. The results from Appendix 9 are presented in Table 5.13 and show 64 efficient DMUs.

Table 5.13 Aggregated Efficiencies after Testing at Individual Business Unit Level

DMUs	n = 231	6 Business units individually
Input Variables	6	Antecedents to CSRMC
Output	1	Aggregated CSRMC score
Result	Success: 64 efficient DMUs identified	

A summary of results from an individual business unit perspective identifies 64 efficient DMUs in total, albeit that this aggregate is a simple summation of the individual scores for each business unit and thus should be viewed in a different context to the results in Table 5.12. A breakdown of this aggregation is presented in Table 5.14 and compared in Table 5.15.

Table 5.14 Individual Business Unit Comparisons Aggregated

DMU Cohort	Number of DMUs	Input Variables	Output Variable	Number of Efficient DMUs
Unit A	6	6	CSRMC	3
Unit B	46	6	CSRMC	20
Unit C	63	6	CSRMC	11
Unit D	57	6	CSRMC	5
Unit E	41	6	CSRMC	16
Unit F	18	6	CSRMC	9
TOTALS	231	6	CSRMC	64

Comparison of efficient DMUs when relative efficiencies were tested against the whole cohort of 231 units (in Table 5.13), and when the efficiencies were tested for relative efficiencies against other DMUs within the business unit cohort (in Table 5.14), show a discrepancy. Only 11 DMUs are fully efficient in cohort testing while an aggregated total of 64 DMUs are shown to be efficient when tested against their own business unit peers. This is presented in Table 5.15 below and will be discussed in Chapter 7.

Table 5.15 Comparison of whole cohort to individual units

Whole of Cohort Test	Individual Business Unit Test	
Efficient DMUs	Business Units	Efficient DMUs
0	A	3
0	B	20
5	C	11
4	D	5
2	E	16
0	F	9
11	Totals	64

Trial 3 CSRMC Expanded to Eight Output Variables

A new trial to test the sensitivity of the DEA was undertaken. If the CSRMC score was an aggregate of the indicative factors of CSRMC, would the results coalesce if this aggregated score was expanded to show each of the indicative factors as being an output measure? Keeping the DMU cohort the same (at 231units) and the inputs as the 6 antecedent factors the output variables were now segregated to the 8 indicative factors: stakeholder identification, stakeholder management, value, dialogue, ethics, ethics atmosphere, social accountability and social reporting.

The summarized results of this trial in Appendix 10 are presented in Table 5.16.

Table 5.16 Trial 3, the eight indicative factors of CSRMC

DMUs	n = 231	Business Units Collectively
Input Variables	6	Antecedents to CSRMC
Output Variables	8	CSRMC indicators
Result	58 Efficient DMUs identified	

An analysis of the results in Table 5.16 provides a breakdown of those efficient DMUs by business unit origin and this is presented in Table 5.17.

Table 5.17 Indicative Factor Efficiencies by Business Units Origin

DMU Cohort	Number of DMUs	Input Variables	Output Variable	Number of Efficient DMUs
Unit A	6	6	8	3
Unit B	46	6	8	9
Unit C	63	6	8	15
Unit D	57	6	8	18
Unit E	41	6	8	12
Unit F	18	6	8	1
TOTALS	231	6	8	58

The values obtained in Table 5.17 suggest that a cohort efficiency achieved by 58 DMUs in the expanded algorithm approximates in number to the cohort efficiency of 64 DMUs achieved in Trial 3, Table 5.16, but not to only 11 efficient DMUs in Table 5.12. A comparison is provided below in Table 5.18.

Table 5.18 Comparison of different DEA trials

DMUs n = 231	Efficient DMUs	Inputs = 6 Antecedents	
Table 5.12	11	CSRMC = 1 output	Cohort
Table 5.15	64	CSRMC = 1 output	Business units
Table 5.17	58	Indicative factors = 8 outputs	Cohort

These results would suggest a closer analysis of which DMUs matched under the three different trial conditions. This was done and presented in Table 5.19.

Table 5.19 Comparison of Efficient DMUs by Trial Condition

Note: 11 DMUs efficient across all trials are shown in bold font**.**

Business Unit	**Trial 1**	**Trial 2**	**Trial 3**
Unit A		108, 152, 182	152,182,219
Unit B		38, 52, 72, 96, 134, 138, 145, 147, 148, 168, 170, 171, 186, 190, 202, 203, 205, 207, 213, 215	134,138,145,147,168,190,203, 205,207
Unit C	**42, 44, 68, 109, 129**	19, 33, 39**, 42**, **44, 46, 68**, 78, b, **129,** 204	19, 25, 33, 39, **42, 44,** 51, 61**, 68,** 78, 105**, 109, 129**, 179, 204
Unit D	**2, 95, 135, 231**	**2,** 81, ,**95, 135, 231**,	**2**, 4, 6,8, 24, 55, 58, 70, 75, 81, 89, **95, 135**, 139, 153, 155, **231**
Unit E	**83, 242**	28, 56, 64, **83,** 98, 107, 113, 119, 146, 187, 198, 216, 218, 221, 241, **242**	16, 21, 28, 56, 64, **83**, 112, 113, 119, 187, 216, **242**
Unit F		27, 31, 65, 92, 123, 128, 174, 183, 223	31
Total Efficient DMUs (by Trial)	**11**	**64**	**58**

When all the efficient DMUs are compared individually in every trial condition, the 11 efficient DMUs from Trial 1 occur in all trials. The remaining efficient DMUs in business unit locations and for the expanded output factors of trials 2 and 3, show a match-up of a further 25 DMUs for the 64/58 comparison respectively.

The analysis of results and a discussion of the findings are conducted in the next chapter.

5.6 Conclusion: The DEA for CG

The literature of DEA application in a CG context is rare. With so many inherently intangible factors CG lends itself to much qualitative analysis and speculative debate. It also displays a spattering of econometric and financial modeling to segments of the discipline that are quantifiable. Consequently an universally accepted paradigm is missing and may be regarded as an academic quest. Nevertheless, some studies that are emerging show progress on this front and provide an incentive for further research, particularly from the DEA perspective.

In 2002, Bradbury and Rouse demonstrated the successful application of DEA in a traditional CG activity; that of auditing. DEA was superior to the analytical hierarchy process in weighting the audit risk factors when planning an audit process. The analytical hierarchy was discussed in Chapter 4. It used the individual evaluation of risk factors by separate auditors, who rated each of the six factors; size, control, change, environment, pressure and scope, on a scale of 1-5 according to their own perceptions of audit risk. The median ratings from all auditors on the six risk factors were then used as the input values for the DEA computation. The audit risk index provided by DEA resulted in a "more representative view of the audit experts' opinions" (p. 274) and subsequently a better performance in the preparation of an audit process.

In a working paper on preferred policy portfolios Bosetti and Buchner (2005) demonstrated the usefulness of two DEA analyses in assessing the relative efficiency of alternate policies (on global warming). The first application was coupled to a cost benefit analysis while the next computed social and environmental benefits. Together these presented agreed future implications of alternate policies and provided a basis for sound decision-making.

Bosetti and Buchner contend that DEA demonstrates its utility as a decision enhancing tool and one that is flexible enough to be adopted in policy design and evaluation. From a CG perspective this study illustrates how DEA could be used as a template for policy formulation. For example, in evaluating the impact and suitability of a particular CSR policy the organisation could find value in using DEA as the diagnostic tool.

This chapter applied the DEA algorithm to CSR as measured by the CSRMC construct. A series of trials testing the model and the correct input and output factors were conducted following the procedure established by Goleny and Roll (1989) and to the rules suggested by Cooper, Seiford and Tone (2006). The failures in the initial test-trials provided direction for the selection of the correct model and decision variables, as well as the choice and number of input and output factors to be analysed. This was done and final trials were successful in discriminating efficient from non-efficient DMUs in all cases. These findings are discussed in the context of their application to CG in particular, and to their significance in the supply network in general, which is done in Chapter 7. The general conclusion however, supports the applicability of DEA as a diagnostic tool which identifies those business entities within the organisation which are efficient exponents of the CSR component of the CG policy of the Australian bank investigated. This is in accord with its consistent high performance and premier achievement on other measures, such as the corporate responsibility index (CRI 2004, 2005, 2006 and 2007), published annually in Australia by The Age and Sydney Morning Herald newspapers for the St James Ethics Centre.

The next chapter analyses the results presented in terms of the application of the DEA algorithm to the construct of CSR. It diagnoses the findings simply from the perspective of how successful the linear programming was in identifying efficient DMUs, inefficient DMUs and those that may exhibit efficiency under certain conditions. It then presents correlation data to support the factors chosen and used to measure CSR.

Chapter 6

Results and Validation of DEA Application to Corporate Social Responsibility

Not everything that counts, can be counted,
and not everything that can be counted counts.
Albert Einstein 1879-1955

6.1 Introduction

This chapter analyses the results of an application of DEA to CSR as conducted in Chapter 5. It is structured so that the evidence obtained from the computations of the empirical data of a successful Australian bank, recognised for its leadership in CG, is used to assess the efficacy of an operations research technique. The objective is to identify which decision making units are efficient and which are not, through the application of the DEA variant of traditional linear programming, as a legitimate stepping stone for the study of organisational performance viewed as the optimal ratio of output to input relationships across the supply chain in which the bank operates. The analysis of results from using existing data in three separate trials should provide this categorisation. Non-efficiency rated DMUs and those disputably efficient must also be analysed and possibly explained. This analysis will take the form of:

- assessing the application of DEA to CSR;
- applying heuristics to the DEA results;
- evaluating the suitability of the DEA model employed and others available;
- commenting on idiosyncratic features of DEA; and
- evaluating the correlations of the input-output factors as computed by the DEA algorithm.

The discussion will then be continued in the next chapter where issues that arise from this evaluation are debated.

6.2 The DEA Application to CSR in the OSTS

6.2.1 The Findings of DEA Application to CSR

Chapter 5 showed that the relationship between CSR, displayed in the scores of CSRMC as a consequence of certain antecedent factors, can be measured by DEA. The results of tests and trials are presented in that chapter but analysed here. In particular, the references are to Trial 1, Trial 2 and Trial 3 with results presented in the tables 5.11 through to table 5.19 earlier in that chapter, but summarized in Table 6.1 below.

Table 6.1 Summary of Trial Structures and Efficiency Results

	Trial 1	**Trial 2**	**Trial 3**
DMUs	Total cohort 231	Total cohort 231 by 6 business units	Total cohort 231
Inputs	6	6	6
Outputs	1	1	8
Efficient DMUs	11 efficient	64 efficient	58 efficient
Efficienct DMUs by Business Unit	Aggregated	Segregated	Aggregated
A	-	3	3
B	-	20	9
C	5	11	15
D	4	5	18
E	2	16	12
F	-	9	1
Total	11	64	58

DEA was able to distinguish those Decision Making Units that were efficient from those that were not. The three trials of input and output factors were all positive. Every trial highlighted those DMUs that outperformed their peers. A common core of efficient DMUs was revealed in each trial. This reinforces the underlying contention that CSR is a measurable construct and that its precursors are not only identifiable but also measurable. Each trial identified DMUs which were efficient performers, and ascribed a rating of unity, as well as others which were rated by the degree to which they were less efficient.

This would suggest that DEA as a diagnostic tool had discrimination ability consistent with its designed purpose.

Table 5.19 summarizes the results of the three trials to show by further selection that there were 11 DMUs which registered as efficient across all trials. There were a further 25 DMUs with matching efficiencies in Trials 2 and 3. In other words, from the broader perspective of a cohort comprising up to 231 DMUs there were:

- 11 efficient DMUs that occurred in all trials;
- 64 efficient performers (in Trial 2); and
- 58 in Trial 3; of which
- Trial 2 and Trial 3 shared 25 common DMUs.

This reveals a number of observations. Firstly, the eleven efficient DMUs across all trials suggest a strong result of unity for each of the measures of efficiency as expressed by the stated input factors and the CSRMC output factor. If the goal were to conservatively estimate a rated cohort of efficient DMUs, then these would be accepted as representing the best achievers.

Next, the fact that 25 more DMUs were pair-matched as efficient in Trials 2 and 3 would imply a robustness in DEA to probe deeper by matching and identifying those further comparably-efficient DMUs. This leaves 28 (from 64) unmatched DMUs in Trial 2 and 22 (from 58) unmatched DMUs in Trial 3 to be explained. This is summarised in Table 6.2 below.

Table 6.2 Summary of DMU Efficiencies by Trial

	Trial 1	Trial 2	Trial 3
Core efficient DMUs	11	11	11
Pair-matched efficient DMUs		25	25
Trial specific efficient DMUs		28	22
Totally efficient DMUs	11	64	58

6.2.2 The Findings of DEA in the OSTS

It has been discussed in Chapter 2 that the dynamics of organisation function and performance are best viewed from an OSTS perspective. In particular, the organisation operates as a conjunction of two subsystems, the humanistic-organic and technological-mechanistic subsystems. The former allows for the individualisation of work and the empowerment of workers to choose, to a certain extent, how to do their tasks, while the latter defines what tasks need to be done to achieve organisational objectives. So, there are organisational requirements for CG and CSR that are prescribed in policy and procedures and there are the interpretative ways in which these are adhered to by the employees in all DMUs, including the cohort sampled in this study. Consequently, the fluid nature of a humanistic style of management together with an evolving corporate mission may provide some explanation for the appearance of additional DMUs which display efficiencies of unity. In a sense this supports the contention that it is difficult to fully quantify a qualitative construct such as CSR. In retrospect it should be expected that this type of a result would be achieved. There was also no detailed biographical profile of the DMUs undertaken in this study. The analysis of such data may have provided an insight into the humanistic stance of the subjects. Furthermore, there are numerous technical reasons why the results are not fully coherent and these are discussed next.

6.3 Technical Considerations of the Findings

6.3.1 Heuristics for DEA to Succeed: The Rules of Thumb

The acceptability of the quantities of DMUs, input and output factors, that work best in the DEA algorithm is not well established, yet pertinent to the results. In Section 5.5 it was mentioned that while there are no fixed rules for choices of these quantities, there appears to be heuristics supporting three rules of thumb. R1 mentions that the number of DMUs in the sample should be greater than the product of inputs and outputs. This condition was satisfied in all three trials. R2 states that the number of DMUs should be greater than or equal to three times the sum of input and output factors.[10] This condition was only achieved in trials 1 and 3. Trial 2 showed business units A and F as those segmented and individually tested cohorts which breached this rule. These units showed three and nine efficient DMUs when Trial 1 showed none and Trial 3 showed three and one efficient DMUs in units A and F respectively.

R3 suggests the sample size is acceptable if the number of fully efficient DMUs is no greater than one-third the sample size. This condition was met by all three trials, including Trial 2 which had sample quantities ranging from six DMUs in Business Unit A to sixty three DMUs in Business Unit C. Thus, Trial 2 with individual business units being tested separately and the results aggregated, was the only one that breached the conditions. Three DMUs in Unit A and nine in Unit F are additionally identified as efficient. These extraneous DMUs were not rated as efficient in any of the other trials. This total of 12 units can explain the presence of some of the 28 unmatched DMUs in Trial 2 above, leaving only a further 16 efficiency-rated DMUs unexplained.

The trial conditions and the results were sent to two cited researchers for verification that these complied with conventional applications of the model generally, and with the quantities of DMUs, inputs and outputs in particular. In personal communication with Professor Coelli from the Centre for Efficiency and Productivity Analysis, University of Queensland, on the 7th September 2006, and Dr Necri Avkiran from the Queensland University Business School, on the 9th September 2006, they both stated that the quantities for DMUs, inputs and outputs were acceptable and the results were also within acceptable parameters.

6.3.2 Different DEA Models

When DMUs are ranked similarly by different models of DEA, the efficiency evaluations are "an indication of the robustness of the technique" (Golany and Roll 1989, p. 244). Trials 1, 2 and 3 were all conducted using the CCR-I and the CCR-O models with no discernable difference. The CCR-I model emphasizes input reduction while the

[10] Golany and Roll (1989) suggest that the number of DMUs in the sample should be at least twice the sum of the number of input and output factors whereas Cooper, Seiford and Tone (2000) state that the number of DMUs should exceed the combined number of inputs and outputs.

CCR-O model emphasizes output enhancement, but in this instance the results were identical. Different DEA models have different specific characterizations. For example, the multiplicative and weighted additive models focus on the impact of the weighting factors, thus the choice of model may have a bearing on the rating of relative efficiencies. The BCC model takes into account the most productive scale size while simultaneously identifying technical inefficiency, such that 'variable' returns to scale rather than 'constant' returns to scale (VRS or CRS, see Section 4.5) will produce results reflecting the contribution of factors such as the size of the DMU. The Additive model is an extension to the BCC model and has VRS, but its difference is in seeking to project the DMU values to the closest point of efficiency on the envelopment surface. Consequently while each of the three models has the same production function displayed by the piecewise linear envelopment surface, the measures of efficiency may differ. Generally, CRS assumes a linear relationship to increasing inputs or outputs and thus tends to lower scores whereas VRS tends to raise them.

In the data analysed for this study, the size of individual units was not gathered and hence not available for analysis. However, it is likely that different DMUs in different business units, and even different geographical regions of branches where the bank operated and sample data were obtained, would have the local operations of each DMU differ to some degree in various respects, e.g. size counts. For example, if the study DMU were a management unit where the customer base was expansive and demanding of specific bank services, it would seem sensible that this particular DMU would have greater technological support to provide these services than in a case where this may be a minor requirement for another DMU. Specifically, with regards to CSR there may be regional forces that pressure the bank to be more responsive to stakeholder demands. Coelli et al. (1998) recognise the impact of 'environmental' factors which can "influence the efficiency of the firm, where such factors are not traditional inputs and are assumed not under the control of the manager" (p. 166), and illustrate this with examples that correspond to our description of stakeholders. This is discussed further in Section 7.3.7.

The CRS model also assumes that all DMUs are operating at an optimal scale when the discussion above suggests this may not be the case because of a variety of imperfect conditions. This situation has been identified by many authors (in Coelli et al. 2005), and adjustments to CRS to account for scale efficiencies have been suggested. One is to run the CRS and the VRS models concurrently and if there is a difference in the scores, decompose them into two components (scale inefficiency and pure technical inefficiency), to indicate which DMUs exhibit scale inefficiencies. This was not done in the present study. More importantly the CRS model assumes linearity, suggesting that CSR has a linear relationship between antecedent factors and the CSRMC factor that represents the concept. While linearity is often a good approximation of non-linear relationships over a limited range, it fails to endorse non-linear functions over the broader spectrum. The concept of the mathematical modeling of CSR for this purpose may warrant further research.

6.3.3 The Extreme Point Technique of DEA

DEA is a powerful tool but has some characteristics which may create problems. As an extreme point technique it is susceptible to system 'noise' even if the noise is symmetrical with mean zero. It can be similarly affected by the 'outliers', those far points on the production frontier representing unusual DMUs and usually units that deviate from the general characteristics of the group, and are included in the comparisons. In particular, the threat and impact of outliers is greater when there are smaller numbers of DMUs in the cohort, as was the case in Trial 2 with individual business units being tested rather than the whole as one group, i.e. when Trial 2 was conducted the efficiency comparisons were made relative to DMUs within the same business unit cohort yet comparisons relative to the total cohort were not computed. This could explain why more efficiencies were recorded when aggregating those from individual business units as smaller cohorts. Some that were included in the aggregation process would possibly have been filtered out if compared to the more efficient DMUs in all business units as one cohort. This is discussed in the next section.

There is an equally strong argument presented concerning the outlier impact when the number of DMUs increases dramatically. This is because as the number of units in the analysed set increases "the lower the homogeneity within the set, increasing the possibility that results may be affected by some extraneous factors which are not of interest" (Golany and Roll 1989, p. 239). Some outliers or extraneous factors in the larger cohort may exist on the production frontier thus changing the envelopment surface used for peer comparisons and affecting which ones are rated as efficient. This does not seem to have occurred in Trial 1 with 231 DMUs because the ‘core 11 efficient’ ones were stable across all the three trials.

Trial 3 was conducted with greater numbers of output factors, eight instead of the one CSRMC. While the number of DMUs remained the same at 231, the opportunity for an outlier effect may come from the extreme measures presented in any of these additional variables. This may project a DMU to the production frontier because of the new computation by the DEA algorithm. Some of these de-segregated variables may thus distort the results by providing DMUs with an efficiency rating of unity which they would have not otherwise achieved. The possibility that this has occurred will be evaluated in Section 6.4.3 where correlations for input and output factors are presented.

6.3.4 The Aggregation and De-aggregation Impact

> The purpose of such categorisation is twofold: one is to gain a better relative assessment of efficiency, by comparing performance within sub-groups of units operating under similar conditions…The other is a comparison between categories. (Golany and Roll 1989, p. 245)

There are implications from this statement that apply to aggregation of variables and values. Trial 2 was conducted with efficiency comparisons made relative to DMUs within the same business unit cohort, of different sample quantities, and results were later aggregated for comparisons against other trials results. In this trial the computations excluded any ratings relative to the total cohort. This could explain why more efficiencies were recorded. As mentioned earlier, those additional DMUs which were identified as efficient when compared ‘relatively’ to others in a smaller sample would have failed in comparisons to a greater sample. This phenomenon is also reported by Golany and Roll (1989). When aggregating individual business units to compare against trials one and three, some of the DMUs included in the aggregation process should possibly have been excluded. This aggregation could explain the efficient DMUs additional to the robust 11 DMUs identified as efficient across all trials.

Trial 3 was based on the de-aggregation of the output factor CSRMC into the component factors that were viewed as variables indicative of CSR. While the 'robust 11' were again supported, additional DMUs not previously identified were rated as efficient. Why are new DMUs revealed?

It is suggested that this is the consequence of reversed aggregation. The CSRMC variable as originally defined and tested was a holistic measure, in part to capture the output as a whole, rather than individual components of CSR which are then aggregated. There are a number of possibilities for these newly rated efficient DMUs:

- the de-aggregated variables include 'outliers', as described in Section 6.3.3;
- the de-aggregation variables are assigned weightings by the DEA algorithm where, in the absence of proscription by the researcher, DEA selects weights that will maximize efficiency outcomes;
- this process has responded to the distortion of introducing variables not strongly correlated to CSR but claiming to be so; and
- the extent to which the input and output factors are continuous or discrete variables is unknown.

The de-aggregation of variables also means that, in accordance with the DEA computation, each is weighted relative to its influence on the final efficiency calculation. This obviates the discretionary weighting of these particular factors that the managers of the DMUs may have imposed, potentially overemphasizing some variables while devaluing others, resulting in some DMUs being elevated to a higher status. In other words, some variables are under greater control of managers while others are not. DEA can cope with discretionary and non-discretionary variables such as these, provided they are segregated at the outset. This was not done nor considered in the design of the investigation for this thesis. In addition to the possible explanations above, the additional efficient DMUs may reflect the discord between CSRMC as an unique holistic measure and those variables chosen as its components. This suggests that those variables now representing the output factor of CSR may not be strongly correlated to CSRMC. Hence, it may be pertinent to have done a correlation analysis of those factors that were going to represent the de-aggregated CSRMC. In the absence of those variables having correlation support, it can be posited that not all of them are related to CSR as represented by the CSRMC construct and thus impose a distortion to the final list of efficiently rated DMUs.[11] Not withstanding this, it must be remembered that the 'robust 11' are part of the final list and that there are also additional DMUs that exist in both Trial 2 and Trial 3. Coelli et al (2005) discuss the importance of correct aggregation and suggest that there are some guidelines for admissible aggregation. For example, in the aggregation of input and output factors of commodities the Hicks and Leontief conditions provide a guide but such a guide, does not seem to exist for CSR.

Trial 3 disaggregated CSRMC into a number of composites resulting in additional DMUs being identified as efficient. Does CSRMC represent a continuous dimension which is not simply the summation of a number of discrete variables? Or, if CSRMC can be a summation of discrete variables, do the ones presented in Trial 3 fully cover CSRMC? These are unanswerable questions in the current study but may provide some explanation for efficient DMUs that appear only in Trial 3 and again would warrant further research as suggested in Section 6.3.2 earlier.

6.3.5 The Quantification of Qualitative Data

An oft cited criticism of DEA is that:

> DEA yields relative efficiencies only, within the examined group of DMUs. Outcomes are also dependent on the factors entered into an analysis and the numerical values accorded to qualitative factors. (Golany and Roll 1989, p. 247)

The implication of this statement is that of factor selection. This has been discussed in Section 3.3.2 and shown in Figure 3.2. While the factors should be screened in the validation process, factor selection may still be pertinent to the results of this study because of the quantification of qualitative values in a construct such as CSR. This has been discussed previously in sections 5.2.2 and 5.3.1 but is worth reiterating. Quantification of a qualitative value is a novelty of the DEA technique which gives it strength because qualitative factors can now participate in the mathematical evaluation

[11] Note that this is later revealed when the DEA computation as part of its printout produces correlation results which support this premise.

of efficiency. However, this may result in a disproportionate representation of the impact of these factors in comparisons made relative to other quantitative factors.

While the usual practice is to locate some measurable surrogate variable that bears some known relation to the varying levels of the qualitative factor, the choice of factor should reflect a significant degree of congruence between the factor and the surrogate as well as the ability to express this in some functional form. How well this is done is uncertain, particularly when dealing with certain variables in CSR that are inherently qualitative. Consequently, this also raises the issue of weighting the factors (as discussed in Section 4.6.1). Instead of allowing the DEA algorithm to assign weights according to an overall beneficial outcome per DMU, which "can be viewed in some cases as covering up the most serious deficiencies of the DMU being analysed" (Golany and Roll 1989, p. 245), it may be more appropriate to specify weights by a method such as the analytical hierarchy process (AHP). If knowledgeable judges are available for factor selection a recursive technique such as the Delphi method could also be employed.

6.3.6 Explaining Efficiency versus Describing Efficiency

'Factors determining efficiency versus factors explaining efficiency' is often a problem of distinction. Those that explain efficiency may "blur the overall picture and reduce the distinction between compared units" (Golany and Roll 1989, p. 241). Trials 1 and 2 retained the output factor to a single CSRMC value that was derived by the original author (Black 2004) as an overall measure of CSR. In Trial 3 the eight output variables were selected as indicative factors of CSRMC (see Tables 5.2 and 5.3). These could possibly be explaining factors as described by Golany and Roll, in which case they obscure the way some factors affect performance. This phenomenon, if present in the current study, could partially explain the 22 unmatched DMU efficiencies in Trial 3.

Furthermore, if descriptive factors are generally used in the comparisons there is a chance that a descriptive factor which appears different to a determinant factor is actually the same factor but named differently. The effect of a variable that appears say twice in a different guise is to amplify the contribution of that variable. This type of problem has been identified (Golan and Roll 1989) and a remedy proposed. The procedure is to carry out a series of regression analyses on known input and output factors, one at a time.

A weak relation to inputs and strong relation to outputs indicates a leaning towards classifying that factor as an input. Similarly, an opposite result would indicate a leaning towards an output classification. Additionally, a weak relation to all factors should suggest a re-examination of that factor or its elimination, while strong relations would indicate the opposite. Fortunately the DEA-Solver-Pro program used in this thesis provides tabulated correlations of factors in the summaries of the computations needed to identify the efficient DMUs.

Black's (2004) regression of factors, in Section 5.3.1, showed correlations of the indicative factors to all be significant at the 0.01 level, with significant ANOVA support for the 8 dimensions of CSRMC. This is pertinent to section 6.4.

6.3.7 The Effect of Input Congestion and Exogenous Factors

The curve representing a production function is the piece-wise frontier constructed by DEA as discussed in Chapter 4, so that efficiency measures can be calculated relative to this surface. In some instances the production function may turn downwards presenting a negative slope for some values and thus causing the "isoquants to bend backwards and obtain a positive slope at some point" (Coelli et al. 2005, p. 195). This can be explained as being due to congestion in the use of the input to the extent that it has a negative marginal product. It is usually argued to exist because of constraints not under the control of management, in situations where pressures from outside the organisation limit efficiency-seeking strategies. The 'congestion inefficiencies' in these instances are contrary to the assumption of strong disposability in inputs and outputs, implicit in standard DEA models. Such external factors may explain some discrepancies in Trials 1 and 2 where DMU efficiencies may reflect responses to pressures from external stakeholders who are acknowledged as having an interest in CSR. This type of problem can be addressed by changing the inequalities in the linear programming equations for inputs, so that strong disposability in the input assumption is replaced with weak disposability. Analogous output disposability assumptions can be similarly accommodated.

Furthermore, the basic DEA models have an implicit assumption that all inputs and outputs are discretionary, i.e. controlled by management.

"However, there may exist exogenously fixed or non-discretionary inputs or outputs that are beyond the control of a DMU's management (Charnes et al. 1994, p. 50)." This could further explain some of the results in Trial 2 and Trial 3.

6.3.8. Efficiency versus Productivity

The study of the piece-wise frontier representing the production function is also important because of a common misunderstanding of the fundamental difference between productivity and efficiency. Productivity is the ratio measure of output to inputs and when all (input and output) factors of production are considered it becomes known as total factor productivity. Efficiency has erroneously become synonymous with this measure. By referring to the early diagrams in Chapter 4 the technical efficiencies are shown as the rays from the origin to the positions on the production frontier where the efficient DMUs operate. Other, non-efficient DMUs are not on this surface and therefore are inefficient by the amount of distance to the nearest point on the production frontier where they are headed. But while all points on the frontier are technically efficient, some have higher productivity. The gradient of the ray from origin to this frontier represents the ratio of the x axis variable to the y axis variable and hence productivity. At different points on the frontier this gradient may be greater than at other points and therefore show higher productivity but equal efficiency. This is possible because the higher productivity DMUs are exploiting scale economies and operating under these more favourable conditions. This presents the formal argument and support for the discussion of VRS in Section 6.3.2 earlier.

The implication of the results for the trials in this study is that different DMUs in the cohort come from samples of different operational departments and divisions within the organisation which, implicit by the very nature of their functional duties, operate on different levels of economic scale. There is particular difficulty in assessing this influence since the data was not originally obtained with this purpose in mind. The relationships between CSR and economies of scale may warrant a separate study in its own right.

6.4 The CSR Construct

The argument supporting CSR as a construct of CG has been presented in Chapter 5. The identification of the factors underlying CSR was then developed from the work of Black (2004) and previous researchers, discussed in Chapter 2. The measurement of these factors was then undertaken with DEA, and the results of trials and tests are shown in Chapter 5. A summary and review of these may assist further analysis and interpretation of the results.

The final trials were conducted on a refined selection of input and output factors. There were six input factors and one output factor of CSRMC, except when this was expanded to eight output variables for Trial 3. The most conservative and strongly supported results were presented in Trial 1. These findings are considered the most suitable to benchmark against as they identified 11 efficient DMUs from the study cohort of 231. The same 11 also turned up in the next two trials thus giving strong support that they were truly the best performers. From this stance we can make observations of the results and compare findings.

The input and output factors as determinants of efficiency using DEA are listed here for convenience.

Input Factors (with study abbreviations and brief descriptions from Table 5.3):

1) Commacc — Communication accuracy where communication is understandable, honest and accurate.
2) Humanist — Humanistic orientation indicating a participative style of management.
3) Integeth — Integrated ethics which includes ethics in everyday practices.
4) Manageth — Management commitment to ethics by talking and demonstrating ethics for the good of the company and society.

5) Pos Perceived organisational support through feelings of empowerment.

6) Justice Distributive justice and ethical behaviour based on fairness of process and outcome.

Output Factors CSR Management Capacity when expanded to its eight indicative factors (as described by Black 2004)

1) Stakid Stakeholder Identity – people understand how the firm's future is linked with its stakeholders.

2) Stakman Stakeholder Management – business decisions take stakeholder needs into consideration.

3) Valueatt Value Attuned Public Affairs – public affairs contribute to business strategy with information about stakeholder values.

4) Dialogue A respectful attitude and power-sharing over the agenda for discussion.

5) Ethicomm Ethics Compliance – ethical behaviour is reinforced through formal systems of rewards and punishments.

6) Ethicatm Ethics Atmosphere – people sincerely care about the wellbeing of others

7) Acctyid Sense of Social Accountability – managers feel accountable to stakeholders for the firm's social impacts.

8) Acctyre Social Accountability Reporting – people perceive that the firm substantively accounts for its social performance without spin.

The computation of DEA rated efficiency scores for DMUs provided by DEA–Solver-Pro also produces a number of additional reports as shown in Section 5.4.2. One of these that becomes useful at this stage of diagnosing the efficiencies and inefficiencies of all the DMUs, as well as presenting figures that support or weaken the inclusion of the chosen variables, is the table of correlations (see below). The descriptive statistics of maximum and minimum rating scales, with average and standard deviation scores, are presented as precursors to the correlation table which shows inter-item correlations as well as correlations between the dependent and independent variables. In this case these are the correlations between the input and output factors. There are other descriptive printouts, but these are not necessary for this discussion.

These correlation tables are presented below as follows: Table 6.3 shows the results for Trial 1; Table 6.4 shows Trial 2 correlations for each of the six business units individually; while Table 6.5 shows those for the third trial which expands the CSRMC output into its constituents.

6.4.1 Correlations for Trial 1

Table 6.3 Correlations for Trial 1

Trial 1 Correlations

Statistics on Input/Output Data

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	7	5	5	5	5	5	6.87
Min	1	1	1	1	1	1	2.32
Average	4.231	3.621	2.826	3.047	3.165	3.270	5.083
SD	1.296	0.797	1.110	0.834	0.979	1.036	0.777

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.312	0.312	0.284	0.308	0.237	0.345
Humanist	0.312	1	0.386	0.509	0.555	0.320	0.621
Integeth	0.096	0.386	1	0.386	0.388	0.231	0.422
Manageth	0.284	0.509	0.386	1	0.596	0.283	0.642
Pos	0.308	0.555	0.388	0.596	1	0.462	0.620
Justice	0.237	0.320	0.231	0.283	0.462	1	0.421
Csrmc	0.345	0.621	0.422	0.642	0.620	0.421	1

Note: Shading indicates correlation below r=0.345

This table shows correlations between the six input factors and the output factor CSRMC. The value of r = 0.345 for input variable Commacc, communication accuracy, is the lowest correlation in the trial where eleven DMUs were identified as efficient. Since Trial 1 has unreservedly identified eleven commonly rated DMUs across all trials it may be chosen as the baseline suited to the task of making comparisons of correlations across variables. This follows the style of the DEA technique which is rooted in relative comparisons for efficiency determination. If r = 0.345 is also used for inter-item correlation of input variables, then Table 6.3 shows eight values below this level, notably Justice (fairness of process) which underscores on four occasions, followed by Commac, another four occasions. In Tables 6.3 through to Table 6.5 those cells which have correlations below r = 0.345 are shaded to ease their visibility for this discussion.

6.4.2 Correlations for Trial 2

In Trial 2 the six business units were assessed individually with the results below.

Table 6.4 Correlations for Trial 2 Unit A

Unit A

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	5.2	4	3.33	4.88	4.2	5	6.29
Min	2	2	1	1.13	2	2	3.78
Average	4.284	2.998	2.332	2.815	3.067	3.722	4.977
SD	1.117	0.654	0.882	1.356	0.862	1.039	0.887

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.893	-0.519	0.753	0.389	0.240	0.718
Humanist	0.893	1	-0.373	0.801	0.389	0.463	0.917
Integeth	-0.519	-0.373	1	-0.564	0.263	0.161	-0.475
Manageth	0.753	0.801	-0.564	1	0.380	-0.114	0.862
Pos	0.389	0.389	0.263	0.380	1	0.045	0.166
Justice	0.240	0.463	0.161	-0.114	0.045	1	0.336
Csrmc	0.718	0.917	-0.475	0.862	0.166	0.336	1

Note: Shading indicates correlation below r=0.345

Unit A reveals that Integeth (integrated ethics in everyday practice) underscores in correlations against all other factors. Justice underscores on 5 of 6 occasions while Pos (perceived organisational support) fails three times and Manageth (management commitment to ethics) twice. Humanist (participative management style) correlates with all except Integeth.

Table 6.5 Correlations for Trial 2 Unit B

Unit B

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	7	5	5	5	5	5	6.55
Min	1.6	1.44	1	1.5	1	1.33	3.64
Average	4.057	3.594	2.913	3.162	3.383	3.366	5.177
SD	1.257	0.735	1.187	0.831	0.919	0.911	0.725

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.478	0.028	0.161	0.470	0.185	0.398
Humanist	0.478	1	0.353	0.486	0.573	0.303	0.727
Integeth	0.028	0.353	1	0.354	0.415	0.305	0.497
Manageth	0.161	0.486	0.354	1	0.670	0.260	0.649
Pos	0.470	0.573	0.415	0.696	1	0.277	0.654
Justice	0.185	0.303	0.305	0.260	0.277	1	0.342
Csrmc	0.398	0.727	0.497	0.649	0.654	0.342	1

Note: Shading indicates correlation below r=0.345

Unit B shows Commac underscoring on 3 of 6 occasions, Integeth and Manageth on 2 of 6 while Justice however, underscores throughout, 6 of 6 for this business unit.

Table 6.6 Correlations for Trial 2 Unit C

Unit C

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	7	5	5	5	5	5	6.62
Min	1	1.89	1	1	1	1	3.24
Average	4.287	3.686	3.073	3.206	3.238	3.246	5.176
SD	1.348	0.774	1.106	0.854	0.919	1.182	0.713

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.367	0.103	0.417	0.388	0.210	0.479
Humanist	0.367	1	0.218	0.459	0.465	0.319	0.519
Integeth	0.103	0.218	1	0.401	0.282	0.092	0.247
Manageth	0.417	0.459	0.401	1	0.547	0.311	0.634
Pos	0.388	0.465	0.282	0.547	1	0.519	0.544
Justice	0.210	0.319	0.092	0.311	0.518	1	0.473
Csrmc	0.479	0.519	0.247	0.634	0.544	0.473	1

In unit C the Commac (2of 6), Integeth (5 of 6) and Justice (4 of 6) again all show scores under the correlation threshold. Pos shows 1 of 6 in this case.

Table 6.7 Correlations for Trial 2 Unit D

Unit D

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	6.8	5	5	4.38	5	5	6.69
Min	1.6	1	1	1.13	1	1	2.32
Average	4.266	3.483	2.637	2.669	2.677	2.918	4.770
SD	1.291	0.913	1.052	0.756	1.048	0.984	0.875

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.217	0.234	0.277	0.366	0.4605	0.296
Humanist	0.217	1	0.424	0.531	0.640	0.290	0.582
Integeth	0.234	0.424	1	0.471	0.382	0.179	0.547
Manageth	0.277	0.531	0.471	1	0.643	0.207	0.580
Pos	0.366	0.640	0.382	0.643	1	0.481	0.676
Justice	0.460	0.290	0.179	0.207	0.481	1	0.394
Csrmc	0.296	0.582	0.547	0.580	0.676	0.394	1

Note: Shading indicates correlation below r=0.345

Unit D has Commac (4 of 6), Integeth (2 of 6), Manageth (2 of 6) and Justice (3 of 6), and Humanist (2 of 6) as scores under the correlation threshold.

Table 6.8 Correlations for Trial 2 Unit E

Unit E

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Min	2	2.33	1	1.63	1	1.83	3.98
Average	4.362	3.675	2.553	3.098	3.378	3.441	5.255
SD	1.307	0.670	1.040	0.672	0.904	0.854	0.667

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.255	0.084	0.175	0.086	0.055	0.232
Humanist	0.255	1	0.642	0.443	0.574	0.467	0.727
Integeth	0.084	0.642	1	0.361	0.493	0.448	0.577
Manageth	0.175	0.443	0.361	1	0.406	0.279	0.533

Pos	0.086	0.574	0.493	0.406	1	0.465	0.625
Justice	0.055	0.467	0.448	0.279	0.465	1	0.474
Csrmc	0.232	0.727	0.577	0.533	0.625	0.479	1

Note: Shading indicates correlation below r=0.345

Unit E shows all Commac, one Humanist, and one Integeth, as well as 2 of 6 Manageth, one for Pos and two for Justice.

Table 6.9 Correlations for Trial 2 UnitF

Unit F

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	6.2	5	5	4.88	5	5	6.6
Min	1.6	2.44	1	2	2	1.33	3.58
Average	4.056	3.987	3.203	3.353	3.444	3.686	5.149
SD	1.188	0.728	1.032	0.677	0.726	0.977	0.691

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.207	0.242	0.428	0.165	0.336	0.218
Humanist	0.207	1	0.554	0.632	0.478	0.128	0.656
Integeth	0.242	0.554	1	0.612	0.547	0.318	0.530
Manageth	0.428	0.632	0.612	1	0.520	0.280	0.806
Pos	0.165	0.478	0.547	0.520	1	0.381	0.327
Justice	0.336	0.128	0.318	0.280	0.381	1	0.204
Csrmc	0.218	0.656	0.530	0.806	0.327	0.204	1

Note: Shading indicates correlation below r=0.345

Unit F has once again Commac and Justice as stand-out underscorers, with Humanist, Integeth and Pos all with 2 of 6 below accepted correlations, and Manageth with one.

Trial 2 was scrutinized in Section 6.3.1 above because it breached one of the accepted conditions for successful DEA application. The correlations presented in Table 6.4 further supports a rationale for excluding these results from further analysis. Notably, Unit A has eight input factors which are below the standard with some as negative correlations. There are also three output correlations below this value. This unit was also highlighted as having scores aberrant to the other two trials as well.

Units B and C have seven input and one output item below the acceptance level while D and E have six input and one output item below acceptance, surprisingly similar yet not unexpected since they were not questioned in the earlier analysis. Unit F, as with Unit A, is a standout non-conformer. It has seven inputs and three outputs, a total of 10 unacceptable correlations

6.4.3 Correlations for Trial 3

Table 6.10 Correlations for Trial 3, Expanded Output Factors

	COMMACC	HUMANIST	INTEGETH	MANAGETH	POS	JUSTICE	STAKID	STAKMAN	VALUEATT	DIALOGUE	ETHICCOM	ETHICATM	ACCTYID	ACCTYREP
Max	7	5	5	5	5	5	7	7	7	7	7	7	7	7
Min	1	1	1	1	1	1	1	2	1	1	2	1	1	2
Average	4.236	3.621	2.827	3.045	3.165	3.270	5.427	5.551	4.721	4.708	5.681	3.765	5.198	5.375
SD	1.298	0.797	1.110	0.833	0.979	1.036	1.076	1.113	0.954	1.014	0.964	1.374	1.183	1.048

INPUT FACTORS

	COMMACC	HUMANIST	INTEGETH	MANAGETH	POS	JUSTICE	STAKID	STAKMAN	VALUEATT	DIALOGUE	ETHICCOM	ETHICATM	ACCTYID	ACCTYREP
COMMACC	1	0.311	0.096	0.282	0.310	0.239	0.268	0.251	0.175	0.249	0.254	0.306	0.343	0.228
HUMANIST	0.311	1	0.387	0.510	0.556	0.319	0.466	0.247	0.392	0.561	0.537	0.512	0.578	0.394
INTEGETH	0.096	0.387	1	0.388	0.388	0.229	0.415	0.165	0.268	0.383	0.454	0.367	0.376	0.228
MANAGETH	0.282	0.510	0.388	1	0.596	0.282	0.549	0.292	0.467	0.545	0.508	0.487	0.520	0.397
POS	0.310	0.556	0.388	0.596	1	0.462	0.565	0.323	0.408	0.496	0.466	0.597	0.504	0.346
JUSTICE	0.239	0.319	0.229	0.282	0.462	1	0.339	0.265	0.301	0.348	0.255	0.347	0.335	0.288

OUTPUT FACTORS

STAKID	0.268	0.466	0.415	0.549	0.565	0.339	1	0.454	0.556	0.643	0.464	0.522	0.592	0.514
STAKMAN	0.251	0.247	0.165	0.292	0.323	0.265	0.454	1	0.388	0.432	0.334	0.228	0.444	0.314
VALUEATT	0.175	0.392	0.268	0.467	0.408	0.301	0.556	0.388	1	0.613	0.430	0.399	0.514	0.551
DIALOGUE	0.249	0.561	0.383	0.545	0.496	0.348	0.643	0.432	0.613	1	0.514	0.550	0.693	0.562
ETHICCOM	0.254	0.537	0.454	0.508	0.466	0.255	0.464	0.334	0.430	0.514	1	0.451	0.557	0.422
ETHICATM	0.306	0.512	0.367	0.487	0.597	0.347	0.522	0.228	0.399	0.550	0.451	1	0.475	0.388
ACCTYID	0.343	0.578	0.376	0.520	0.504	0.335	0.592	0.444	0.514	0.693	0.557	0.475	1	0.588
ACCTYREP	0.228	0.394	0.228	0.397	0.346	0.288	0.514	0.314	0.551	0.562	0.422	0.388	0.588	1

Note: Shading indicates correlation below r=0.345

Trial 3 contended that if CSRMC was the measure that represented CSR, then the crucial variables could be elicited by expanding this output to include the indicative factors as expressed by the eight output variables.

The correlations in Table 6.10 do not fully support this. Stakeman fails to achieve correlation thresholds against all input factors and on three occasions against the other seven output factors. Acctyrep and Valueatt fail the correlation threshold against three of the six input factors.

6.4.4 Correlation Summaries for all Trials

In Trial 1 all input factors correlated with CSRMC. Inter-item correlations between each input factor against the other five showed (in Table 6.3) that Commac failed on all occasions while Justice failed on four of five occasions. This is shown by the success of each factor in Table 6.11 below.

Table 6.11 Summary of Acceptable Correlations for Trial 1

Correlation of Items Exceeding Acceptability Threshold		
Inter-item Input Factors		Output Factor CSRMC
Commac	0 of 5	All
Humanist	4 of 5	All
Integeth	4 of 5	All
Manageth	4 of 5	All
Pos	5 of 5	All
Justice	2 of 5	All

Trial 2 was the most equivocal of the three trials because it failed to satisfy the conditions as specified in Section 6.3.1, but it still revealed results that suggest Commac and Justice are questionable input variables. Since there were six business units each with input variables being correlated against five others, we are able to calculate how many of the inter-item correlations were acceptable. This is shown in Table 6.12 as a summary of Table 6.4 through to Table 6.9. Similarly, in Trial 3 the inter-item correlations were conducted for each input variable against five other inputs and eight outputs so that correlations could be tabulated as successes against 13 comparisons. Notably, Trial 2 and Trial 3 produced results which do not support Commac and Justice as strong input factors (see Table 6.12).

Table 6.12 Summary of Acceptable Correlations in Trial 2 and Trial 3

Successful Correlations		
Input Factors	Trial 2 (30 comparisons)	Trial 3 (13 comparisons)
Commac	14	0
Humanist	22	10
Integeth	18	8
Manageth	26	10
Pos	28	11
Justice	12	3

The three trials all produced correlations for the six input factors. The aggregated results of tables 6.11 and 6.12 are summarized in Table 6.13 below.

Table 6.13 Aggregated Correlations of All Trials for Six Input Factors

Aggregated Correlation Totals for all Trials				
Input Factors	Trial 1	Trial 2	Trial 3	Total
Commac	0	14	0	14
Humanist	4	22	10	36
Integeth	4	18	8	30
Manageth	4	26	10	40
Pos	5	28	11	44
Justice	2	12	3	17

Table 6.13 shows strong correlation support for four of the input factors. These are those that represent humanistic or participative style of management, integrated ethics in everyday practice, management commitment to ethics by talking and demonstrating good ethics, and perceived organisational support. The two factors that rated poorly are communication accuracy and distributive justice or fairness of process and outcome.

In Trial 3 the single CSRMC output factor was de-segregated into the eight output variables so that these can also be correlated against the input factors. Stakman did not correlate acceptably on any occasion while Valueatt and Acctyrep only matched on three of six occasions as drawn from Table 6.10 and shown in Table 6.14 below.

Table 6.14 Trial 3 Correlations of Output Factors to Inputs

Trial 3 Acceptable Correlation	
Output Factors	Number of Acceptable Input Factor Correlations
Stakid	5 of 6
Stakman	0 of 6
Valueatt	3 of 6
Dialogue	5 of 6
Ethiccom	4 of 6
Ethicatm	5 of 6
Acctyid	4 of 6
Acctyrep	3 of 6

Stakman is stakeholder management where business decisions consider the stakeholder, valuatt is the value attuned public affairs contribution to business strategy, while acctyre is social accountability reporting where people perceive that the firm substantially accounts for its social performance without spin. Interestingly, the strongly supported correlations are the four: stakeholder identity where people understand the firm's future is linked to stakeholders; dialogue which is respectful attitude and power sharing; ethicom and ethicatm representing ethics compliance and atmospheres; and acctyid which is the sense of accountability to stakeholders.

6.5 Conclusion

This chapter analysed the results of trials where DEA was used to measure the construct of CSR. It addressed the application of the DEA algorithm to CSR, the heuristics for its application and the suitability of the model. It also found idiosyncratic features of DEA which were relevant to CSR. Finally it assessed the correlations produced by DEA to identify the strength of input and output factors of CSR.

The application of DEA to CSR proved successful in identifying 11 efficient DMUs in all trials. This was a robust result. It identified further efficient DMUs, 25 common ones in the later trials with a maximum of 64 in one trial. The possible explanations for the additional efficient DMUs came from further analysis. In relation to CSR the DEA algorithm measured a construct with factors such as communication, humanistic management, practices demonstrating integrated ethics and organisational support, leading to a metric for CSRMC. By their very nature these factors are qualitative descriptors with amorphous characteristics, yet DEA was able to solicit efficient DMUs. The CCRDEA model is the most strict and conservative version of the algorithm and thus usually of first choice. In this case the relationship between the input and output factors is assumed to be linear but may not be necessarily so. Other versions such as the Cobb Douglas model could be more appropriate.

There are heuristics which are claimed to assist in structuring the DEA problem, but no formal rules as such. The necessary task of selecting the appropriate DMUs, the proper input and output variables, and the number of each, is often undertaken by ‘trial and error’. The three ‘rules of thumb’ adopted for this study showed that Trial 2 was in breach of one of the rules and anecdotally was less in accord with the results produced by the other two trials. This would suggest that the findings of this trial, additional to those consistent with the other two trials, are questionable and should be discarded for the purposes of this thesis. It should be noted however, that those findings of Trial 2 consistent with the other trials actually reinforce their acceptance since a poor trial still endorses the ‘core 11 efficient DMUs’.

DEA as a non-parametric technique has some idiosyncratic features which stands it apart from other methods such as regression analysis and hypothesis testing. It is an extreme point technique which can be adversely affected by deviant DMUs. Usually labelled as ‘outliers’, these DMUs that exist on the production frontier and have characteristics unlike those common to the group can significantly impact the categorization of efficient units. DEA also is unique in its attribution of weights or ‘multipliers’ to the input and output factors. In the absence of defined weight constraints, it selects the weights which enhances each DMU’s movment toward the efficient frontier, but which can be assigned a priori by the researcher.

DEA also assumes that all the variables can be varied at the discretion of management or others, when in fact there exist ‘non-discretionary’ variables not subject to management control. These ‘exogenously fixed’ variables can be included by formulating a modification to the CCR or BCC model.

There are many versions of the DEA model developed since its inception and designed to accommodate the characteristics of ‘real world’ problems. It is no different in this situation. The CCR DEA model was chosen because of its historical strength. It has been used and validated extensively since its inception. It also provides the strictest and therefore the most conservative criteria for unit efficiency comparisons. One characteristic of the CCR model is its constant returns to scale which reflects the linearity of the relationship between inputs and outputs. The analysis suggests that the BCC model may have been more appropriate because through VRS it does not stipulate linearity as a requirement. Furthermore, the additive model as an extension to the BBC model would also explain the differences between efficiency and productivity discussed earlier. It could similarly accommodate the input congestion phenomenon.

A novelty of DEA is its ability to work with qualitative values. They have to be assigned numerical values to participate in the mathematical evaluation of efficiency. The usual practice is to find a measurable surrogate with a known relation to the qualitative factor. This is particularly appropriate to CSR and the success of DEA hinges on the validated quantification of these variables.

When all factors for CSR were analysed for correlations above the $r = 0.345$ baseline, the support for the construct was strengthened. The value of 0.345 was chosen as the threshold for acceptable inter-item correlations because this was the lowest correlation value for the CSRMC metric. In doing so, all trials fully supported the choice of the ‘core 11 efficient’ DMUs while identifying Commacc and Justice as questionable input variables. Many correlation values below the acceptance threshold in Trial 2 supported the exclusion of the results from this trial. On the other hand, Trial 3 supported most of the factors indicative of CSRMC with the exception of Stakman, Acctyrep and Valueatt. Generally, the analysis of correlations provides support for the findings discussed above.

The implications of these findings and their bearing on the construct will be discussed in the following chapter.

Chapter 7

Implications for OBPM, SCM and Organisation Design

If I have seen further than others
it is by standing upon the shoulders of giants.
Sir Isaac Newton 1642-1727

7.1 Introduction

This chapter will discuss the research findings in terms of the implications of an OBPM model for enterprises in the contemporary global knowledge economy. It will answer the question of what the results of the research mean and how the findings can be extrapolated to further develop the model and broaden its applicability to any firm operating in the new era of global knowledge economics. The need to develop this new framework is argued on the basis that practices of the past are inappropriate for businesses of the future, and that the major findings of this research support a new approach based on the tenets of this thesis. The way forward is then viewed as a series of steps defined in a proactive strategy focused on corporate change to the new mode of operations. What must change is discussed, as is the ultimate objective.

7.2 Implications of the Results

The research investigating the framework for an OBPM model of productive units in the supply chain of an Australian enterprise achieved its objectives. It identified the humanistic management style as the participative mode of organisational behaviour enhancing the performance of the enterprise. In particular, through CSR, with the indicative factors of CG including stakeholder engagement, ethical business behaviour, social accountability, value communication and dialogue, DEA was able to distinguish the organisational business units which were at the forefront of efficiency in the enterprise, and that communication and dialogue were only minor factors. This ability to identify the successful DMUs supports the PM methodology of OR through the DEA algorithm. The enterprise which was the subject of this research is a major Australian bank operating nationally and globally.

To be successful it must be responsive to the competitive forces, processes and methods that drive performance in a modern global business, as well as being able to address stakeholder concerns. It is clearly responding to these as demonstrated by its achievement of a number of national and international awards. Its performance and accolades reflect that it takes the interests of stakeholder groups along with their contribution and importance to every stage of the production and supply chain.

The critical review and assessment of past research in the field of OB theory and supply chain performance in a contemporary global environment, with its emphasis on rapid knowledge transference, governance and sustainability, led to the development of a new approach to analysing organisational performance by using DEA to measure this performance in a modern enterprise. Other performance metrics and measurement processes were found to be myopic and often fragmented, reflecting the use of historical modalities to analyse contemporary systems.

The new model was tested, and the new approach applied quantitative methodology to field data, thus validating the framework by identifying strengths and weaknesses in the model. However, this research covered only one aspect of corporate operations and would need further study of the same nature to confidently exptrapolate the model to the rest of the organisation and its SC.

7.2.1 The Need for Further Development

Globalisation, the encroachment of knowledge-empowered advanced economies on world affairs, and the quest for sustainability of operations globally, reaffirms the need for a new approach to doing business. The OECD's (2006b) 'Conference on Globalization and the Knowledge Economy' identifies one facet of globalization that remains in relative obscurity; what is the link between innovation, structural change and productivity growth on the one hand and cross-border linkages? The Issues Paper of that conference commences with new evidence on globalization and its impacts: current globalization is driven by strong growth in trade and foreign investment; value chains are becoming increasingly globalised through ICT facilitation, meaning the production process is fragmented across many countries; international outsourcing of inputs create arms-length relationships; and there are more intermediaries in the value chain.

Global value chains positively affect some countries (those starting from a low base) but this is mitigated by the intensity of the technology required in particular industry sectors, and while globalization contributes to falling manufacturing employment its de-industrialisation effect is largely domestic. Finally, there are a variety of positive as well as negative effects, with the negative ones generally regarded as relatively short term. Globalisation results in higher firm productivity but for advanced knowledge economies this means moving up the value chain (Porter 1998) because specialization in traditional cost-based industries is a much less viable option. The shift should be to more technology and more knowledge intensive activities, but globalization also means that the related R&D activities, including R&D facilities and investments, will also become globalised. Furthermore, Manning and Baines (2004) note that the 2002 Commission of the European Communities' statement of the goal for the EU to "become the most competitive and knowledge based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion" identifies CSR as a major strategy for meeting this goal. The bank studied in this research has recently (2007) begun advertising its number one global rating for CSR.

Industries should integrate into a single policy the social and environmental concerns in their operations and their interface with internal and external stakeholders. The costs of social and welfare legislation are key factors in an organisation's competitiveness. To quote Manning and Baines:

> Global governance and the interrelationship between foreign direct investment, trade and sustainable development are key dynamics to CSR policy and the demands of both internal stakeholders and those of external stakeholders for more sustainable investments, compliance with internationally accepted standards and agreed instruments. The interest in CSR benchmarking for social and environmental performance has led to an increase in guidelines and codes of practice and also to social accountability. (p. 12)

These observations and projections support the contention of this thesis that the present and future strategies of businesses in advanced knowledge economies do not benefit by using antiquated management theories, traditional supply chain concepts and stultified division of labour principles. Instead there is a need to redesign organisations, advance holistic frameworks as a means of measuring the performance of these resurrected organisations, and to support further work on developing optimization models such as DEA. The redesign of the enterprise should commence with its commercial position in the global knowledge economy and its standing with regards to governance and sustainability. The redesign of an enterprise for the 21st century follows.

7.2.2 Strategy for Organisation Design of the Future

Setting organisational direction and establishing priorities is a difficult task at the best of times. Planning for the future under incumbent scenarios requires effort at the helms of industry. The senior managers of the organisation need to set future strategy with foresight. They should adopt an OBPM-based strategy and plan for change since there is no question that change is needed. OBPM as described in this thesis is an all-encompassing construct based on certain axiomatic requirements which ultimately dictate the use of quantification through optimisation models. These axioms include empowerment, empathy, business ethics and support for employees. This is no small task and challenging to the best of organisations. Some guidance in undertaking such a strategic change comes from the experiences of Kaplan and Norton (2001) who state that the:

> …key to executing your strategy is to have people in your organisation who understand it, including the crucial but perplexing processes by which intangible assets will be converted into tangible outcomes. (p. 167)

In the knowledge economy businesses must increasingly create and deploy intangible assets such as customer relationships, employee skills and knowledge capital, ICT, and a corporate culture based on humanistic management and its encouragement of localized problem-solving and organisational improvement. An OSTS model considers this as seminal to organisational performance. In fact it encourages it through the vessels of knowledge capital of people and technologically refined processes. We should not be bound to the developments in the 20th century which were based on the optimization of ideas and assumptions of 19th century principles (Van Amelsvoort 2000). The design of the organisation is a critical issue. It should be a quality conscious organisation with focus on customers, and flexible enough to be fully responsive to needs as they change. More importantly, it must be innovative enough to produce an uniqueness in product/service attractive to customers. This may, or may not, require some lateral collaboration with supply chain partners.

The design of the new organisation should ideally comply with the synchronization of four ideal-type models: the efficient organisation, the quality organisation, the flexible organisation and the innovative organisation. Each an ideal type in the past, they evolve and morph into the next as the company learns and grows (a Kaplan and Norton strategy in the BSC). The organisation design for the globalised knowledge economy is one of innovation, with tentacles into the virtual structures and transactions possible on the internet. This is already happening as witnessed by the emergence of some of the biggest companies the world has ever known.

The efficient organisation (type 1) is modeled on Porter's cost leadership competitive position which accentuates the need for efficiency of operations based on proven strategies such as Lean, Six Sigma, JIT, BPR, and sometimes the integration of these (Arnheiter and Maleyeff 2005) as well as the myriad of techniques that are known to work. The efficient organisation of the future will also embrace ICT and the computerisation of many routine tasks and processes, thus releasing human operators to develop and apply their knowledge capital, adding to operational efficiencies. On the next level, the quality organisation (type 2) embraces philosophies such as TQM where good customer relationships are viewed as a competitive weapon. The quest is to provide a quality product/service as defined by the customer and, not unlike the efficient organisation, *kaizen*, or continuous improvement being the focus of attention. Again, this invites employee participation and ownership through various teams-based approaches to solve problems and improve processes. They are supported in their goal by a plethora of kaizen tools, improved channels of communication, increased individual and team responsibilities and, in typical fashion, a flattened organisation hierarchy.

The flexible organisation (type 3) is one which is able to respond to the changing demands of a volatile market. The demands can include faster yet reliable deliveries, greater product range and better service. These demands manifest themselves across the whole supply network requiring a streamlined adaptability by the organisation. Collaboration and cooperative relationships as well as a reduction in the number of steps in processes can lead to reduced lead times and greater customer satisfaction. The ‘order winners’ or ‘critical success factors’ become the primary focus, and management and ancillary processes serve only in supporting roles. ICT can facilitate this by providing information for decision making at the local level, thus again speeding up business processes. This approach to flexibility and responsiveness, and an understanding of supply chain partners’ needs, leads to an anticipatory mode of operation which bridges the organisation to the next type, the innovative organisation (type 4). Uniqueness of product/service provides a competitive advantage, as cited by Porter’s second strategic position. The company can respond quickly and adapt itself to the demands of the new situation. Temporary organisational structures can be created and formal job descriptions diminish under increased person responsibilities. ICT also plays a role by structuring flexibility into the information systems so that information may be readily accessed by those that need it. The culture is customer-oriented together with a focus on the personal development of employees so that they are more empowered and able to handle situations that are not dictated in procedure manuals. This is a feature of humanistic style management.

The strategic requirements to achieve the 21^{st} century organisation design have six dimensions, based on: structure, systems, task content and involvement, employee knowledge and skills, working relationships, and industrial relations. How the 21^{st} century enterprise may look under this design is as follows in Table 7.1.

Table 7.1 Organisation Design for the 21st Century

Strategic Requirements	21st Century Organisation Design
Structure	Organic structures with temporary project-based teams Decentralised staff and support specialists Decentralised R&D Integration of functions: marketing, operations, supply networks Strategically focused
Systems	Rapid innovation-capability Knowledge rewarded Performance rewarded Knowledge and competence management Localized variations encouraged
Task Content and Involvement	Contribution and knowledge focus Job descriptions unimportant Creative tasks fostered
Employee Knowledge and Skills	Personal leadership encouraged Teams supported Customer oriented Drive for constant change
Working Relationships	Cross functional teamwork Team process, communication Work allocation, coordination
Industrial Relations	Participation and direct representation (excluding third parties) Shared vision and interests Financial participation and shared ownership

This organisation design is consistent with the proposal in this thesis of an OSTS system integrating the complete supply network and incorporating governance principles. In the OBPM model, based on the OSTS system, integration occupies a central role since innovation and sustained improvement can only be achieved by a willing and motivated workforce, comprising the social subsystem of OSTS.

In traditional systems complexity and specialization of functions form an integral part of a structure that has worked successfully for many decades. It has been extremely effective because of stable environments, economies of scale, long lead times and handicapped logistics systems. This is no longer the case, so the adaptive, responsive and innovative system is the answer to the design of the new enterprise.

If OSTS were to be implemented in an organisation there are fundamental principles that must be adhered to:

- reduce organisation complexity;
- develop and establish strong ongoing ICT support systems;
- regulate locally through self managed teams;
- disintegrate management but integrate management decisions by decentralizing responsibilities;
- adopt horizontal structures in coordinating decentralized decision-making;
- make the self-managed team the smallest unit based on its task;
- allow self-fulfilment to leadership roles in teams;
- minimize rules and procedures allowing teams to set them;
- promote personal growth, participation and ownership; and
- measure performance on agreed results-based macro-outcomes rather than the minutiae of individual task achievements.

A main tenet of OSTS, rooted in the original theory, is the importance of the 'joint optimisation' of the social and technical subsystems. The organisation design discussed above emphasizes the social and cultural changes needed. The technical system requirements, especially with regard to performance management, is discussed next.

7.2.3 Integrating the PMS into the OSTS Designed Enterprise

The design of organisations in the 21st century must discard systems of the nineteenth and twentieth centuries as mentioned in the above section. This applies equally to those measures that are used to monitor performance of the organisation across all its operations, including the SN. A system of measures, as required in any organisation design, is also required for the OSTS design but adapted to the new environment. While other management systems provide guidance through standards and codes, quality and environment management standards (ISO 9000, QS 9000 and ISO 14000, in Waller (2002)) are examples, there are no such auditable reference models available for PM (Bititci, Carrie and Turner 2002). Those PM systems models discussed in the review earlier, namely BSC, PP, TdeB, etc., are not universally accepted nor do they prescribe system requirements as do auditable reference models of international standards. A new PM system needs to be developed and can be based on the germination of this research.

The new system must mimic the OSTS design and comply with its principles. It must use the organisation hierarchical structure, in this case very horizontal, as a template for the structural relationships between the various measures. Preferably this would be an integrated auditable system which would allow performance comparisons and benchmark standards. Theses standards would reflect benchmarking methodology where overall measures are used in making judgments, and would not be standards built up from traditional 'standard data' type Taylorist systems. These benchmarks could, in many instances be obtained from DEA studies, and in other cases from similar operations research methodologies which provide global organisation metrics.

With the importance of knowledge capital, and the pervasiveness and benefactions of ICT it would be integral to the system that PM be computer-based and internet-facilitated across the complete supply network. The PM system should also facilitate efficiency gains for all collaborative partners in the network because benchmarks of performance could provide the drive for improvement. As an integrated system it would also allow all stakeholders to access performance against their own particular goals, thus maximizing ownership and facilitating proactive management. Furthermore, a PM system should be simple to understand, incorporate control versus improvement measures, and be user-friendly. It should be current, responsive and dynamic, allowing for resources bargaining and movement to where they are best deployed. It should also be able to project trends in the internal and external environments. This is best done, easier to achieve, and most likely to succeed through ICT facilitation.

The PMS model which comes closest to meeting the requirements of an OSTS is the proposal by Bititci, Carrie and Turner (2002), which adopts various systems models and applies business process architecture to a four level hierarchy of the organisation's performance requirements. From the top down these metrics apply to: the business, business units, business processes, and activities. These are described as follows.

> The business operates a number of business units…each business unit operates a number of operating processes, which are supported by a number or support processes. Finally each business process operates a series of activities to fulfill its purpose. (p. 179)

Each of these levels has four elements.

1) Stakeholder Requirements – direction is set on an understanding of the requirements of the stakeholders.
2) External Monitors – monitoring world best practice, competition and developments against stakeholder needs.
3) Internal Objectives – set and deploy targets as needed, identified by gap analysis.
4) Coordinate – monitor, review and communicate through PMS reports.

The Bititci proposal has a number of attractions that can be built on to meet the needs of the OSTS design.

It reflects stakeholder requirements and the external competitive environment to identify critical success criteria. It distinguishes between measures for improvement and those for control, with the ability to distinguish between those that are leading and lagging, and how critical these are. Qualitative measures are also accommodated. Simple communication and direct access to metrics fosters an understanding of the relationship between measures and promotes learning within the organisation as well. However, while these are all valuable features of the PMS in OSTS, they are not enough. The OSTS is embedded as a holistic model which includes all partners within the SN. The Bititci proposal needs a fifth business level at the top of the hierarchy. This could be the SN level. While Bititci does cater for stakeholder needs in his proposal, it appears that this is tacit acknowledgment of stakeholders as part of the business environment rather than a proactive engagement with them as part of the SN. It has been argued earlier that corporate performance is related to supply chain performance and the latter therefore should take part in the measurement system. The positive findings of this research, within the Bank's supply chain stakeholders affected by its CSR, supports that contention. A supply network level within the business hierarchy architecture should be included.

7.2.4 Integrating the Supply Network into the OSTS Designed Enterprise

The integration of the SC into the OSTS poses additional problems to merely asking supply chain partners to adopt a similar management philosophy and to use common metrics. Members of the SC are usually sovereign companies in their own right and with idiosyncratic features which will probably differ to the main orchestrating partner and others in the network, so it is unlikely that one model fits all. However, extensive work by Cigolini, Cozzi and Perona (2004) has identified commonalities in over 100 companies they empirically surveyed in seven different industry sectors. They note the schools of thought on SCM have evolved from traditional logistics to modern logistics, where information flow joins physical flow as an important part of a system-wide approach focusing on the customer rather than cost reduction, to the integrated process redesign school, where radical redesign based on the pioneering work of Forrester (1961, 1968) led to the dynamic multi-echelon supply systems of quantitative models.

This was followed by the industrial organisation school with strategic alliances between partners in the SC being based on transactional relationships stemming from discrete transactions to cooperative arrangements to long term partnerships and ownership. This thesis argues that the SC of the 21st century will exhibit the three latter designs with an importance on system-wide ICT enhanced information flow, with collaborative arrangements between partners, and with metrics such as DEA allowing chain-wide efficiency comparisons.

There are two essential components to this new SC. These can be described as SC system hardware and SC interfaces. The hardware relates to company choice of operational system such as JIT, Continuous Replenishment, or Distribution

Requirements Planning while SC interfaces are the enablers of SC processes, whether related to the design and configuration of the supply chain or its management. The literature provides three broad categories of support for the SC interface. These interface support mechanisms (ISM) are information tools, coordination and control tools and organisation tools.

> Information tools are utilized to gather, transmit and share data. They create and direct the flow of information. Coordination and control tools are utilized to monitor and influence the decision-making process, by measuring performances and setting rewards based on achievement of certain results, while organisation tools are used to support cross-company communication and coordination (Cigolini, Cozzi and Perona 2004 p. 17)..

Cigolini et al. designed a matrix to evaluate the main strategies of over 100 case studies in their empirical survey. Essentially, they matched each company's ISM against SC configuration and SC management to define the SCM strategy of each organisation. All companies used performance metrics and accounting to evaluate past performance, i.e. to monitor performance, yet only 67% adopted performance metrics and 44% adopted SC cost accounting systems to support vendor managed inventory or continuous replenishment on-line. No one company met all the required criteria on the matrix, and less than one-tenth had interface managers to facilitate the complex and articulated relational work involved in long lasting collaborative relationships. They argue that cross-firm performance metrics, accounting and incentive systems, are essential tools for exploiting the full potential of an integrated supply chain.

Understanding how SCM strategies are generated and implemented can be improved. A step forward may be to adopt the tenets of this thesis.

7.2.5 Integrating CG into the OSTS Designed Enterprise

Mainstream CG models: principal-agent, market model, executive power, and stakeholder models (Letzo, Sun and Kirkbride 2004), rest their ideas and assumptions on the theory of the firm which evolved from company law and classical economics in the last century. Recent studies of CG depart from such old concepts of the firm, where the perspective of the bounded entity of the shareholder gives way to stakeholder perspective, and the firm is viewed as a permanent social entity which operates on universal principles such as moral value and ethics, social justice and mutual trust, with ownership rights maintained. Child and Rodrigues (2003) for example, argue for a new organisation form which sees employees and junior partners co-opted into ownership and governance to promote inclusive control, mutual monitoring and trust. This is not contrary to an OSTS designed enterprise. All of this is possible within the views of the corporation as a single entity, or an aggregation of individual entities, with blurred divisions between inside and outside stakeholders and the environment. Once the bridge to stakeholder acknowledgement is crossed the constructs of earlier organisation CG, such as the agency problem, are less valid. Theories grounded on simple economic rationalism do not account for the irrationalities of emotion, values and beliefs, culture and social relationships, but these factors need to be included. If for no other reason, this research shows that they must be considered in any system of corporate PM, and that they can be measured. The task at hand is to develop this idea further so that measures become meaningful to the CG debate and to organisation performance.

Another task is to develop a meaningful measure of CG as the stepping stone to measuring all those other critical success factors in the whole SN. In effect a scorecard approach is warranted. The metrics for the ultimate score could be the aggregation of the individual DEA results of earlier studies. One of these, the CSR component of CG has been focused on in this thesis. The empirical work for such an approach was reported at the 1st International Conference on Corporate Governance in Birmingham 2002.

Strenger (2004) suggests a two-step approach: establish a 'Code of Practice' for CG and then develop a scorecard from this code. The scorecard should: provide for investors and analysts to be able to easily review issues of governance; enable companies to assess their penetration to stakeholder engagement; allow scoring of performance, minimums and benchmarks; and allow rapid communication to interested parties via enabled internet facilities. Such an idea fits snugly with the tenets of this thesis. The relevant metrics could be labeled as KPIs for: CG Commitment, Shareholder and General Meeting Issues, Stakeholder Issues, Board Remunerations, Supervisory and Auditory Standards, Transparency, and Auditing and Financial Reporting Standards. Each would invite an efficiency performance score. These suggested indicators would necessarily need to be weighted according to their importance and impact. Weighting, as discussed earlier, is a recognized influential component of the DEA algorithm. If the DEA approach to weighting factors is unacceptable then an alternative such as AHP is a worthy contender, while alternative techniques such as ‘genetic algorithms’ are also being suggested. Weighting is generally an heuristic issue. The governance metric from these computations would provide a partial score for the overall scorecard which would have other partial scores from the other dimensions: supply chain suppliers, customers and internal operations of the firm. These too, would naturally be weighted for importance of contribution. The total picture is now emerging. The scorecard is really a ‘score dashboard’ where there are a number of important indicators displaying various aspects of performance. This novel concept is worth pursuing.

7.3 Conclusion

This chapter discussed the implications of the research findings on the development of a contemporary OBPM model appropriate to the enterprise of the 21st century. It has highlighted the need for a responsive, proactive and engaging organisation in the new global knowledge economy. The first step toward this goal is through CG with CSR as a major strategy. CSR can be measured, with operations research methodology as shown in this thesis, so it can therefore be analysed and used in strategy formulation. The research showed strong support for humanistic management, empowerment and business ethics, thus enhancing the knowledge capital of employees.

This cultivates positive stakeholder relationships giving the enterprise a competitive edge in the current economic climate. To achieve such a goal the organisation must adopt OSTS and develop a comprehensive PM system. The PMS should cross the dimensions of the performance pyramid to integrate CG, company operations, and the supply network.

Chapter 8

Summary, Conclusion and Future Research

Science, not rule of thumb.
Harmony not discord.
Cooperation, not individualism.
Fredrick Winslow Taylor 1856-1915

8.1 Introduction

This chapter concludes the thesis by providing a summary of the development of the main study and a review of its achievements. It commences with an analysis of the contemporary business arena as the backdrop for this study. It then critically reviews those academic disciplines and fields of study that are pertinent to this research. This then germinates the new approach to PM which is tested with a novel optimization model founded in econometrics and operations research. PM and OB are then discussed in view of the results obtained from the testing of empirical data from a large Australian commercial enterprise. The contributions of this thesis are revisited and the limitations of the current research are discussed. It concludes by discussing emergent issues and directions for future research.

8.1.1 Foundations in a Global Knowledge Economy

The first chapter established Australia's position in the global economy with a review of its unprecedented growth to become one of the world's top economies. It identifies the challenge of meeting the competitive demands of globalisation as the major issue for companies in the 21st century. PM is introduced as the mechanism which allows benchmarking for international competitiveness. At the same time, there is also a need for a new approach to OB theory. The recognition of the value of human capital in the knowledge-economy company means that a 'people focused' model is needed. How the company is run also depends on its CG so this element is introduced here to address the needs of all the different stakeholders and their pressures on the company. Systems theory allows the firm to be viewed as part of the greater supply chain in which it operates and where many of the stakeholders play their roles. At this point we highlight the significant impact of developments in computerization and ICT in the recent past, and the greater role they will play in the future global knowledge economy.

The number of failings in traditional approaches to measuring organisation performance suggests the need for a move from traditional measures to new ones relevant to the new era. The optimization technique of DEA, with its econometric success in the measurement of efficiency, is introduced as a tool for the new era. This chapter then states the objectives of this research, namely to: identify the new role of management; identify the competitive forces driving performance; identify the stakeholders and their involvement; and to develop a new approach to PM. By revealing the flaws in PM approaches of the past, the study identifies the gap in knowledge which this thesis addresses. Its contribution lies in the integration of the fields of OB and organisation design, SCM and PM, through the positivist stance allowed in an operations research methodology. Its contribution permits the analysis of organisation performance as measured by pragmatic relative efficiencies of equitable business units across defined functional and social relationships in the total supply chain. The efficiency comparisons can be conducted in parallel with other benchmarks or key performance indicators that already exist, but DEA provides greater insight where these are absent or unattainable by other methods. The principal contribution however, is the new application of DEA as part of the methodology which allows the measurement and analysis of performances of organisations in their conduct of CSR, often viewed as a qualitative construct.

8.1.2 Critical Review of the Literature

A review of current and significant past thinking on the subject of this thesis indicates there is much evidence to suggest that the globalization witnessed in the past few decades is not a repeat of expansive global economic movements of the past. The discriminating feature is the emergence of the pervasive technologies inherent in computerization and its information communication technologies, including the worldwide web and the internet. The exponential expansion of computing power and the reciprocal decrease in computing costs has meant that processes and communications previously burdensome, time-consuming and costly have given way to cheap, expedient and instantaneous modern equivalents of those tasks. Going beyond the 'information age', it is now argued by many that we are in a 'knowledge age' and thus within a global knowledge economy. Australia has fared well because of its fluidity and responsiveness to these developments and other factors as well, but needs to maintain the competitive momentum as much of the rest of the world catches up. This requires a revamp of successful past strategies to be relevant to the new globalised marketplace.

The changes require a new mode of management involving OSTS design of organisations and the CG view of responsibilities to stakeholders and the environment. The OSTS has a convincing foundation in the Human Relations School of Management and the work of the Tavistock Institute, together with systems theory. This approach posits the proposition that CG, in the modern context of ethics and morality in business, is the procreator of successful performance in the organisation and the supply chain in which it operates. The acceptance of an humanistic style of management also fares well with enhancing the strengths of knowledge capital through the 'empowerment' of self-directed teams. A minimalist organisation structure designed around a knowledgeable workforce empowered to work responsibly makes for a flexible, responsive and efficient enterprise. These issues were reviewed under the headings of globalization, OSTS of OB, CG and CSR. The related issues that followed dealt with the SCM contribution to organisation competitiveness and the need for its inclusion in models of efficiency because the SC is in reality a network of stakeholders who can impact on company operations through their operational relationships. Measures of organisation performance have traditionally been modeled on company operations as singular units rather than unit-parts of a network. If the established modes of measuring efficiency are lacking then what can replace them? The answer lies in the application of operations research methodology which provides macro-measures, rather than the aggregation of minutiae blocks of efficiency metrics. DEA is able to perform well under these requirements, and the literature attests to how well it has performed under extremely diverse scenarios and often in unexpected studies. A history of the development of DEA provides an insight into its suitability as a novel application for this study, and leads to discussion about the development of DEA as the new approach to PM.

8.2 A New Approach to PM

8.2.1 The Conceptual Framework for the Measurement Methodology

The research methodology of this thesis is positivistic and empirically based. Chapter 3 describes the conceptual framework for the measurement of performance and draws on previous research that delineates precursors for successful organisation performance systems. As a result, a conceptual PM framework, resulting in a performance pyramid is proposed. This framework addresses the need to include all stakeholders in corporate strategy formulation, and to consider financial and non-financial factors as well as CG, as the crucial success factors that need to be measured. The roles of ICT and computerisation are acknowledged as integral to the PMS that evolves. The concept of this framework is projected onto the supply network, from suppliers to customers, and of course on internal company operations. The thesis postulates however, that organisation performance is founded in CG or the way the company is run, therefore this should be the pertinent starting point. Organisational performance is measured by productivity as the ratio of all outputs to all inputs, i.e. of all goods and services to all resources used in achieving these, and therefore improvements in productivity lead to improvements in performance. The instrument to do this, through an operations research methodology, is discussed the DEA algorithm is demonstrated as the most suitable.

8.2.2 DEA

As a linear programming methodology, the mathematics of the DEA technique is explained and exposited. The algorithm is compared to other ways of measuring efficiency and to other related mathematical models, concluding that they are not suitable for the purpose of this study.

The chapter on DEA is seminal to this thesis because it discusses the basis for performance as the efficiency computation for total factor productivity where the key elements are the input and output factors expressed in ratios that define the production frontier.

This construct of efficiency is that each DMU has a standing in relation to the production frontier and that those that are the best performers on a particular measure are the ones that delineate the frontier and define the levels of best performance. Others are matched against these best performers, hence the success of the technique in that it does not try to impose best performance but merely identify best performers, a true benchmarking metric.

Since DEA is well established and has undergone development and refinement since the late 1950s, the basic model explained in this chapter is extended to show the value and impact of some of the additional work on the model, including how it can be married with other techniques such as Analytical Hierarchy Process to strengthen its application. There are however, some assumptions, limitations and related issues that the researcher must be aware of and these are fully discussed in the chapter.

8.3 DEACSR Model and Results

8.3.1 DEA for Corporate Governance

As a methodology for measuring performance, DEA is fully analysed in its premise that performance is measured by efficiency. The theory of efficiency of the input-output transformation in production economics is scrutinized as a basis for this model's suitability for the research purpose. The analysis commences from the basic model to extensions that were later developed, and an interpretation of their meanings in relation to the study requirements. Technical and allocative efficiencies with input or output orientations, with slack and different returns to scale were all considered as integral to the model required. An emphasis was also placed on the importance of the weighting factors and how these are assigned, with evidence of differing approaches from various authors. The strengths of DEA were investigated with a precaution on the assumptions that are made. As a non-parametric technique there is also reference to the limitations of this type of technique and some thought given to alternatives. Other related equivocal issues, such as numbers of DMUs and the number of input and output factors are also discussed. Once it was established that this approach was suitable for measuring efficiencies in dimensions of CG, it was tailored to the factors affecting CSR.

In particular, it was tailored to build on recently completed research which had already established an organisational capacity for CSR. CSRMC as a concept had recently been validated by the doctoral thesis of Dr Black at Monash University (Melbourne, Australia). The raw data and empirical findings of her research for a major Australian bank were made available for this study. It should be noted that there is no relationship between the research of that thesis and this one other than the use of the same data pool. The model developed and tested in this research is the application of DEA to the measurement of performance of an organisation on its CSR (known as the DEACSR model).

8.3.2 The DEACSR Model

The DEACSR model was formulated from the application of DEA methodology to the factors governing CSR performance. The CSRMC construct identified a number of antecedent factors which correlated with, and were predictive of CSR performance, but while these correlations supported the construct they did not identify which were the best performing business units, nor the combination of factors which provided an efficiency rating of 100% for the best performing units. The application of the DEACSR model required an analysis of all factors in the CSRMC construct to identify those that met the criteria of input factors and those that were extraneous to efficiency calculations. The antecedents of CSR in the CSRMC model are communication, humanistic organisation, organisational support, integrated ethics, justice and commitment to ethics. A number of trials were conducted to ascertain the relevant variables, resulting in six factors as input for the singular CSR output. These input factors were: 1) communication, 2) humanistic orientation, 3) integrated ethics, 4) commitment to ethics, 5) perceived organisation support, and 6) distributive justice. They were then tested in a number of permutations of all factors, including a de-segregation of the single output factor. The tests provided unequivocal support for 11 DMUs from a cohort of 231. Others were found to be efficient under different constraints, while some results remained debatable. The strength of the findings was in the unambiguous support for the same eleven units in all tests, and in the technical explanations why some others could be rated as efficient in given circumstances.

These results give strong support for DEA's ability to discriminate between efficient and non-efficient units in the organisation, which then allows further analysis of the various factors.

The inter-item correlations of the indicative factors across all tests allowed an analysis of the antecedents of CSR in the CSRMC model. The results provide strong endorsement for an humanistic organisation that is supportive of its employees. This type of organisation is strongly committed to business ethics, and these are integrated in all business dealings. There was little support for communication and perceived justice as antecedents of CSR. This may be possibly explained by the view of the study respondents that the organisation did not communicate freely with external stakeholders, nor that it distributed justice equally.

8.4 Performance Measurement and Organisation Behaviour

The results of the trials and tests in this study were discussed in Chapter 6 but are worth visiting in terms of their meaning to OB and the measurement of factors of performance often judged to be qualitative. It is maintained, and supported by the literature, that styles of management affect OB in distinctive ways. A humanistic style of management is more empathetic and understanding of its employees and likely to encourage empowered decision-making and more responsibility for self-directed teams. This should improve organisation performance. Substantial support for these ideas was reported in the findings of the 231 DMUs in six divisions of the bank, 11 of them were found to be the most efficient. An analysis of the efficient units then revealed a number of contributing factors which align with the contention above.

Perceived organisational support through feelings of empowerment was strongly correlated with other factors of efficiency, exceeding the threshold in 38 of the 48 inter-item comparisons. This was strongly followed by the two factors humanistic orientation and management commitment to ethics, with both scoring 34 of the 48 inter-item comparisons. Integrated ethics also exceeded the correlation threshold, while communication accuracy and distributive justice both rated very poorly. Other factors of significance to the OSTS model were: stakeholder identity, where the firm realizes its future is linked to these groups; dialogue, which is a respectful attitude and power-sharing; and ethics atmosphere where people sincerely care about others.

Slightly less significant were the factors of ethics compliance, meaning the formalization of ethical systems, social accountability and reporting, and attuned public awareness of stakeholder values. These lend support to the OB stance of the OBPM model, just as the DEACSR supports the measurement of efficiency.

The ability of DEACSR to measure the performance of one aspect of CG suggests it has further use in the assessment of how well other critical success factors are performing. The OSTS-designed organisation can for example, be measured in terms of its structural flexibility, knowledge management, team leadership and customer orientation, as well as shared vision and a strategic focus on driving change. It may be amalgamated with other necessary and well established measures of performance such as financial accounting, quality, and environmental codes, which have the backing of auditable reference models of international standards.

8.5 Limitations and Areas for Further Research

8.5.1 Limitations of the Present Research

This study provides strong support for a PM DEACSR model, but it has limitations incurred by the constraints of a doctoral thesis: lack of resources for a more in-depth investigation, and inherent deficiencies in some of the applications. These limitations fall into four categories: the DEA technique and its quirks, the source and quality of secondary data, the CSR construct itself, and the extrapolation of results to the complete supply network.

DEA is an established powerful non-parametric technique. It is so well established that it has had many applications and a variety of developmental changes to the base model. There are so many versions with different criteria that the first question is ‘which is the right model of DEA for this task?’ Should it be input or output oriented? Should it have an increasing, decreasing, or constant returns to scale? Should the technique be one of the more exotic models or a new adaptation? These concerns were addressed by being conservative in choice and thus possibly being conservative in findings. But there are related concerns with DEA as a technique. It is unduly influenced by outliers, such that a single DMU with particular input-output characteristics can significantly change the production frontier, thus rearranging the rated efficiencies of all other DMUs.

This outlier may also be hard to detect. However, there is no reason to suspect the presence or influence of outliers in this research.

The other widely debated feature of DEA is the assignment of weightings to the various factors. Different weights will undoubtedly affect the results of the computation. For this reason it was decided to be conservative in the present study and allow weighting to be assigned by the technique itself. It has been hailed for not requiring or providing absolute scores, that its strength is in its comparative nature; but sometimes absolute values are necessary for detailed analysis of the result. Instances where analysis may be needed include when the homogeneity of DMUs is a concern. DEA assumes all units are homogenous but in qualitative and poorly selected variables this may not always be true. Its non parametric nature means that inferential statistics cannot be applied, and there are no specific rules for its application prescribing limits on DMUs and number of input or output variables. At best there are the heuristic ‘rules of thumb’ advised by some researchers.

The most significant limitation of DEA however, is its inability to provide measures of efficiency for singularly different DMUs which have no others to compare against. For example the case of one supplier, if there are not a number of suppliers with comparable characteristics in the supply chain then the concept of comparison against other equivalents is untenable. Other KPIs are required.

Another limitation of this study is the data source and its quality. While secondary data used in this study is only one step from the primary source, it will never provide the depth of information gathered first hand with specific intent. The data was gathered for another purpose with a focus on other needs, so it does not have all the information that could be valuable in a study of this sort. For example, while there was no need in the original data collection to note the physical surrounds of the DMUs and features of the working environment, this information may have been useful in a question, as raised above, of returns to scale: does the physical environment have a bearing on the research question? The data gathering for the other study and used in this one, is assumed to be robust and statistically validated. While that study provided the evidence to support this notion, there is no evidence that the questionnaire design was scrutinized and standardized for the frames of reference for this study.

The third limitation to this study is the question surrounding the CSR construct. It has been assumed for this thesis, on the basis of solid literature, that CSR is an important dimension of CG. Firstly, how important is it to CG, what is its weighting, and what other factors need to be included in the CSR construct? Can it be treated as an unique element within the CG dimension, and therefore studied as such, or is it part of the greater concept where all the elements are intertwined? If it can be studied in isolation to the whole CG dimension, then what other elements are significant contributors to CSR? In this particular study however, there needs to be further analysis of the eleven efficient DMUs to compare and contrast their input factors to understand why they were the outstanding performers.

The final limitation is the substantiation of a major model for PM to the whole supply network from what could be considered seminal beginnings. As discussed in the next section, the attainment of an holistic PMS, which is applicable to all enterprises across their respective supply chains, is a mammoth task. To extrapolate from the successful yet relatively minor findings of this study requires more academic research.

8.5.2 Implications and Direction for Future Research

The objective of PM as described in this study, and integral to the thesis, is the value that it places on organisational systems which are designed to make the company competitive and responsive to changes as they speedily present themselves in a globalised knowledge economy. The ultimate objective of measuring performance is that it provides a benchmark against which decision-making is leveraged. The past performances are judged against present performances and analyses, and these help in the quest forward. In no diminished sense are these metrics used for strategy formulation. Numbers count and "wherever you can, count" (Sir Francis Galton 1822-1911).

The future lies in the numbers which enunciate superior performance. The 'score' is the composite of many factors, each important and indicative in its own right. Because it is unlikely that there will ever be an ideal score consistent with a DEA axiom, it is probably better to pursue performance excellence on a number of fronts with ultimate competitive superiority the quest. The successful DMUs in the diverse areas of the company form the basis for comparisons and therefore the basis for improvement.

Hence there are areas for immediate further research as follows.

- Extend the DEACSR model to other areas of CG, identified and deemed as important by other authors, and develop one for the complete CG dimension, incorporating these enhancers of CG performance.
- Design the PMS to include financial, non-financial, and other critical success factors into the efficiency metric. This will require a conjunction of DEA with other mathematical techniques. This partnership with DEA has been done in other studies but not for PM. The synergy of DEA and the BSC is one example of this possibility.
- Design an ICT facilitated PMS with all the features and requirements as prescribed throughout this thesis.
- Integrate the holistic PMS by providing metrics for the SCN, thus allowing for external contributors to register on the performance score.

This thesis has maintained that ultimate corporate performance rests on the synthesis of performances in the whole SN. It has identified the domains of internal operations of the enterprise, supply chains and OB theory, expressed in styles of management and governance of the corporation. These components merit a place in the equation for the performance pyramid scorecard expressed as a dashboard score of:

$$P_{Org} = \Sigma \{ af(\Sigma I_O) + bf(\Sigma S_{CN}) + cf(\Sigma C_G) \} \qquad (7.1)$$

where:

$I_O = E_{O1} \ldots E_{On}$ where $Eo_1 \ldots . E_{On}$ are efficiencies of other factors within the Company Operations dimension;

$S_{CN} = E_{CN1} \ldots E_{CNn}$ where $E_{CN1} \ldots E_{CNn}$ are efficiencies of individual SC partners in the network;

$C_G = E_{G1} \ldots E_{Gn}$ where $E_{G1} \ldots E_{Gn}$ are efficiencies of different CG dimensions;

P_{Org} is the performance score for the corporation within the whole SC, quantifying all scores across all dimensions of the pyramid;

I_O is the metric indicating internal operations performance from KPIs for $_O =1$ to n;

S_{CN} is the function of the supply network for $N=1$ *to* n; and

C_G is the representative statistic for CG across G=*1* to *n*; and

a, b, c are weighting factors for each efficiency dimension.

The challenge remains, not only to develop this scoring dashboard, but to generalize its applicability to any enterprise across its supply chain. This would be the appropriate integrated PMS for enterprises in the 21st century.

8.6 Conclusion

The new application in this research has been the development of an holistic framework for PM of an Australian enterprise using DEA to ascertain the efficiencies of various business units with regard to their CSR contribution to CG. This has been achieved within the context that the firm operates in a supply network which must facilitate the needs of all stakeholders. Such outcomes are also concomitant to the style of management espoused by OB theory which, in this instance, involved the paradigm factors of OSTS theory that provide the platform for competitiveness in the new global knowledge economy.

The ongoing commercial success and public affirmation of the enterprise's corporate citizenship attest, at least in some part, to the performance achievements of business units as studied in this thesis. This research also endorses the company's commitment to performance improvement through the adoption of a mantra of 'management by empowerment and ethics'. The success of the latter is also the test that justifies the transfer of a theoretical construct to 'real world' settings and validates its application. However, pragmatically and academically the journey has just begun.

The holistic framework provided by this thesis is the foundation for further academic research. It allows other researchers to investigate and contribute to a number of facets of this paradigm. There is a rich array of future research in the disciplines of OB, supply chain and operations management, and CG. Each of these merit further investigation from a PM stance that uses DEA in an operations research methodology. By identifying and measuring the critical factors in each of these dimensions they may contribute to the 'scoring dashboard' and the ultimate performance metric. The author will continue to research topics in this exciting fertile area and work towards stimulating and supporting others to do likewise.

Bibliography

ABS, 2006a, *Business Operations and Industry Performance, Australia 2000-2001*, cat. no. 8140.0, Australian Bureau of Statistics, Canberra, viewed 10 Jan 2007, <www.abs.gov.au>.

ABS 2006b, *Australian Industry 2004-2005*, cat. no. 8155.0, Australian Bureau of Statistics, Canberra, viewed 8 Feb 2007, <www.abs.gov.au>.

ABS 2006c, *Innovation in Australian Businesses 2005*, cat. no. 8158.0, Australian Bureau of Statistics, Canberra, viewed 12 Feb 2007, <www.abs.gov.au>.

ABS 2006d, *Australian National Accounts: Information and Communication Technology Satellite Account 2002-2003,* cat. no. 5259.0, Australian Bureau of Statistics, Canberra, viewed 11 Feb 2007, <www.abs.gov.au>.

ABS, 2006e, *Year Book Australia 2006*, cat. no. 1301.0, Australian Bureau of Statistics, Canberra, <www.abs.gov.au>.

Adams, C & Neely, A 2000, 'The performance prism to boost M&A success', *Measuring Business Excellence,* vol. 4, no. 3, pp. 19-23.

Adler, A & Docherty, P 1998, 'Bringing business into sociotechnical theory and practice', *Human Relations,* vol. 51, no. 3, p. viewed 20 November 2006, <http://infotrac.galegroup.com>.

Afriat, SN 1972, 'Efficiency estimation of production functions', *International Economic Review,* vol. 13, no. 3, pp. 568-598.

Agrawal, A & Knoeber, C 1996, 'Firm performance and mechanisms to control agency problems between managers and shareholder', *Journal of Financial and Quantitative Analysis,* vol. 31, no. 3, pp. 377-397.

Aguilera, RV, Williams, CA, Conley, JM & Rupp, DE 2006, 'Corporate governance and social responsibility: a comparative analysis of the UK and the US', *Corporate Governance: An International Review,* vol. 14, no. 3, pp. 147-158.

Ahmad, N, Berg, D & Simons, GR 2006, 'The integration of analytical hierarchy process and DEA in a multi-criteria decision-making problem', *International Journal of Information Technology and Decision Making,* vol. 5, no. 2, pp. 263-276.

Ahmed, NU, Montagno, RV & Firenze, RJ 1996, ‘Operations strategy and organisational performance: an empirical study’, *International Journal of Operations and Production Management*, vol. 16, no. 5, pp. 41-53.

Aigner, DJ & Chu, SF 1968, ‘On estimating the industry production function’, *American Economic Review*, vol. 58, pp. 826-839.

Aigner, DJ, Lovell, CAK & Schmidt, PJ 1977, ‘Formulation and estimation of stochastic frontier production function models’, *Journal of Econometrics*, vol. 69, July, pp. 21-37.

Allens, Arthur and Robinson 2004, *ASX Corporate Governance Council: Disclosure*, viewed 30 August 2004, <www.aar.com.au/corpgov/asx/disc.htm>.

Alves, C & Mendes, V 2004, ‘Corporate governance policy and company performance: the Portuguese case’, *Corporate Governance*, vol. 12, no. 3, pp. 290-301.

Amaratunga, D, Baldry, D & Sarshar, M 2001, ‘Process improvement through performance measurement: the balanced scorecard methodology’, *Work Study*, vol. 50, no. 5, pp. 179-188.

Anderson, T 2005, *A DEA (DEA) Home Page*, viewed 26 May 2006, <www.emp.pdx.edu/dea/homedea.html>.

Armistead, C & Machin, S 1997, ‘Implications of business process management for operations management’, *International Journal of Operations and Production Management*, vol. 17, no. 9, pp. 886-898.

Armistead, C, Harrison, A & Rowlands, P 1995, ‘Business process re-engineering: lessons from operations management’, *International Journal of Operations and Production Management*, vol. 15, no. 12, pp. 46-58.

Arnheiter, ED & Maleyeff, J 2005, ‘The integration of lean management and six sigma’, *The TQM Magazine*, vol. 17, no. 1, pp. 5-18.

Arthur D Little 2003, *Global corporate citizenship: the leadership challenge for CEOs and boards*, Beacon Press, London.

ASX CG Council 2003, *Principles of Good Corporate Governance and Best Practice Recommendations*, viewed 1 May 2005. <www.asx.com.au/supervision/governance/index.htm>.

Atkinson, AA, Banker, RD, Kaplan, RS & Young, SM 1997, *Management accounting*, 2nd edn, Prentice Hall, New York.

Austin, R and Gittell, K 2002, 'When it should not work but does: anomolies of high performance', in A Neely (ed.) *Business performance measurement : theory and practice*, Cambridge University Press, Cambridge, pp. 80-106.

Avkiran, NK 2006a, personal communication 9 September.

Avkiran, NK 2006b, *Productivity analysis in the service sector with DEA*, 3rd edn, Avkiran, Ipswich Australia.

Avriel, M & Golany, B 1996, *Mathematical programming for industrial engineers*, Marcel Dekker, New York.

Bain, N & Band, D 1996, *Winning ways through corporate governance*, Macmillan Business, Hampshire.

Bamford, DR & Forrester, PL 2003, 'Managing planned and emergent change within an operations management environment', *International Journal of Operations and Production Management*, vol. 23, no. 5, pp. 546-564.

Banker, RD, Charnes, A & Cooper, WW 1984, 'Some models for estimating technical and scale inefficiencies in DEA', *Management Science*, vol. 30, no. 9, pp. 1078-1092.

Barratt, M 2004, 'Unveiling enablers and inhibitors of collaborative planning', *International Journal of Operations and Production Management*, vol. 15, no. 1, pp. 73-90.

Basu, R 2001, 'New criteria of performance management: a transition from enterprise to collaborative supply chain', *Measuring Business Excellence*, vol. 5, no. 4, pp. 7-12.

Batten, JA & Fetherston, TA (eds) 2003, *Social responsibility: corporate governance issues*, vol. 17, JAI Elsevier Science, Oxford.

Beach, R & Muhlemann, AP 2000, 'Manufacturing operations and strategic flexibility: survey and cases', *International Journal of Operations and Production Management*, vol. 20, no. 1, pp.7-30.

Beamon, BM 1998, ‘Supply chain design and analysis: models and methods’ *International Journal of Production Economics*, vol. 55, no. 3, pp. 281-294.

Beasley, JE 1990, ‘Comparing university departments’, *Omega*, vol. 18, no. 2, pp. 171-183.

Beauchamp, TL & Bowie, NE 1993, *Ethical theory and business*, 4th edn, Simon & Schuster, New Jersey.

Bertalanffy, LV 1968, *General systems theory: foundation, development, applications*, G. Braziller, New York.

Bessent, A, Bessent, W, Kennington, J & Reagan, B 1982, ‘An application of mathematical programming to assess productivity in the Houston independent school district’, *Management Science*, vol. 28, no. 2, pp. 82-107.

Bhasa, M, P. 2004, ‘Understanding the CG quadliteral’, *Corporate Governance,* vol. 4, no. 4, pp. 7-15.

Bititci, US, Carrie AS & McDevitt, L 1997, ‘Integrated performance measurement systems: a development guide’, *International Journal of Operations and Production Management*, vol. 17, no. 5, pp. 522-534.

Bititci, US, Carrie, AS & Turner, TJ 2002, ‘Integrated PM systems: structure and dynamics’, in A Neely (ed.) *Business PM: theory and practice,* 1st edn, Cambridge University Press, Cambridge, pp. 174-197.

Bititci, US, Nudurupati, SS, Turner, TJ & Creighton, S 2002, ‘Web-enabled PM systems; management implications’, *International Journal of Operations and Production Management*, vol. 22, no. 11, pp. 1273-1287.

Bititci, US, Turner, TJ & Begemann, C 2000, ‘Dynamics of performance measurement systems’, *International Journal of Operations and Production Management*, vol. 20, no. 6, pp. 692-704.

Black, LD 2004, ‘How companies manage for good: a model of management capabilities developed from social responsiveness and public relations theory and tested in Australia’, Doctoral Thesis, Monash University.

Bosetti, V & Buchner, B 2005, *Using DEA to assess the relative efficiency of different climate policy portfolios*, Milano. Research Paper 82.2005 Fondazione Eni Enrico Mattei, viewed 9 June 2006, <http://ssrn.com=740306>

Bourne, M 2003, 'Guest editorial: business performance measurement and management', *Management Decision,* vol. 41, no. 8, pp. 679-679.

Bourne, M, Franco, M & Wilkes, J 2003, 'Corporate performance management', *Measuring Business Excellence,* vol. 7, no. 3, pp. 15-21.

Bourne, M, Mills, J & Faull, N 2003, 'Operations strategy and performance: a resource-based view', *International Journal of Operations and Production Management,* vol. 23, no. 9, pp. 944-946.

Bourne, M, Mills, J, Wilcox, M, Neely, A & Platts, K 2000, 'Designing, implementing and updating performance measurement systems', *International Journal of Operations and Production Management,* vol. 20, no. 7, pp. 754-771.

Bourne, M, Neely, A, Platts, K & Mills, J 2002, 'The success and failure of performance measurement initiatives: perceptions of participating managers', *International Journal of Operations and Production Management,* vol. 22, no. 11, pp. 1288-1310.

Bowersox, DJ, Closs, DJ & Cooper, MB 2007, *Supply chain logistics management*, 2nd edn, McGraw Hill Irwin, Boston.

Bradbury, M & Rouse, P 2002, 'An application of DEA to the evaluation of audit risk', *Abacus,* vol. 38, no. 2, pp. 263-279.

Bradley, N 2004, 'Corporate governance scoring and the link between corporate governance and performance indicators: in search of the Holy Grail', *Corporate Governance,* vol. 12, no. 1, pp. 8-10.

Briffaut, JP & Saccone, G 2002, 'Business performance sustainability through process modeling', *Measuring Business Excellence,* vol. 6, no. 2, pp. 29-36.

Brown, LD & Caylor, ML 2004, 'Corporate governance and firm performance', *SSRN Social Science Research Network,* viewed 7 April 2005, <http;//papers.ssrn.com/sol3/papers.cfm?abstract_id=586423>

Brown, R 2001, 'DEA: application issues in the financial services sector', University of Melbourne, Melbourne.

Buchanan, B 2004, ‘Australian corporate casualties’, in MJK Hirschey, & AK Makija, (eds) *Corporate governance and finance; advances in financial economics*, vol. 8, Elsevier, Oxford, pp. 55-79.

Burgess, TF 1998, ‘Modeling the impact of reengineering with system dynamics’, *International Journal of Operations and Production Management*, vol. 18, no. 9, pp. 950-963.

Business in the Community (BITC), 2003, ‘The Business Case for Corporate Responsibility’, viewed 8 August 2005, <www.bitc.org.uk/applications/dynamic/publications.rm?>.

Business Sector Advisory Group on Corporate Governance 1998, *Corporate governance: improving competitiveness and access to capital in global markets*, OECD, Paris.

Buxley, G 2000, ‘Strategies in an era of global competition’ *International Journal of Operations and Production Management*, vol. 20, no. 9/10, pp. 997-1117.

Caplan, J 2002, *Whose Company Is it, Anyway?*, viewed 6 March 2005, <www.cfo.com/prinTable/article.cfm/3005096?f=options>.

Carr, A & Pearson, J 1999, ‘Strategically managed buyer-supplier relationships and performance outcomes’, *Journal of Operations Management*, vol. 17, no. 5, pp. 497-519.

Carter, N, Klein, R & Day, P 1992, *How organisations measure success*, Routledge, London.

Chan, FTS & Qi, HJ 2003, ‘An innovative performance measurement method for supply chain management’, *Supply Chain Management: an International Journal*, vol. 8, no. 3, pp. 209-223.

Charnes, A, Cooper, WW & Rhodes, EL 1978, ‘Measuring the efficiency of decision making units’, *European Journal of Operational Research*, vol. 2, no. 6, pp. 429-444.

Charnes, A, Cooper, WW, Golany, B, Seiford, L & Stutz, J 1985, ‘Foundations of DEA for Pareto Koopmans efficient empirical production functions’, *Journal of Econometrics*, vol. 30, pp. 91-107.

Charnes, A, Cooper, WW, Lewin, AL & Seiford, LM 1994, *DEA: theory, methodology, and application*, Kluwer Academic Publishers, Boston.

Cheng, EWL & Li, H 2001, 'Analytic hierarchy process: an approach to determine measures for business performance', *Measuring Business Excellence*, vol. 5, no. 3, pp. 30-36.

Cherns, A 1987, 'Principles of sociotechnical design revisited', *Human Relations*, vol. 40, no. 3, pp. 153-161.

Child, J & Rodrigues, SB 2003, 'Corporate governance and new organisational forms: issues of double and multiple agency' *Journal of Management and Governance*, vol. 7, no.3, pp. 337-360.

Cigolini, R, Cozzi, M & Perona, M 2004, 'A new framework for supply chain management: conceptual model and empirical test', *International Journal of Operations and Production Management*, vol. 24, no. 1, pp. 7-41.

Clark, B 2002, 'Measuring performance: the marketing perspective', in A Neely (ed.) *Business PM: theory and practice.* Cambridge University Press, Cambridge, pp. 22-40.

Clarke, F & Dean, G 2004, 'No heart and soul in the pitiless corporate body', 1 November, Australian Financial Review, p.17.

CLERP9, 2004, *Corporate Law Economic Reform Program Act 2004*, viewed 9 March 2004, <www.asic.gov.au/asic_polprac.nsf/byheadline/CLERP+9?openDocument>.

Cobbold, IC & Lawrie, GJC 2004, 'Third-generation balanced scorecard: evolution of an effective strategic control tool', *International Journal of Productivity and Performance*, vol. 53, no. 7, pp. 611-623.

Coelli, TJ 2006, Personal communication 7 September.

Coelli, TJ, Rao, DSP, O'Donnell, CJ & Battese, GE 2005, *An introduction to efficiency and productivity analysis*, 2nd ed, Springer, New York.

Conger, JA, Finegold, D & Lawler III, EE 1998, 'Appraising boardroom performance', *Harvard Business Review*, vol. 76, no. 1, pp. 136-149.

Cooper, WW 2001, ‘DEA’, in SI Gass, & CM Harris, (ed.) *Encyclopedia of operations research and management science*, Kluwer Academic Publishers, Boston, pp. 183-194.

Cooper, WW, Seiford, LM & Tone, K 2000, *DEA: a comprehensive text with models, application, references and DEA solver software*, Kluwer Academic Publishers, Norwell, Massachusetts.

Cooper, WW, Seiford, LM & Tone, K 2006, *Introduction to DEA and its uses with DEA-Solver software and references*, Springer, New York.

Core, JE, Holthausen, RW & Larker, DF 1999, ‘Corporate Governance, chief executive officer compensation, and firm performance’, *Journal of Financial Economics*, vol. 51, pp. 371-406.

Cornelius, PK. & Kogut, B 2003, *Corporate Governance and Capital Flows in a Global economy*, Oxford University Press, New York.

Corporate Responsibility Index 2004, The Age Special Report 28 August, pp. 1-4.

Corporate Responsibility Index 2005, The Age Special Report 4 April, pp. 1-4.

Corporate Responsibility Index 2006, The Age Special Report 15 May, pp. 1-4.

Corporate Responsibility Index 2007, The Age Special Report 14 May, pp. 1-4.

Cox, A 1999, ‘Power, value and supply chain management’ *International Journal of Production and Operations Management*, vol. 4, no. 4, pp. 167-175.

Crawford, K & Cox, J 1990, ‘Designing performance measurement systems for just-in-time operations’, *International Journal of Production Research*, vol. 28, no. 11, pp. 2025-2036.

Croon, S 2001, ‘Restructuring supply chains through information channel innovation’ *International Journal of Operations and Production Management*, vol. 21, no.4, pp. 504-516.

Curran, T & Lald, A 2000, *SAP R/3 Reporting and ebusiness intelligence*, Prentice Hall PTR, Upper Saddle River.

Daugherty, PJ, Ellinger, AE & Gustin, CM 1996, ‘Integrated logistics: achieving logistics performance improvements’, *Supply Chain Management*, vol. 1, no. 3, pp. 25-33.

Davies, R 2004, ‘Why global corporate citizenship matters for shareholders: a survey of leading CEOs’, *The International Business Leaders Forum.*

Davis, S & Albright, T 2004, ‘An investigation of the effect of balanced scorecard implementation of financial performance’, *Mangement Accounting Research*, vol. 15, pp. 135-153.

Dean, G & Clarke, F 2004, ‘True, fair and harder to avoid’, August 5-11, *Business Review Weekly*, pp. 108.

DEA-Solver Pro (Professional Version 4.1), purchased 8 November2005, available at <www.saitech-inc.com>.

DEAzone 2005, viewed 16 March 2005, <www.DEAzone.com>.

Denardo, EV 1996, ‘Dynamic programming’, in M Avriel, & B Golany, (eds) *Mathematical programming for industrial engineers,* Marcel Dekker, New York, pp. 307-382.

Denis, DK 2001, ‘Twenty-five years of corporate governance research...and counting’, *Review of Financial Economics,* vol. 10, pp. 191-212.

deWaal, AA 2003, ‘Behavioural factors important for the successful implementation and use of performance management systems’, *Management Decision,* vol. 41, no. 8, pp. 688-697.

deWaal, AA 2003, ‘The future of the balanced scorecard: an interview with Professor Dr Robert S. Kaplan’, *Measuring Business Excellence,* vol. 7, no. 1, pp. 30-35.

deWaal, AA 2004, ‘Stimulating performance-driven behaviour to obtain better results’, *International Journal of Operations and Production Management,* vol. 53, no. 4, pp. 301-316.

Dine, M & Haynes, K 1999, ‘Sources of regional inefficiency: an integrated shift-share, DEA an input-output approach’, *The Annals of Regional Science,* vol. 33, no. 4, pp. 469-489.

Dixon, J, Nanni, A & Vollman, T 1990, *The new performance challenge-measuring operations for world-class competition*, Dow Jones-Irwin, Illinois.

DJSI 2005, Dow Jones Sustainability Indexes, viewed 17 September 2005, <www.sustainability-indexes.com/htmle/assessment/criteria.html>.

Donaldson, T 2005, 'Defining the value of doing good business', *Financial Times*, 2 June, viewed 5 June 2005, <http://news.ft.com/cms/s/74812be-d377-11d9-ad4b-000002511c8,dwp_uuid>.

Doran, D 2003, 'Supply chain implications of modularization', *International Journal of Operations and Production Management*, vol. 23, no. 3, pp. 316-327.

Dornier, PP, Fender M & Kouvelis P. 1998, *Global operations and logistics: text and cases*, John Wiley & Sons, New York.

Drucker, PF 1968, *The practice of management*, Pan Books, London.

Duffy, R & Fearne, A 2004, 'The impact of supply chain partnerships on supplier performance', *The International Journal of Logistics Management*, vol. 15, no. 1, pp.57-71.

Dulewicz, V & Herbert, P 2004, 'Does the composition and practice of boards of directors bear any relationship to the performance of their companies?', *Corporate Governance*, vol. 12, no. 3, pp. 263-280.

Easton, L, Murphy, D & Pearson, JN 2002, 'Purchasing performance evaluation: with DEA', *European Journal of Purchasing and Supply Management*, vol. 8, no. 3, pp. 123-135.

Eccles, RG 1991, 'The PM manifesto', *Harvard Business Review*, vol. 69, no. Jan/Feb, pp. 131-138.

Eilat, H, Golany, B & Shtub, A 2006, 'Constructing and evaluating balanced portfolios of R & D projects with interactions: a DEA based methodology', *European Journal of Operational Research*, vol. 172, pp. 1018-1039.

Elkington, J 1997 *Cannibals with forks: the triple bottom line of 21st century business,* Capstone Publishing, London.

Emery, FE 1982, ‘Sociotechnical foundations for a new social order’, *Human Relations*, vol. 35, no. 12, pp. 1095-1122.

Emery, FE 1995 ‘Participative design: effective, flexible and successful, now!’ *The Journal for Quality and Participation*, vol. 18, no. 1, pp. 6-12.

Emery, FE & Thorsrud, E 1976, *Democracy at work*, Martinus Nijhoff, Leiden, Netherlands.

Emery, FE & Trist, EL 1965, ‘The causal texture of organisational environments’ *Human Relations*, vol. 18, pp. 21-32.

Emjrouznejad, E & Podinovski, V (ed.) 2004, *DEA and performance management*, Aston University, UK.

Emrouznejad, A & Thanassoulis, E 2005, *An extensive bibliography of data envelopment analysis (DEA) volume 1, working papers*, viewed 22 March 2005, <www2.warwick.ac.uk/fac/soc/wbs/subjects/oris/research/dea>

Entani, T & Tanaka, H 2006, ‘Improvement of efficiency intervals based on DEA by adjusting inputs and outputs’, *European Journal of Operational Research*, vol. 172, pp. 1004-1017.

Epstein, MJ & Manzoni, J 1997, ‘The balanced scorecard and tableau de bord: translating strategy into action’, *Management Accounting*, vol. 79, no. 2, pp. 28-37.

Eriksson, H & Hansoon, J 2003, ‘The impact of TQM on financial performance’, *Measuring Business Excellence*, vol. 7, no. 1, pp. 36-50.

Ernst & Young 2005, ‘Corporate governance: web survey, key findings and valuable insights’, viewed 3 September 2005, <www.ey.com/global/contents.nsf/International>.

Ernst & Young 2005, ‘Effective governance model: an operating framework’, viewed 3 September 2005, <www.ey.com/global/contents.nsf/International>.

Eskildsen, J, Westlund, AH & Kristensen, K 2003, ‘The predictive power of intangibles’, *Measuring Business Excellence*, vol. 7, no. 2, pp. 46-54.

ESRC 2005, ‘World economy and global trade’, Economic and Social Research Council fact sheet, viewed 11 December 2006, <www.esrc.ac.uk/ESRCinfoCentre/facts/international/economy.aspx.>.

Ethics Digest 2006, ‘The relationship between corporate citizenship and employee commitment, customer loyalty, and financial performance’, viewed 17 February 2006, <www.e-businessethics.com/orgcitizen4.htm>.

Evans, JR 2007, *Quality and performance excellence: management, organisation and strategy,* 5th edn, Thomson South-Western, Ohio.

Evans, JR and Lindsay, WM 2005, *The management and control of quality,* 6th edn, Thomson South-Western, Ohio.

Farrell, MJ 1957, ‘The measurement of productive efficiency’, *Journal of the Royal Statistical Society,* vol. 120, no. 3, pp. 253-290.

Fitzgerald, L & Storbeck, JE 2003, ‘Pluralistic views of performance’, *Management Decision*, vol. 41, no. 8, pp. 741-750.

Forrester, JW 1961, *Industrial dynamics*, MIT Press, Cambridge, Mass.

Forrester, JW 1968, ‘Industrial dynamics: after the first decade’, *Management Science,* vol. 14, no. 7, pp. 398-415.

Forsund, FR & Hjalmarsson, L 1979, ‘Generalised Farrell measures of efficiency’, *Economic Journal*, vol. 89, no. June, pp. 274-315.

Forsund, FR & Jansen, ES 1977, ‘On estimating average and best practice homothetic production functions via cost functions’, *International Economic Review,* vol. 18, no. 2, pp. 463-476.

Franco, M & Bourne, M 2003, ‘Factors that play a role in managing through measures’, *Management Decision,* vol. 41, no. 8, pp. 698-710.

Frei, F & Harker, P 1999, ‘Projections onto efficiency frontiers: theoretical and computational extensions to DEA’, *Journal of Productivity Analysis,* vol. 11, no. 3, pp. 275-300.

Friedman, TL 1999, *The Lexus and the Olive Tree: understanding globalisation,* Farrer, Strauss and Giroux, New York.

Friedman, TL 2005, *The world is flat: a brief history of the twenty-first century*, Allan Lane, London.

Frohlich, MT & Westbrook, R 2002, ‘Demand chain management in manufacturing and services: web-based integration, drivers and performance’, *Journal of Operations Management*, vol. 20, pp. 729-745.

FTSE 2005, *FTSE4Good Index Series*, viewed 14 September 2005, <www.ftse.com/Indices/FTSE4Good Index Series/index.jsp.>

Fundin, AP & Bergman, BLS 2003, ‘Exploring the customer feedback process’, *Measuring Business Excellence*, vol. 7, no. 2, pp. 55-65.

Gardner, DL 2004, *Supply chain vector*, J Ross Publishing, Florida.

Garver, MS & Mentzer, JT 1999, ‘Logistics research methods: employing structural equation modeling to test for construct validity’, *Journal of Business Logistics,* vol. 20, no. 1, pp. 33-57.

Gass, SI & Harris, CH 2001, *Encyclopedia of operations research and management science*, Kluwer Academic Publishers, Boston.

Gettler, L 2005a, ‘Taking care of business’, *The Age* , 4 April, p. 4.

Gettler, L 2005b, ‘There's a moral in making money’, *The Age* , 4 June, p. 7.

Globalisation Guide, viewed 22 September 2005, <www.globalisationguide.org/>.

Golany, B & Roll, Y 1989, ‘An application procedure for DEA’, *Omega,* vol. 17, no. 3, pp. 237-250.

Governance Metrics International 2005, viewed 5 November 2005, <www.gmiratings.com>.

Grant, GH 2003, ‘The evolution of corporate governance and its impact on modern corporate America’, *Management Decision,* vol. 41, no. 9, pp. 923-934.

Greenberg, R & Numaker, T 1987, ‘A generalized multiple criteria model for control and evaluation of non-profit organisations’, *Financial Accountability & Management,* vol. 3, no. 4, pp. 331-342.

Greene, WH 1980, 'Maximum likelihood estimation of econometric frontier functions', *Journal of Econometrics*, vol. 13, May, pp. 26-57.

Grewal, B, Xue, L, Sheehan, P & Sun, S (eds) 2002, *China's future in the knowledge economy*, Centre for Strategic Economic Studies, Victoria University, Melbourne.

Griffis, SE, Cooper, M, Goldsby, TJ & Closs, DJ 2004, 'Performance measurement: measure selection based upon firm goals and information reporting needs', *Journal of Business Logistics*, vol. 25, no.2, pp. 95-118.

Grunberg, T 2004, 'Performance improvement: towards a method for finding and prioritising potential performance improvement areas in manufacturing operations', *International Journal of Operations and Production Management*, vol. 53, no. 1, pp. 52-71.

Gunasekaran, A, Patel, C & Tirtiroglu, E 2001, 'Performance measures and metrics in a supply chain environment', *International Journal of Operations and Production Management*, vol. 21, no. 1, pp. 71-87.

Hakansson, H & Person, G 2004, 'Supply chain management: the logic of supply chains and networks', *International Journal of Logistics Management*, vol. 15, no. 1, pp. 11-26.

Hammer, M & Champy, J 1993, *Reengineering the corporation: a manifesto for business revolution*, Harper Business, New York.

Hazell, PBR & Norton, RD 1986, *Mathematical programming for economic analysis in agriculture*, Macmillan Publishing, New York.

Heugens, P & Otten, J 2005, 'Corporate governance reforms around the *world*', Discussion Paper Series 05-08, Tialling C Koopmans Research Institute, The Netherlands, viewed 22 April 2006, <www.koopmansinstitute.uu.nl>.

Hill, N & Alexander, J 2000, *Handbook of customer satisfaction and loyalty measurement*, Gower Publishing Company, Burlington.

Hines, PLR, Jones, D, Cousins, P & Rich, N 2000, 'Value stream management: strategy and excellence in the supply chain', *Financial Times and Prentice Hall*, Harlow.

Hirschey, M 2003 ‘Organisation structure and corporate governance: a survey’, in Hirschey, MJK & Makija, AK (eds) *Corporate governance and finance: advances in financial economics,* vol. 8, Elsevier, Oxford, pp. 65-112.

Holweg, M 2005, ‘The three dimensions of responsiveness’, *International Journal of Operations and Production Management,* vol. 25, no. 7, pp. 603-622.

Hosmer, LT 2000 ‘It’s time for empirical research in business ethics’, *Business Ethics Quarterly,* vol. 10, no. 1, pp. 233-242.

Hosmer, LT 2006, *The ethics of management,* 5th edn, McGraw Hill Irwin, Boston.

Houghton, J & Sheehan, P 2000, ‘A primer on the knowledge economy’, Centre for Strategic Economic Studies, Victoria University, Melbourne.

Huang, CJ 1984, ‘Estimation of stochastic frontier production function and technical inefficiency via the EM algorithm’, *Southern Economic Journal,* vol. 50, no. 3, pp. 847-856.

Hudson, M, Smart, A & Bourne, M 2001, ‘Theory and practice in SME performance measurement systems’, *International Journal of Operations and Production Management,* vol. 21, no. 8, pp. 1096-1115.

Industry Commission 1998, *Conference on Productivity and Microeconomic Reform*, Australian National University, Canberra, Australia, February.

Inman, R & Simmering, M (eds) 2006, *Performance Management* 5th edn, Thomson Gale, Detroit.

Institute of Internal Auditors UK and Ireland Online (IAA) 2004, AA1000, 2004a, A1000 Series, Institute of Internal Auditors UK and Ireland Online, viewed 27 May 2005, <http://www.iia.org.uk/knowledgecentre/keyissues/ethics.cfm?Action=1&ARTICLE_ID=1070>.

Institute of Social and Ethical Accountability (ISEW) 2004, AA1000 Series, London, viewed12 June 2005 <www.accountability.org.uk/aa1000/default.asp?pageid=286>.

Jensen, AJ & Sage, AP 2000, ‘A systems management approach for improvement of organisational Performance Measurement systems’, *Information Knowledge Systems Management,* vol. 2, no. 1, pp. 33-62.

Jensen, M & Meckling, W 1976, ‘Theory of the firm: managerial behavior, agency costs and ownership structure’, *Journal of Financial Economics,* vol. 3, no. 4, pp. 305-360.

Johnson, H & Kaplan, R 1987, *Relevance lost: the rise and fall of management accounting*, Harvard Business School Press, Boston.

Jondrow, J, Lovell, CAK, Materov, IS & Schmidt, P 1982, 'On the estimation of technical inefficiency in the stochastic frontier production function model', *Journal of Econometrics,* vol. 19, August, pp. 233-238.

Jones, B 1999, *Sleepers, wake! technology and the future of work*, Oxford University Press, Melbourne.

Kanter, RM 1994, 'Collaborative advantage: the art of alliance', *Harvard Business Review,* July-August, pp. 96-108.

Kaplan, RS 1986, 'Accounting lag: the obsolescence of cost accounting systems', *California Management Review,* vol. 28, no. 2, pp. 174-199.

Kaplan RS 1990, *Measures for manufacturing excellence*, Harvard Business School Press, Boston.

Kaplan, RS & Norton, D 1992, 'The balanced scorecard: measures that drive performance', *Harvard Business Review,* vol. Jan-Feb, pp. 71-79.

Kaplan, RS & Norton, D 1993, 'Putting the balanced scorecard to work', *Harvard Business Review,* vol. Sept-Oct, pp. 134-147.

Kaplan, RS & Norton, DP 1996, 'Using the balanced scorecard as a strategic management system', *Harvard Business Review,* vol. 74, no. 1, pp. 75-86.

Keah, CT, Lyman, SB & Wisner, JD 2002, 'Supply chain management a strategic perspective', *International Journal of Operations and Production Management,* vol. 22, no. 5, pp. 614-631.

Keasey, K & Wright, M 1993, 'Issues in corporate accountability and governance: an editorial', *Accounting and Business Research,* vol. 23, no. 91A, pp. 291-303.

Keegan, DP, Eiler, RG & Jones, CR 1989, 'Are your performance measures obsolete?', *Management Accounting*, June, pp. 38-43.

Kennerly, M & Neely, A 2002, 'A framework of the factors affecting the evolution of performance measurement', *International Journal of Operations and Production Management,* vol. 22, no. 11, pp. 1222-1245.

Kennerley, M & Neely, A 2003, ‘Measuring performance in a changing business environment'’, *International Journal of Operations and Production Management,* vol. 23, no. 2, pp. 213-229.

Kennerley, M, Neely, A, & Adams, C 2003, ‘Survival of the fittest: measuring performance in a changing business environment’, *Measuring Business Excellence,* vol. 4, no. 4, pp. 37-43.

Kidd, J, Richter, F & Stumm, M 2003, ‘Learning and trust in supply chain management disintermediation, ethics and cultural pressures in brief dynamic alliances’, *International Journal of Logistics: Research and Applications,* vol. 6, no. 4.

Krause, O 2003, ‘Beyond BSC: a process based approach to performance management’, *Measuring Business Excellence,* vol. 7, no. 3, pp. 4-14.

Kuhn, TS 1970, *Structure of scientific revolutions,* 2nd edn, Chicago University Press, Chicago.

Kuwaiti, ME 2004, ‘Performance measurement process: definition and ownership’, *International Journal of Operations and Production Management,* vol. 24, no. 1, pp. 55-78.

Lambert, DM & Pohlem, TL 2001, ‘Supply chain metrics’, *International Journal of Operations and Production Management,* vol. 12, no. 1, pp.1-19.

Lambert, DM, Garcia-Dastugue, SJ & Croxton, KL 2005. ‘An evaluation of process-oriented supply chain management frameworks’, *Journal of Business Logistics,* vol. 26, no. 1, pp. 25-51.

Lambert, DM, Knemeyer, AM & Gardner, JT 2004, ‘Supply chain partnerships: model validation and implementation’, *Journal of Business Logistics,* vol. 25.no. 2, pp. 21-41.

Larker, D, Richardson, S & Tuna, I 2005, ‘Ratings add fire to the governance debate’, *Financial Times,* 26 May, viewed 6 June 2005, <www.financialtimes.printthis.clickability.com/pt/cpt?>

Lau, HCW, Lau, PKH, Chan, FTS & Ip, RWL 2001, ‘A real time performance measurement technique for dispersed manufacturing’, *Measuring Business Excellence,* vol. 5, no. 1, pp. 9-15.

Lebas, M & Euske, K 2002, ‘A conceptual and operational delineation of performance’, in A Neely (ed.) *Business performance measurement theory and practice,* Cambridge University Press, Cambridge, pp. 65-79.

Lebas, MJ 1995, ‘Performance measurement and performance management’, *International Journal of Production Economics,* vol. 41, no. 1, pp. 23-35.

Leblanc, RW 2005, ‘What's wrong with corporate governance: a note’, *Corporate Governance,* vol. 12, no. 4, pp. 436-441.

Lee, HL & Whang, S 2000, ‘Information sharing in a supply chain’, *International Journal of Manufacturing Technology and Management,* vol. 1, no. 1, pp. 79-93.

Letza, S, Sun, X & Kirkbride, J 2004, ‘Shareholding versus stakeholding: a critical review of corporate governance’, *Corporate Governance,* vol. 12, no. 3, pp. 242-262.

Lewin, AY, Morey, CR & Cook, TJ 1982, ‘Evaluating the administrative efficiency of courts’, *Omega,* vol. 10, no. 4, pp. 401-411.

Li, Z, Kumar, A & Lin, YG 2002, ‘Supply chain modeling: a co-ordination approach’, *Integrated Manufacturing Systems,* vol. 13, no. 8, pp. 551-561.

Logsdon, JM & Lewellyn, PG 2000’ ‘Expanding accountability to stakeholders: trends and predictions’, *Business and Society Review,* vol. 105, no. 4, pp. 419-435.

Lovell, CAK & Schmidt, P (eds) 1988, *A comparison of alternative approaches to the measurement of productive efficiency*, Kluwer Academic Publishers, Boston.

Lowson, RH 2002, ‘Operations strategy: genealogy, classification and anatomy’, *International Journal of Operations and Production Management,* vol. 22, no. 10, pp. 1112-1129.

Lynch, RL & Cross, KF 1991, *Measure up!*, Mandarin, London.

Macbeth, DK 2002, ‘Emergent strategy in managing cooperation supply chain change’, *International Journal of Operations and Production Management,* vol. 22, no. 7/8, pp. 728-740.

MacBryde, J & Mendibil, K 2003 ‘Designing performance measurement systems for teams: theory and practice’, *Management Decision,* vol. 41, no. 8, pp. 722-733.

Maignan, I & Ferrell, OC 2001, 'Antecedents and benefits of corporate citizenship: an investigation of French businesses', *Journal of Business Research,* vol. 51, pp. 37-51.

Maignan, I, Ferrell, OC & Hult, GTM 1999, 'Corporate citizenship: cultural antecedents and business benefits', *Journal of Academy of Marketing Science,* vol. 27, no. 4, pp. 455-469.

Maleyeff, J 2003, 'Benchmarking performance indices; pitfalls and solutions', *Benchmarking: An International Journal,* vol. 10, no. 1, pp. 9-28.

Malina, MA & Selto, FH 2004, 'Choice and change of measures in performance measurement models', *Management Accounting Research,* vol. 15, pp. 441-469.

Manning, L & Baines, RN 2004, 'Globalisation: a study of the poultry-meat supply chain', *British Food Journal,* vol. 106, no. 10/11, pp. 819-836.

Manoochehri, G 1999, 'Overcoming obstacles to developing effective performance measures', *Work Study,* vol. 48, no. 6, pp. 223-229.

Manzoni, A & Islam, SN 2006a, 'Measuring the performance of collaborative relationships in supply chain networks using DEA: a corporate governance perspective', in *4th International Logistics and SCM Congress,* Ismir University of Economics, Turkey.

Manzoni, A & Islam, SN 2006b, 'Measuring the performance of supply chain networks in Australia: a business process model using DEA', in *Proceedings of the 4th International Conference on SCM & Information Systems* Institute of E Commerce, National Chung Hsing University, Taichung, Taiwan.

Manzoni, A & Islam, SN 2006c, 'An improved performance scorecard for supply chain networks in the Australian context', in *International Conference on Logistics and SCM 2006*, University of Hong Kong, Hong Kong.

Manzoni, A & Sadler, I 2005, 'An improved performance scorecard in the Australian context', in *19th ANZAM Conference,* Australian National University, Canberra.

Marr, B & Neely, A 2003, 'Automating the balanced scorecard-selection criteria to identify appropriate software applications', *Measuring Business Excellence,* vol. 7, no. 2, pp. 29-36.

Marr, B & Schiuma, G 2003, 'Business performance measurement: past, present and future', *Management Decision,* vol. 41, no. 8, pp. 680-687.

Maull, RS, Tranfield, DR & Maull, W 2003, 'Factors characterising the maturity of BPR programmes', *International Journal of Operations and Production Management,* vol. 23, no. 6, pp. 596-624.

McAdam, R & Bailie, B 2002, 'Business performance measures and alignment impact on strategy', *International Journal of Operations and Production Management,* vol. 22, no. 9, pp. 972-996.

Mclaren, D 2004, 'Global stakeholders: corporate accountability and investor engagement', *Corporate Governance: An International Review,* vol. 12, no. 2, pp. 191-201.

Medori, D & Steeple, D 2000, 'A Framework for auditing and enhancing performance measurement systems', *International Journal of Operations & Production Management,* vol. 20, no. 5, pp. 520-533.

Meeusen, W & Van den Broeck, J. 1977, 'Technical efficiency and dimension of the firm: some results on the use of frontier production functions', *Empirical Economics,* vol. 2, no. 2, pp. 109-122.

Metters, R, Frei, F & Vages, V 1999, 'Measurement of multiple sites in service firms with DEA', *Production and Operations Management*, vol. 8, no. 3, pp. 264-281.

Meyer, MM 2002, 'Finding performance: the new discipline in management', in A Neely (ed.) *Business performance measurement: theory and practice,* Cambridge University Press, Cambridge, pp. 51-62.

Mills, J, PK, Bourne, M, & Richards, H 2002, *Strategy and performance: competing through competences,* Cambridge University Press, Cambridge.

Mills, J, Platts, K, Neely, A, Richards, H, & Bourne, M 2002, *Strategy and performance: creating a winning business formula,* Cambridge University Press, Cambridge.

Min, S & Mentzer, JT 2004, 'Developing and measuring supply chain management concepts', *Journal of Business Logistics,* vol. 25, no. 1. pp. 63-99.

Min, S, Roath, AS, Daugherty, PJ, Genchev, SE, Chen, H & Arndt, A 2005, ‘Supply chain collaboration: what’s happening’, *The International Journal of Logistics Management*, vol. 16, no. 2, pp. 237-256.

Mitchell, VL & Nault, BR 2003, ‘The emergence of functional knowledge in sociotechnical systems’, Working Paper¸ viewed 23 October 2006, <www.haskayne.ucalgary.ca/research/WorkingPapers/research/media/MIS_working_papers/2003_16>.

Morin RA & Jarrell SL 2001, *Driving shareholder value: value-building techniques for creating shareholder wealth*, McGraw-Hill, New York.

Mumford, E 1995, *Effective systems design and requirements analysis: the ETHICS approach*, Macmillan, London.

Mumford, E 2003, *Redesigning human systems*, IRM Press, London.

Neef, D 2004, *The supply chain imperative*, Amacom, New York.

Neely, A (ed.) 2002, *Business performance measurement: theory and practice*, Cambridge University Press, Cambridge.

Neely, A, Adams, C & Crowe, P 2001, ‘The performance prism in practice’, *Measuring Business Excellence,* vol. 5, no. 2, pp. 6-12.

Neely, A & Austin, R 2002, ‘Measuring performance: the marketing perspective’, in A Neely (ed.) *Business performance measurement: theory and practice,* Cambridge University Press, Cambridge, pp. 22-40.

Neely, A & Bourne, M 2000, ‘Why measurement initiatives fail’, *Measuring Business Excellence*, vol. 4, no. 4, pp. 3-6.

Neely, A & Powell, S 2004, ‘The challenges of performance measurement’, *Management Decision,* vol. 42, no. 8, pp. 1017-1023.

Neely, A, Bourne, M & Adams, C 2003, ‘Better budgeting or beyond budgeting’, *Measuring Business Excellence*, vol. 7, no. 3, pp. 22-28.

Neely, A, Gregory, M & Platts, K 1995, ‘Performance measurement system design: a literature review and research agenda’, *International Journal of Operations and Production Management*, vol. 15, no. 4, pp. 80-116.

Neely, A, Mills. J, Platts. K, & Richards. H 2002, *Strategy and performance: getting the measure of your business*, Cambridge University Press, Cambridge.

Neely, A, Mills, J, Platts, K, Richards, H, Gregory, M, Bourne, M & Kennerley, M 2000, ‘Performance measurement system design: developing and testing a process-based approach’, *International Journal of Operations and Production Management,* vol. 20, no. 10, pp. 1119-1145.

Niepce, W & Molleman, E 1998, ‘Work design issues in lean production from a sociotechnical systems perspective: neo-Taylorism or the next step in sociotechnical design?’, *Human Relations,* vol. 51, no. 3, pp. 259-288.

Nonaka, I & Peltokorpi, V 2006, ‘Objectivity and subjectivity in knowledge management: a review of 20 top articles’, *Knowledge and Process Management,* vol. 13, no. 2, pp. 73-82.

Norreklit, H 2000, ‘The balance on the balanced scorecard: a critical analysis of some of its assumptions’, *Management Accounting Research,* vol. 11, pp. 65-88.

Nyhan, R & Martin, L 1999, ‘Comparative performance measurement: a primer on DEA’, *Public Productivity and Management Review,* vol. 22, no. 3, pp. 348-364.

O'Donnel, FJ & Duffy, AHB 2002, ‘Modeling design development performance’, *International Journal of Operations and Production Management,* vol. 22, no. 11, pp. 1198-1221.

OECD 2006a, *Economic survey of Australia 2006 policy brief,* Paris, viewed 15 October 2006,<www.oecd.org/publications/Policybriefs>.

OECD 2006b, ‘Conference on globalisation and the knowledge economy’, Issues Paper, Paris, October, viewed 30 November 2006, <www.oecd.org/>.

Oketch, MO 2004, ‘The corporate stake in social cohesion’, *Corporate Governance,* vol. 4, no. 3, pp. 5-19.

Olve, N, Roy, J & Wetter, M 1999, *Performance drivers: a practical guide to using the balanced scorecard,* John Wiley, Chichester.

O’Reagan, N & Ghobadian, A 2004, ‘Short- and long-term performance in manufacturing SMEs: different targets, different drivers’, *International Journal of Productivity and Performance Management,* vol. 53, no. 5, pp. 405-424.

O'Sullivan, M 2003, 'Employees and corporate governance', in C Kogut (ed.) *Corporate governance and capital flows in a global economy,* Oxford University Press, New York.

Otley, DT & Fakiolas, A 1995, 'Reliance on accounting performance measures: dead end or new beginning', *Accounting, Organisations and Society*, vol. 25, no. 4, pp. 497-510.

Otley, DT 1999, 'Performance management: a framework for management control systems research', *Management Accounting Research,* vol. 10, pp. 363-382.

Otley, DT 2002, 'Performance measurement-functional analysis', in A Neely (ed.) *Business performance measurement: theory and practice,* 1st edn, Cambridge University Press, Cambridge, pp. 3-21.

Oxley, A 2000, *Seize the future: how Australia can prosper in the new century*, Allen & Unwin, St Leonards, NSW.

Paganetto, L 2004, *Knowledge Economy, Information Technologies and Growth*, Ashgate, Hampshire, England.

Palmer, E & Parker, D 2001, 'Understanding performance measurement systems using physical science uncertainty principles', *International Journal of Operations and Production Management,* vol. 21, no. 7, pp. 981-999.

Parham, D 1999, *The new economy? A new look at Australia's productivity performance*, Productivity Commission Staff Research Paper, AusInfo, Canberra, May.

Parham, D 2002, *Productivity growth in Australia: are we enjoying a Miracle? towards opportunity and prosperity*, The Australian Conference, Melbourne Institute, 4-5 April, Melbourne.

Parker, C 2000, 'Performance measurement', *Work Study,* vol. 49, no. 2, pp. 63-66.

Passmore, WA 1982, 'Sociotechnical systems: a North American reflection on empirical studies of the seventies', *Human Relations*, vol. 35, no. 12, pp. 1179-1204.

Passmore, WA 1988, *Designing effective organisations: the sociotechnical systems perspective*, John Wiley, New York.

Pastor, JL & Sirvent, RI 1999, 'An enhanced DEA Russell graph efficiency measure', *European Journal of Operational Research*, vol. 115, no. 3, pp. 596-607.

Pitelis, C 2004, '(Corporate) Governance, (Shareholder) Value and (Sustainable) Economic Performance', *Corporate Governance,* vol. 12, no. 2, pp. 210-223.

Porter, ME 1998, *Competitive advantage: creating and sustaining superior performance*, Free Press, New York.

Porter, ME 2004, 'Location, competition, and economic development: local clusters in a global economy', in J Cantwell (ed.) *Globalization and the location of firms: globalization of the world economy,* vol. 15; Cheltenham, U.K. pp. 59-78.

Quazi, A 2003, 'Identifying the determinants of corporate managers' perceived social obligations', *Management Decision,* vol. 41, no. 9, pp. 822-831.

Ragsdale, CT 2004, *Spreadsheet modeling and decision analysis,* Thomson South-Western, Mason Ohio.

Ramanathan, R 2003, *An introduction to DEA: a tool for performance measurement*, Sage Publications India, New Delhi.

Rich, N & Bateman, N 2003, 'Companies' perceptions of inhibitors and enablers for process improvement activities', *International Journal of Operations and Production Management,* vol. 23, no. 2, pp. 185-199.

Richmond, J 1974, 'Estimating the efficiency of production', *International Economic Review,* vol. 15, no. 2, pp. 515-521.

Rickards, RC 2003, 'Setting benchmarks and evaluating balanced scorecards with DEA', *Benchmarking: An International Journal,* vol. 10, no. 3, pp. 226-245.

Ricks, DA 2003, 'Globalization and the role of the global corporation', *Journal of International Management,* vol. 9, pp. 355-359.

Roethlisberger, FJ & Dickson, WJ 1939, *Management and the worker*, Harvard University Press, Cambridge.

Ross, A, Venkataramanan, MA & Ernstberger, KW 1998, 'Reconfiguring the supply network using current performance data', *Decision Sciences,* vol. 29, no. 3, pp. 707-728.

Rouse, APB 1997, ‘A methodological framework of performance measurement with applications using DEA’, Doctoral thesis, University of Auckland.

Rouse, P & Putterill, M 2003, ‘An integral framework for performance measurement’, *Management Decision,* vol. 41, no. 8, pp. 791-805.

Rungtusanathan, M, Salvador, F, Forza, C & Choi, TY 2003, ’Supply chain linkages and operational performance’, *International Journal of Operations and Production Management,* vol. 23, no. 9, pp. 1084-2000.

SAI 2004, Social Accountability 8000 (SA8000) Standard, New York, viewed 12 June 2004, <www.cepaa.org>

Sanders, NR & Premus, R 2005, ‘Modeling the relationship between firm IT capability, collaboration, and performance’, *Journal of Business Logistics,* vol. 26, no. 1.

Santos, SP, Belton, V & Howick, S 2002, ‘Adding value to performance measurement by using system dynamics and multicriteria analysis’, *International Journal of Operations and Production Management,* vol. 22, no. 11, pp. 1246-1272.

Sarbannes-Oxley Act 2002 (USA)

Sarkis, J 1999, ‘A methodological framework for evaluating environmentally conscious manufacturing programs’, *Computers and Industrial Engineering,* vol. 36, no. 4; 4, pp. 793-810.

Schmitz, J & Platts, KW 2003 ‘Roles of supplier performance measurement: indication from a study in the automotive industry’, *Management Decision*, vol. 41, no. 8, pp. 711-721.

Seiford, L & Lewin, A 1997, ‘Extending the frontiers of DEA’, *Annals of Operations Research,* vol. 73, no. 1, pp. 1-11.

Sengupta, JK 1969, *Economic analysis and operations research: optimization techniques in quantitative economic models,* North-Holland, Amsterdam.

Sengupta, JK 2003, *New efficiency theory: with applications of DEA*, Springer-Verlag, Berlin.

Senior, B & Swailes, S 2004, ‘The dimensions of management team performance: a repertory grid study’, *International Journal of Productivity and Performance Management*, vol. 53, no. 4, pp. 317-333.

Sgro, PM 2003, ‘Globalisation, the environment and recent trends in international trade’, in JA Battten, & TA Fetherston, (eds) *Social responsibility: corporate governance issues*, vol. 17, JAI Elsevier Science, Oxford. pp. 21-45.

Sharif, AM 2002, ‘Benchmarking performance management systems’, *Benchmarking: An International Journal*, vol. 9, no. 1, pp. 62-85.

Sheehan, PJ, Pappas, N, Tikhomirova, G & Sinclair, P 1995, *Australia and the knowledge economy: an assessment of enhanced economic growth through science and technology*, Centre for Strategic Economic Studies, Victoria University, Melbourne.

Sherman, H 2004, ‘Corporate governance ratings’, *Corporate Governance*, vol. 12, no. 1, pp. 5-7.

Sim, K & Koh, HC 2001, ‘Balanced scorecard: a rising trend in strategic performance measurement’, *Measuring Business Excellence*, vol. 5, no. 2, pp. 18.

Simatupang, TM & Sridharan, R 2002, ‘The collaborative supply chain’, *International Journal of Logistics Management*, vol. 13, no. 1, pp. 15-30.

Simatupang, TM & Sridharan, R 2005, ‘An integrative framework for supply chain collaboration’, *International Journal of Operations and Production Management*, vol. 16, no. 2, pp. 257-274.

Sink, DS 1985, *Productivity management: planning measurement and evaluation, control and improvement*, John Wiley, New York.

Slack, N 1994, ‘The importance-performance matrix as a determinant of improvement priority’, *International Journal of Operations and Production Management*, vol. 14, no. 5, pp. 59-75.

Slack, NCS & Johnston, R 2004, *Operations management*, 4th edn, Pearson Education Prentice Hall, Harlow.

Smith, JH 1998, ‘The enduring legacy of Elton Mayo’, *Human Relations*, vol. 51, no. 3, pp. 221-250.

Smith, MR & Marx, L 1994, *Does technology drive history: the dilemma of technological determinism,* MIT Press, Cambridge.

Sonnenfeld, J 1985, ‘Shedding light on the Hawthorne Studies’, *Journal of Occupational Behaviour,* vol. 6, pp. 111-130.

Sonnenfeld, J 2004, ‘Good governance and the misleading myths of bad metrics’, *Academy of Management Executive,* vol. 18, no. 1, pp. 108-113.

Soonhong, M, Roath, AS, Daugherty, PJ, Genchev, SE, Chen, H, Arndt, AD & Richey, RG 2005, ‘Supply chain collaboration: what's happening?’, *The International Journal of Logistics Management*, vol. 16, no. 2, pp. 237-256.

Soteriou, AC & Stavrinides, Y 1997, ‘An internal customer service quality DEA model for bank branches’, *International Journal of Operations and Production Management,* vol. 17, no. 8, pp. 780-789.

Soyster, AL & Ventura, JA 1996, ‘Linear programming’, in M Avriel, & B Golany, (eds) *Mathematical programming for industrial engineers,* Marcel Dekker, New York, pp. 11-116.

St James Ethics Centre 2005, *Corporate Responsibility Index,* viewed 5 October 2005, <www.corporate-responsibility.com.au>.

Stapleton, G 2005, ‘Taking an audit of the audit committee’, The Age 3 June 2005, pp. 37.

Steering Committee for the Review of Commonwealth/State Service Provision 1997, *DEA: A technique for measuring the efficiency of government service delivery*, AGPS, Canberra.

Strenger, C 2004, ‘The corporate governance scorecard: a tool for the implementation of corporate governance’, *Corporate Governance,* vol. 12, no. 1, pp. 11-15.

Sumanth, DJ 1984, *Productivity engineering and management*, McGraw-Hill Book Company, New York.

Tabucanon, MT 1996, ‘Multiobjective programming for industrial engineers’, in M Avriel, & B Golany (eds) *Mathematical programming for industrial engineers*, Marcel Dekker, New York, pp. 487-542.

Tangen, S 2003, ‘An overview of frequently used performance measures’ *Work Study,* vol. 52, no. 7, pp. 347-354.

Tarr, J 1994, ‘Developing performance measurement systems that support continuous improvement’, *Hospital Material Management Quarterly,* vol. 17, no. 3, pp. 59-67.

Terziovski, M 2002, ‘Achieving performance excellence through an integrated strategy of radical innovation and continuous improvement’, *Measuring Business Excellence,* vol. 6, no. 2, pp. 5-14.

Thomsen, S 2004, ‘Corporate values and corporate governance’, *Corporate Governance,* vol. 4, no. 4, pp. 29-46.

Thorpe, R & Beasley, T 2004, ‘The characteristics of performance management research: implications and challenges’, *International Journal of Operations and Production Management*, vol. 53, no. 4, pp. 334-344.

Toffler, A 1971, *Future shock*, Bantam Books, New York.

Tone, K 2001, ‘A slack-based measure of efficiency in DEA’, *European Journal of Operational Research*, vol.130, pp. 498-509.

Toni, AD & Tonchia, S 2001, ‘Performance measurement systems: models, characteristics and measures’, *International Journal of Operations and Production Management*, vol. 21, no. 1, pp. 46-71.

Towill, DR 1997, ‘The seamless supply chain-the predator’s strategic advantage’ *International Journal of Technology Management*, vol. 13, no. 1, pp. 15-27.

Tracy, DL & Chen, B 2005, ‘A generalized model for weight restrictions in DEA’, *Journal of the Operational Research Society*, vol. 56, pp. 390-396.

Trent, RJ 2004, ‘The use of organisational design features in purchasing and supply management’, *The Journal of SCM*, vol. 40, no. 3, pp. 4-18.

Trist, EL 1981, *The evolution of socio-technical systems: perspectives on organisation design and behaviour*, John Wiley, New York.

Trist, EL & Murray, H 1993, *The social engagement of social science: a Tavistock anthology*, vol. 2, University of Pensilvania Press, Philadelphia.

Troutt, MD, Ehie, IC & Brandyberry, AA 2007, 'Maximally productive input-output units', *European Journal of Operational Research*, vol. 178, no. 2, pp. 359-373.

Van Amelsvoort, P 2000, *The design of work and organisation: the modern sociotechnical systems approach*, 1st edn, St-Groep, The Netherlands.

Van Der Zwaan, AH 1975, 'The sociotechnical systems approach: a critical evaluation', *International Journal of Production Research*, vol. 13, no. 2, pp. 149-163.

Van Der Zwaan, AH & Vries, JDE 1999, 'A critical assessment of the modern sociotechnical approach within production and operations management', *International Journal of Production Research*, vol. 38, no. 8, pp. 1755-1767.

Van Hoek, RI 2001, 'The contribution of performance measurement to the expansion of third party logistics alliances in the supply chain', *International Journal of Operations and Production Management*, vol. 21, no. 1/2, pp. 15-29.

Verweire, K & Van den Berghe, L 2003, 'Integrated performance management: adding a new dimension', *Management Decision*, vol. 41, no. 8, pp. 782-790.

Vollman, TE, Berry, WL, Whybark, DC, & Jacobs, FR 2005, *Manufacturing planning and control for SCM*, McGraw-Hill Irwin, Boston.

Waller, DL 2002, *Operations management: a supply chain approach*, Thomson, London.

Washington, M & and Hacker, M 2000, 'System equivalence: the application of joint optimization', *Measuring Business Excellence*, vol. 4, no. 4, pp. 18-23.

Wiener, N 1950, *The human use of human beings: cybernetics and human beings*, Eyre and Spottiswoode, London.

Weiner, N 1967, *The human use of human beings: cybernetics and society*, Avon Books, New York.

Wilcox, M & Bourne, M 2003, 'Predicting performance', *Management Decision*, vol. 41, no. 8, pp. 806-816.

Williamson, OE 1988, 'Corporate finance and corporate governance', *The Journal of Finance*, vol. 43, no. 3, pp. 567-583.

Winston, WL 1991, *Operations research: applications and algorithms*, 2nd edn, PWS-Kent, Boston.

Wolf, M 2004, *Why globalization works*, Yale University Press, Cambridge, Mass.

Wongrassamee, S, Gardiner, PD & Simmons, JEL 2003, 'Performance measurement tools: the balanced scorecard and the EFQM excellence model', *Measuring Business Excellence,* vol. 7, no. 1, pp. 14-29.

World Bank, 2004, 'FDI confidence index' *Global Business Policy Council,* Vol. 7, viewed 17 March 2006, <http://rru.worldbank.org/PapersLinks/Open.aspx?id=4644>.

Wren, DA 1994, *The evolution of management thought*, 4th edn, John Wiley & Sons, New York.

Young, B 2003, 'Corporate governance and firm performance: Is there a relationship?', *Ivey Business Journal,* vol. 68, no. 1, pp. 1-5.

Yurdakul, M & Ziraat Bankasi, YT 2005, 'Development of a performance measurement model for manufacturing companies using the AHP and TOPSIS approaches', *International Journal of Production Research*, vol. 43, no. 21, pp. 4609-4642.

Zahir, S 2006, 'Eliciting ratio preferences for the analytic hierarchy process with visual interfaces: a new mode of preference measurement', *International Journal of Information Technology and Decision Making,* vol. 5, no. 2, pp. 245-261.

Zairi, M 1994, *Measuring performance for business results*, Chapman & Hall, London.

Zairi, M 1998, *Benchmarking for best practice: continuous learning through sustainable innovation*, Butterworth-Heinemann, Oxford.

Zhang, Y & Bartels, R 1998, 'The effect of sample size on the mean efficiency in DEA with an application to electricity distribution in Australia, Sweden and New Zealand', *Journal of Productivity Analysis,* vol. 9, pp. 187-204.

Zhu, J 2003, *Quantitative models for performance evaluation and benchmarking*, Kluwer Academic Publishers, Boston.

Zonneveldt, M 2004, 'Westpac tops social ranking', *Herald Sun,* 9 September, pp.4.

Appendices

Appendix 1: Definitions of Key Terms

Agency Theory. In agency theory terms, the owners are principals and the managers are agents and there is an agency loss which is the extent to which returns to the owners fall below what they would be if the principals as owners, exercised direct control.

Allocative Efficiency. The extent to which the DMU minimizes inputs in optimal proportions through substitution and reallocation, given their respective prices, yet maintaining outputs. It is calculated as the ratio of cost efficiency to technical efficiency.

Activity Based Costing. An alternative to traditional accounting by identifying activity centres and allocating costs to them based on frequency of their transactions.

Balanced Scorecard. A strategic approach through a performance management system that translates company vision and strategy into action by taking the 4 perspectives of finance, customers, processes, and growth and learning. (Kaplan and Norton, 1992)

Business Process Reengineering. A fundamental rethink and radical redesign of organisational processes to achieve dramatic improvements in performance. Information technology plays an important part.

Comparative Advantage. A concept from Ricardian economics that states a country has a comparative advantage over another if it is able to produce some good at a lower opportunity cost.

Competitive Advantage. Company strategy is about taking offensive or defensive action to create a defendable position for the company, through low cost (cost leadership) or differentiation.

Constant Returns to Scale (CRS). Under this option the outputs change in direct proportion to the change in inputs, regardless of the size of the DMU, assuming that the scale of operations does not influence efficiency.

Corporate Governance. The system by which companies are directed and controlled, in the interest of shareholders and other stakeholders, to sustain and enhance value.

Corporate Citizenship (CSR). Corporate activity motivated in part by a concern for the welfare of non-owners of the company, and by an underlying commitment to basic principles such as integrity, fairness and respect for people.

Cost Efficiency. Another name for economic efficiency

DEA. A non-parametric technique for assessing the relative efficiencies of a group of DMUs where the units use multiple incommensurate inputs to produce incommensurate outputs

DEA Excel Solver. A Microsoft Excel Add-In for over 150 DEA models. Developed by Zhu.

DEA-Solver-PRO. DEA software for 130 DEA models in 32 clusters which uses the Microsoft Excel platform. Developed by Tone.

Decision Making Unit. An organisational unit of research interest which can be defined by a set of input-output characteristics which are common to other comparable units.

Decreasing Returns to Scale. When increases in inputs result in outputs increasing proportionately less than the inputs.

Economic Efficiency (Cost Efficiency or Overall Efficiency). The total efficiency when the allocative and technical efficiencies are combined as a ratio of the minimum production cost to the actual production cost of the DMU.

Economic Value Added. A financial performance measurement method of calculating the true economic value of a firm.

Globalisation. The process of global economic integration, facilitated by lower transaction costs and lower barriers to the movement of capital, goods, services and labour, thus creating a single market for inputs and outputs.

Increasing Returns to Scale. When increases in inputs results in proportionately greater increases in outputs.

Input Orientation (Input Contraction or Input Minimization). When levels of outputs are maintained and gains are achieved by trying to minimize inputs while operating in the same environment.

Knowledge Economy. Knowledge based economies are those which are directly based on the production, distribution and use of knowledge and information, and the role of knowledge, as compared with natural resources, physical capital, and low-skill labour, has taken on greater importance.

Knowledge Work. The work is the productive activity which is intellectual rather than physical and results in value-creating transformation of information.

Linear Programming. A mathematical technique that seeks to maximize or minimize some quantity (expressed as the objective function) in the presence of restrictions or constraints that limit the achievement of the objective. It evaluates alternative courses of action under relations that are expressed as linear equations or inequalities.

Output Orientation (Output Expansion or Output Maximization). When levels of inputs are maintained and gains are achieved by trying to maximize outputs while operating in the same environment.

Overall Efficiency. Another name for economic efficiency

Pareto Optimality. A measure of efficiency from game theory where each player's outcome is optimal with at least one player better, and the outcomes cannot be improved without at least one becoming worse off.

Partial Productivity. A ratio of output to one class of input.

Performance Prism. A second generation PM framework which addresses all of the organisation's stakeholders through five facets of performance: stakeholder satisfaction, stakeholder contribution, strategies, processes and capabilities.

Performance Pyramid. The final organisation performance aggregate scorecard measuring the dimensions of CG, supply networks, customer relations, and internal company operations.

Productivity. The partial or total ratio of outputs to inputs.

Pure Technical Efficiency. The technical efficiency when independent of returns to scale.

Returns to Scale (RTS). A long-run concept which reflects the degree to which proportional increases in input increases outputs. They may be constant RTS or variable RTS.

Slack. The amount of under-produced output or over-utilized input relative to the efficient DMUs which have no slack. The amount of slack measures the improvement potential for the inefficient DMU.

Stakeholders. Those groups or individuals who can affect, or are affected by, the firm's activities because of their material, political, affiliative, informational, symbolic or spiritual interest in a firm. Because they have a legitimate interest, they have a moral right to managerial attention.

Stewardship Theory. An alternative to agency theory whereby the executive manager, far from being an opportunist at the expense of the owners, essentially wants to do a good job, and be a good steward of corporate assets. Thus, this theory holds that performance variations arise due to differences in the structural situation facilitating effective action by the executive.

Supply Chain Management (SCM). The multi-firm relationships of integrated networks from upstream supplier to downstream customers that share information, product, services, finance and knowledge.

Theory of Constraints. A model that claims changes to most variables in the organisation have little impact on overall performance while there are a few vital ones which can have a significant impact. These are the constraints to higher achievement and often regarded as 'bottlenecks'.

Technical Efficiency. The extent to which the DMU obtains output from the inputs without regard to prices and costs.

Total Factor Productivity (Total Productivity). The productivity ratio when all factors of production are included, all inputs and all outputs.

Total Quality Management. A management philosophy with a focus on quality and the development and adaptation of techniques for achieving customer satisfaction. It includes a corporate culture based on self-directed work teams (SDWT) and employee participation.

Variable Returns to Scale (VRS). Changing inputs may not result in proportional changes in outputs, a preferred DEA assumption. An Increasing RTS occurs when a proportional increase in all inputs results in a more than proportional increase in output. A Decreasing RTS occurs when an increase in inputs results in proportionally less increases in outputs.

Appendix 2a: Spreadsheet Modeling of DEA in Linear Programming

Modeling languages allow users to do mathematical programming in a straightforward manner by the system mimicking the manual approach to solving the problem. Symbols are written almost the same as on paper, defining the data parameters, selecting the solver to use, and running the model.

Spreadsheet optimizers are tools readily available in the spreadsheet application of business software suites. Probably the most well-know of these is Solver in the Microsoft Excel application. It requires very little training as it is largely menu driven and the user defines variables, constraints, and functions by selecting them from the available list and then invoking Solver. Ragsdale (2004) for example, provides a strong spreadsheet-oriented text with a CD which includes Premium Solver™ and other software.

There are several mathematical techniques that are now solvable using software programs built into spreadsheet packages. Once the linear programming problem is formulated correctly and communicated to the computer in the acceptable format, the large number of iterations typical of LP problems is handled quickly and easily. LP in particular, is seen as important enough to warrant built-in optimization tools called 'solvers'. These are readily available in popular spreadsheet programs such as Excel, Quattro Pro and Lotus 1-2-3 and in more specialized packages such as CPLEX, MPSX, LINDO, MathPro, Crystal Ball Professional, etc.

There are four steps that summarize what needs to be done to implement a LP solution to a DEA problem in a spreadsheet. These are:

1) organize the data;

2) represent the decision variables;

3) create a formula for the left-hand-side of the constraint; and

4) create a formula representing the objective function.

One of the first steps is to organize the data for the formulation of the LP problem. This consists of the coefficients in the objective function, the coefficients in the constraints, and the right-hand-side (RHS) values for the constraints. The clarity of data, its purpose and meaning should be clear through visual layout and correct labeling of the information.

Step 2 is to represent the decision variables in the empty cells arranged in a structure paralleling the mathematical formulation, i.e. column headings for each decision variable with the cells beneath for each of their coefficients, on the LHS of the spreadsheet. The next step, on the LHS and in columns under the decision variables, is to implement the constraints and to create a formula that corresponds to those constraints. The fourth step is to create a formula that represents the objective function. The formula corresponding to the objective function is created by referring to the data cells where the objective function coefficients have been entered and the corresponding cells representing the decision variables. It is not necessary to include the common LP 'non-negativity conditions' as if they were another form of constraint because Solver allows these to be specified as simple upper and lower bounds for the decision variables by referring directly to the cells that represent them. Solver can now be used to find the optimal solution.

This process is best illustrated by a typical LP problem translated into the DEA form which determines how efficiently an operating unit converts inputs to outputs, as required and discussed in Chapter 5 of this thesis.

The mechanics of using Solver can be demonstrated by fabricating an example. A banking company (ABCo) is interested in maximizing profit through an efficient use of two key resources, employees and building. The number of employees per customer is said to represent customer service by being able to provide individualized account management while the area per customer is said to provide an attractiveness for customer to attend the branch. In this scenario the constraints are the actual floorspace available and the employees available per branch.

Max:	$Z=$	$350X_1$ +	$300X_2$			Profit
subject to:	$1X_1$	+	$1X_2$	≤ 200		Branch per customer constraint
	$9X_1$	+	$6X_2$	$\leq 1{,}566$		Labor per customer constraint
	$12X_1$	+	$16X_2$	$\leq 2{,}880$		Area per customer constraint
	$1X_1$			≥ 0		Simple lower bound
			$1X_2$	≥ 0		Simple lower bound

An early step in building a spreadsheet representation of the LP problem is to organize the data for the model. In the illustrations that follow we can show how ABCo optimizes its branch resources with regard to customer service and facility attractiveness.

Figure 3.4 below displays the data layout to show the decision variables and objective function, and the LHS formulas of constraints.

Cells B5 and C5 are the decision variables (called variable or changing cells in Solver) and Cells B6 and C6 show the yearly unit profits per customer against these parameters, with the objective function (called set or target cell by Solver) at D6.

The LHS formulas of constraints (called constraint cells by Solver) are shown in D9:D11. This spreadsheet should match the algebraically formulated LP problem above and shows how Solver views this formulation in Figure A3.4 and Figure A3.5.

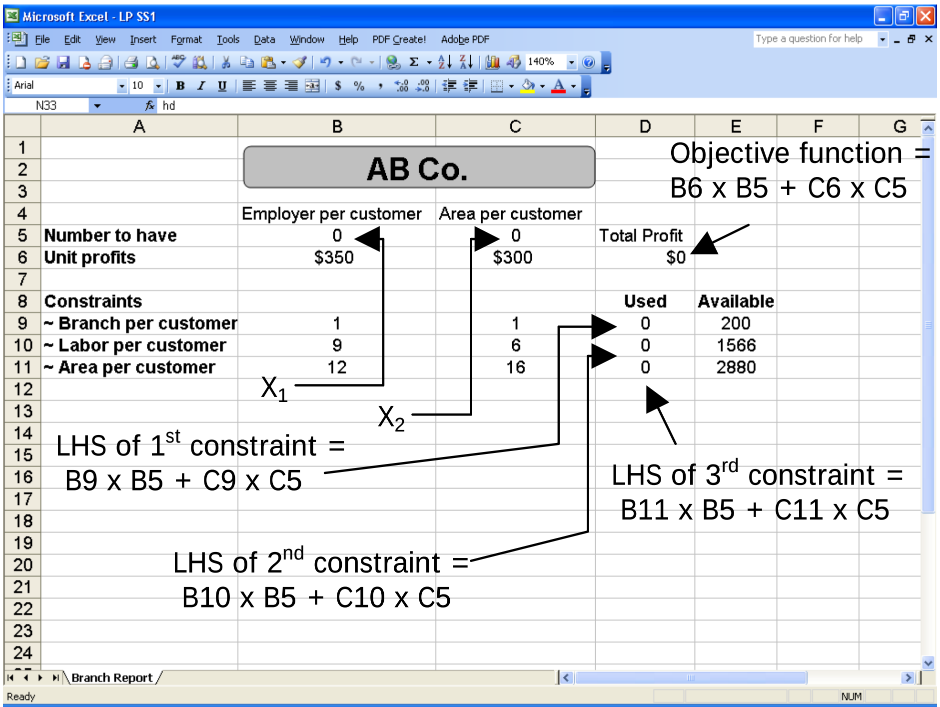


Figure A3.4 A Spreadsheet Model for the ABCo

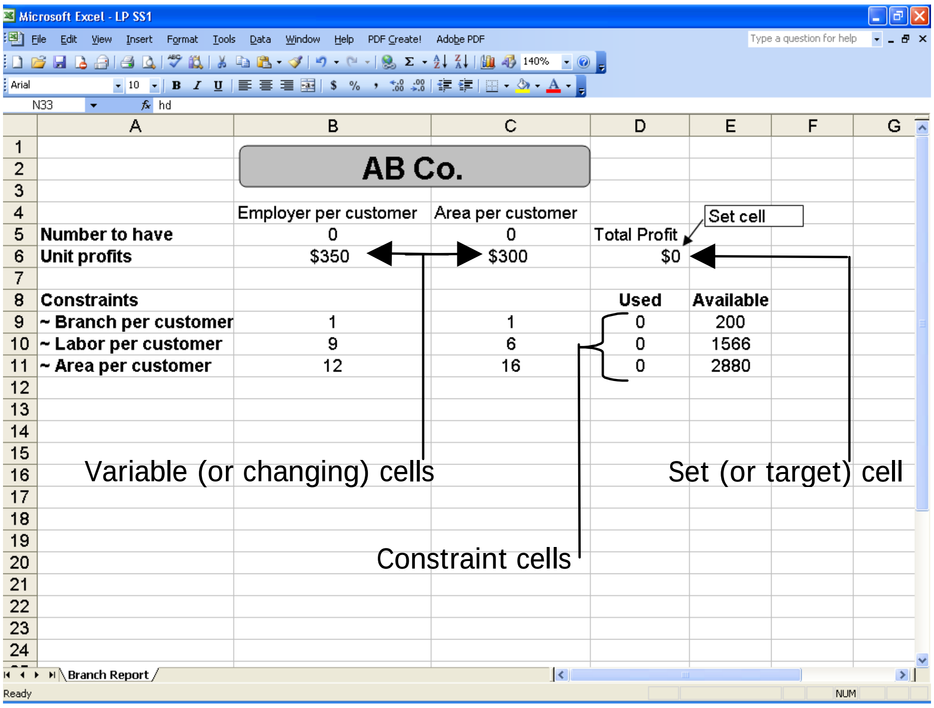


Figure A3.5 Summary of Solver's View of the Model

Having set up the LP model in the spreadsheet, the next step is to invoke Solver in Excel. Choosing Solver in the drop down Tools menu in Figure A3.6 should display the Solvers Parameters dialogue box in Figure A3.7. Clicking the Premium button displays the user interface which allows the algorithm known as 'Standard Simplex LP' to be used in solving the LP problem. Premium Solver™ has three different algorithms for solving optimization problems. Standard Simplex LP is one of these (Figure A3.8).

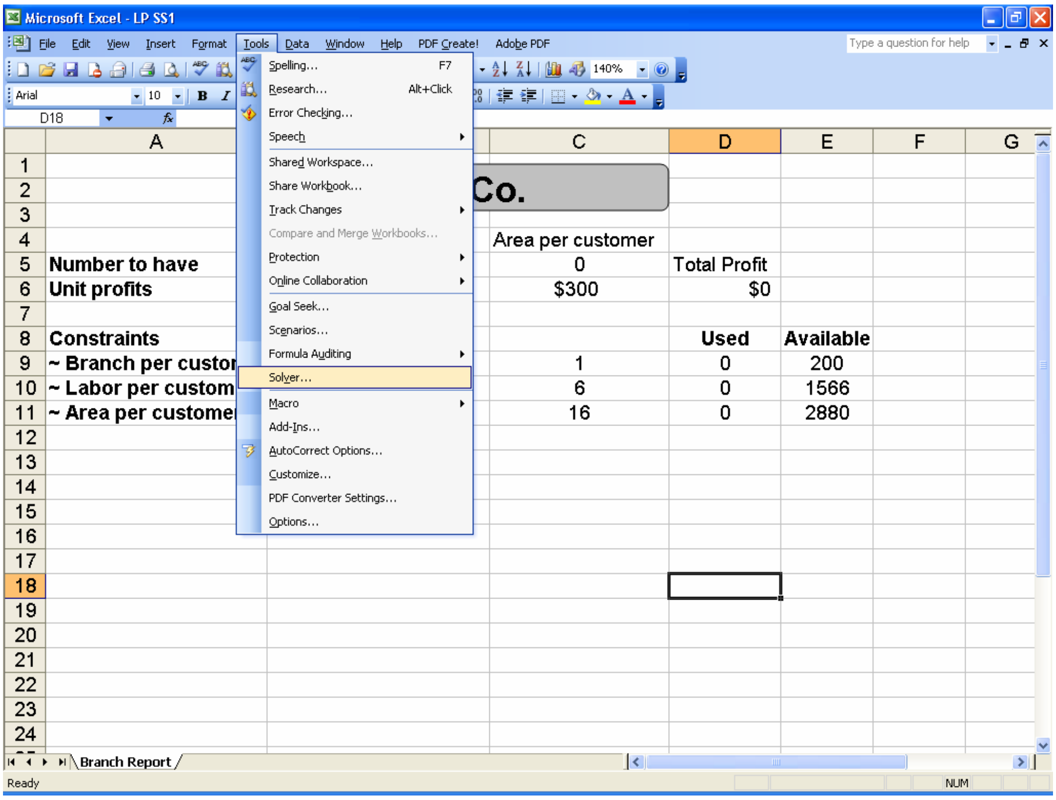


Figure A3.6 Invoking Solver from the Tools Dropdown Menu

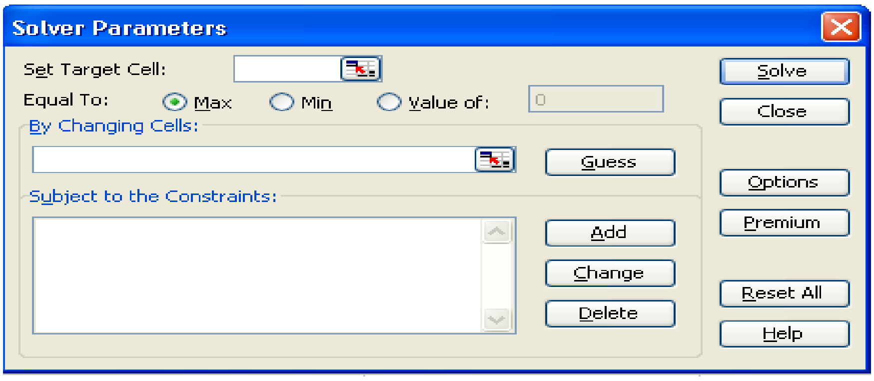


Figure A3.7 Solver Parameters Dialogue Box: Click Premium

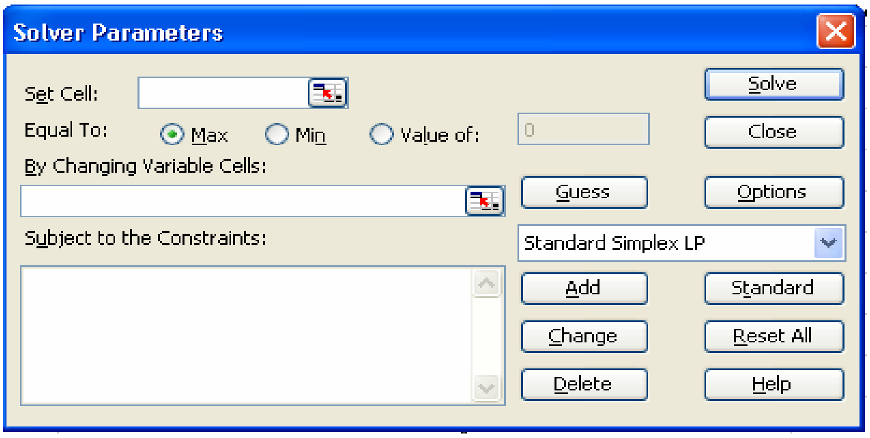


Figure A3.8 Solver Parameters Dialogue Box: Select LP Option

The task now is to specify the location of cells that represent the objective function, 'Set Cell' and the decision variables 'variable cells'. Figure A3.9 shows D6 as the cell containing the formula for the objective function and the Max button is selected to tell Solver to maximize this value. Figure A3.10 shows the variable cells specification.

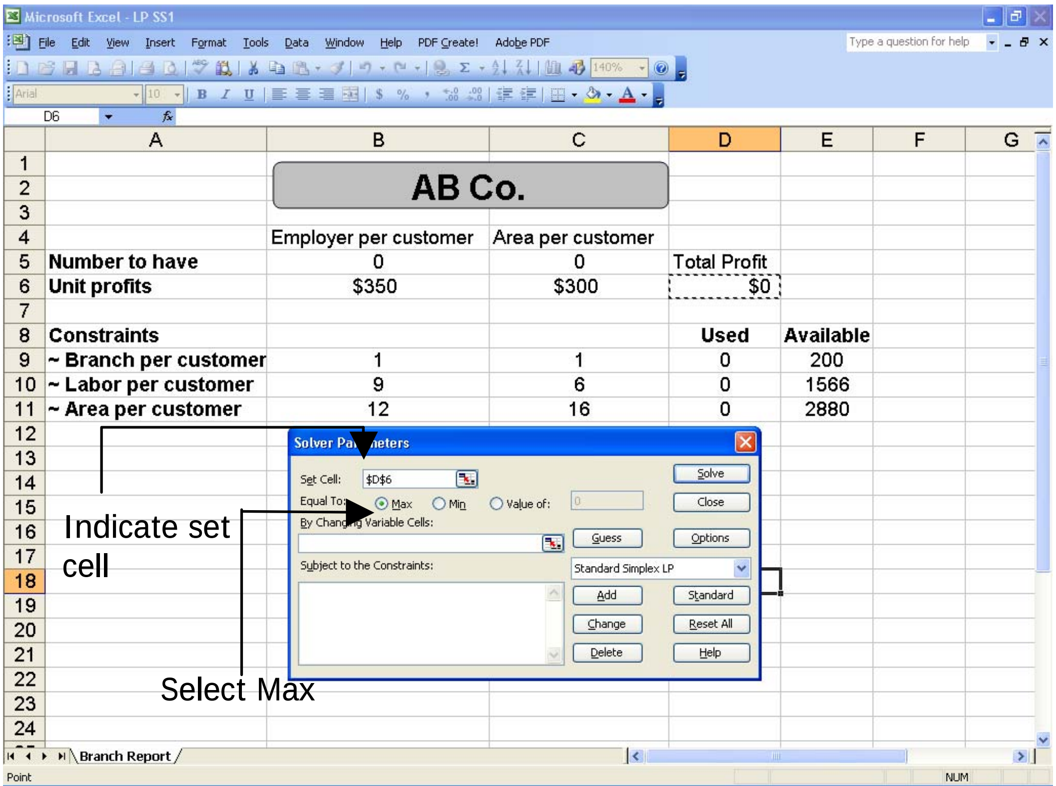


Figure A3.9 Specify the Set Cell

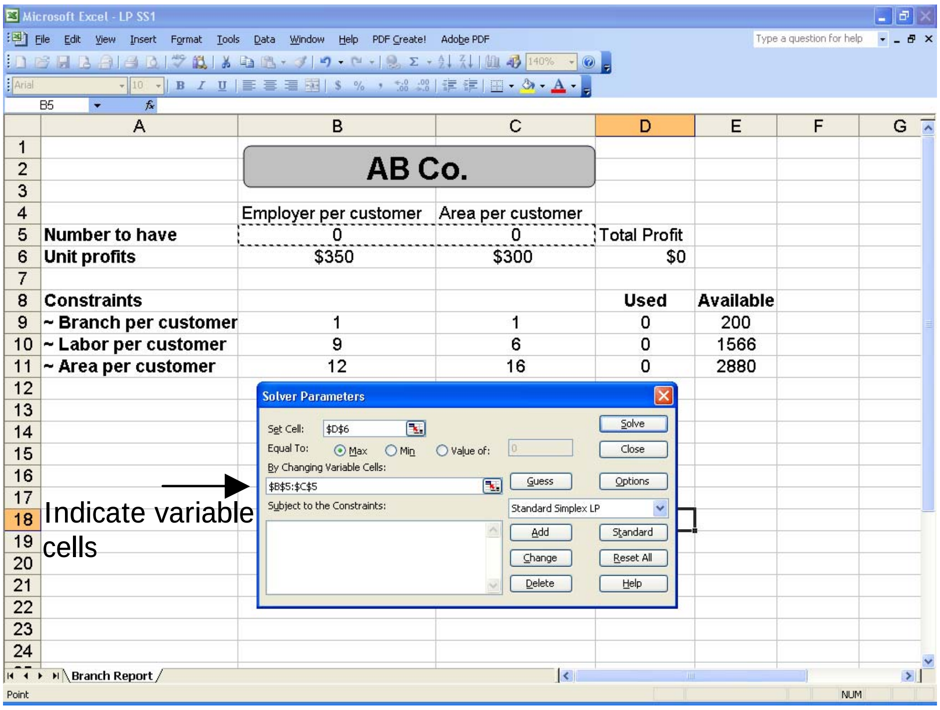


Figure A3.10 Specify the Variable Cells

The constraint cells must also be specified, as shown in Figure A3.11.

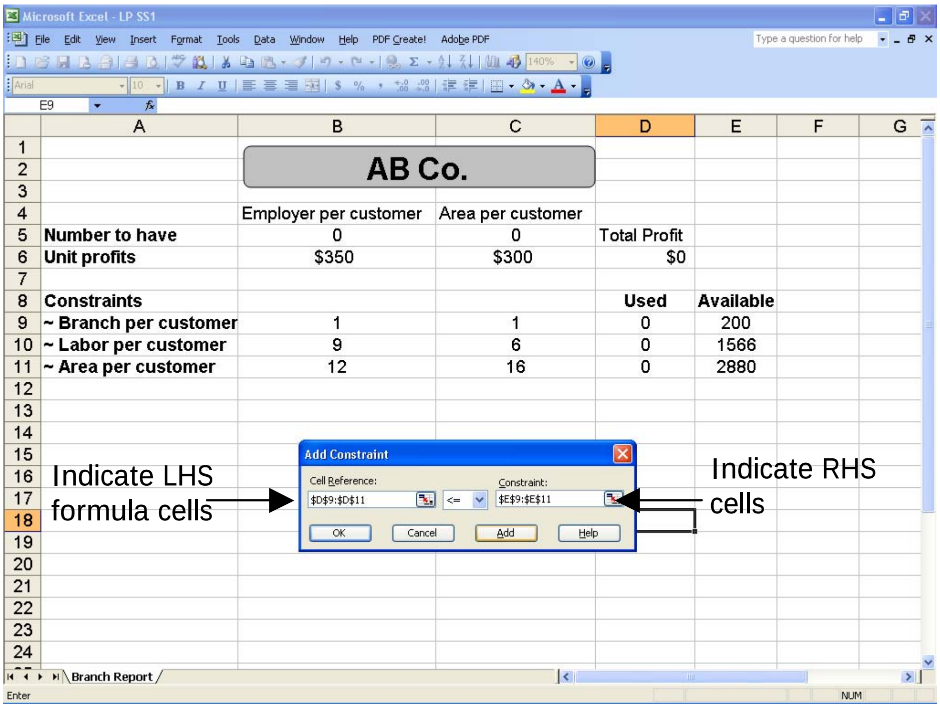


Figure A3.11 Specify the Constraints Cells

The restrictions that apply to these constraints must be defined, including the non-negativity conditions for the problem. These are shown in Figure A3.12.

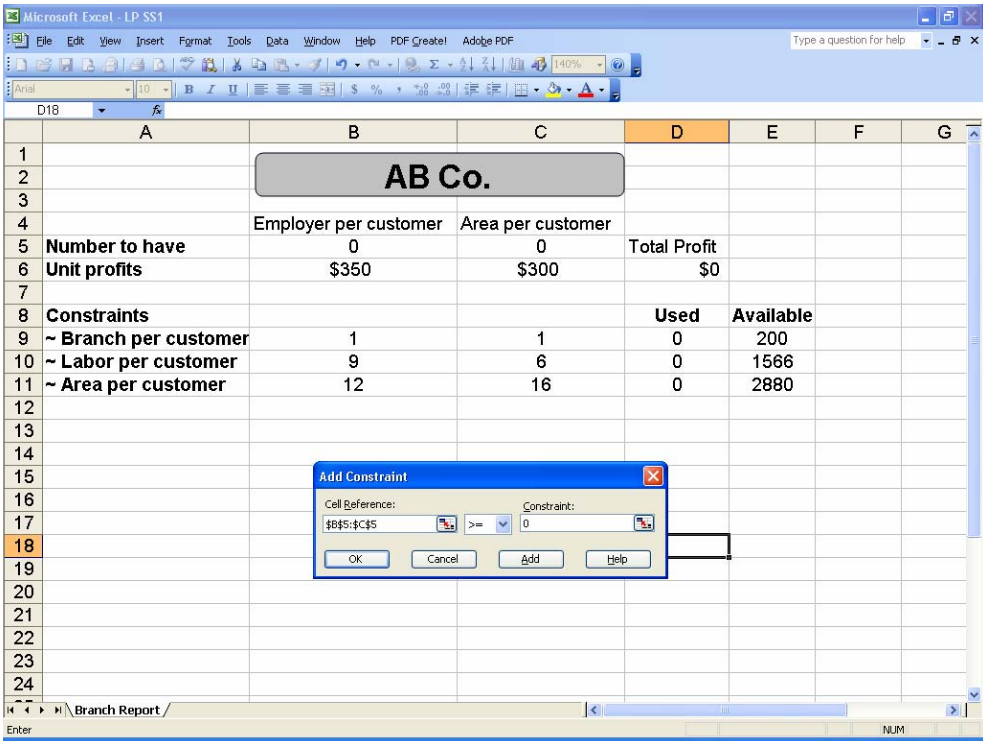


Figure A3.12 Add the Non-negativity Conditions

When all the problem specifications are completed the final Solver Parameters dialogue box appears, and shows how the program views the model. This is shown in Figure A3.13 and allows a review of the information that has been entered to allay any errors and to provide for correction before continuing. If all is correct then the 'Options' button on this dialogue box provides a number of options that Solver can use in solving the problem. This is shown in Figure A3.14. Once the options are chosen the 'Solve' button can be clicked and the optimal solution found. This is provided in Figure A3.15. The solution to this example would suggest that the most profitable of the branch configuration for the bank would be those where each bank employee has a customer portfolio of 122 clients in a facility which provides 78 sq. cms, say, of space per customer.

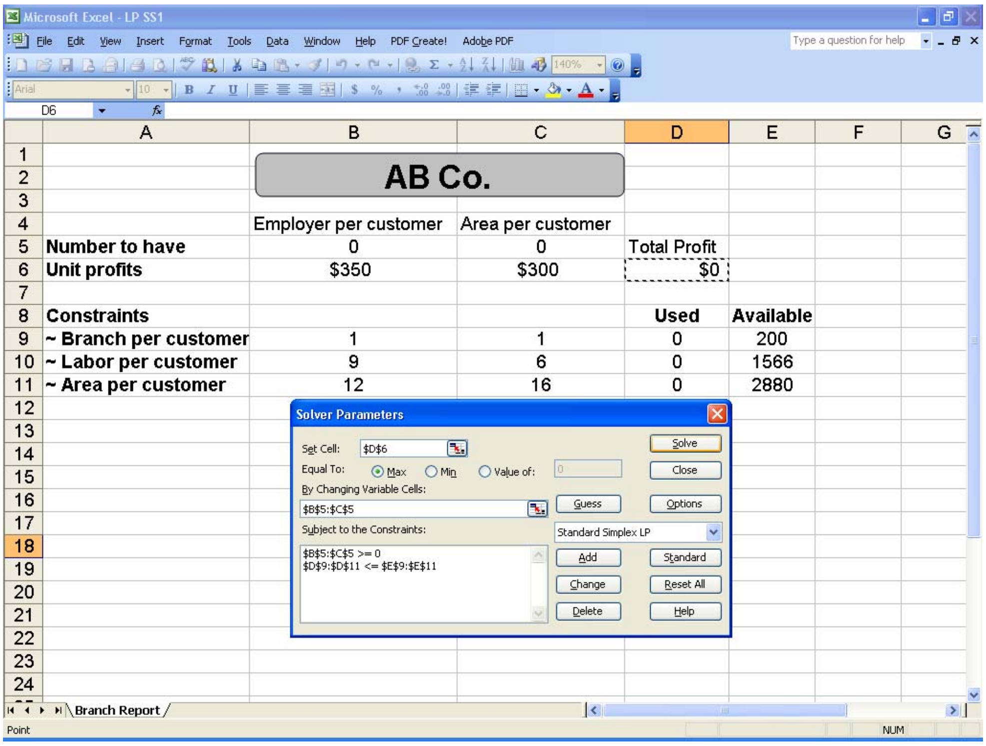


Figure A3.13 Summary of how Solver Views the Model

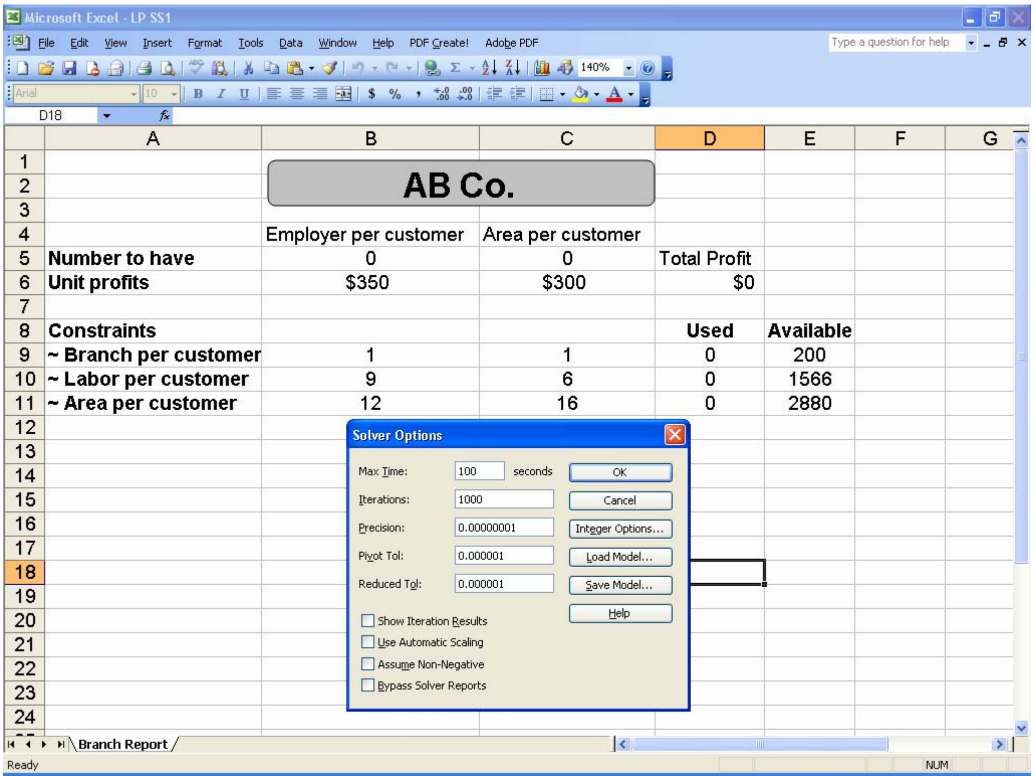
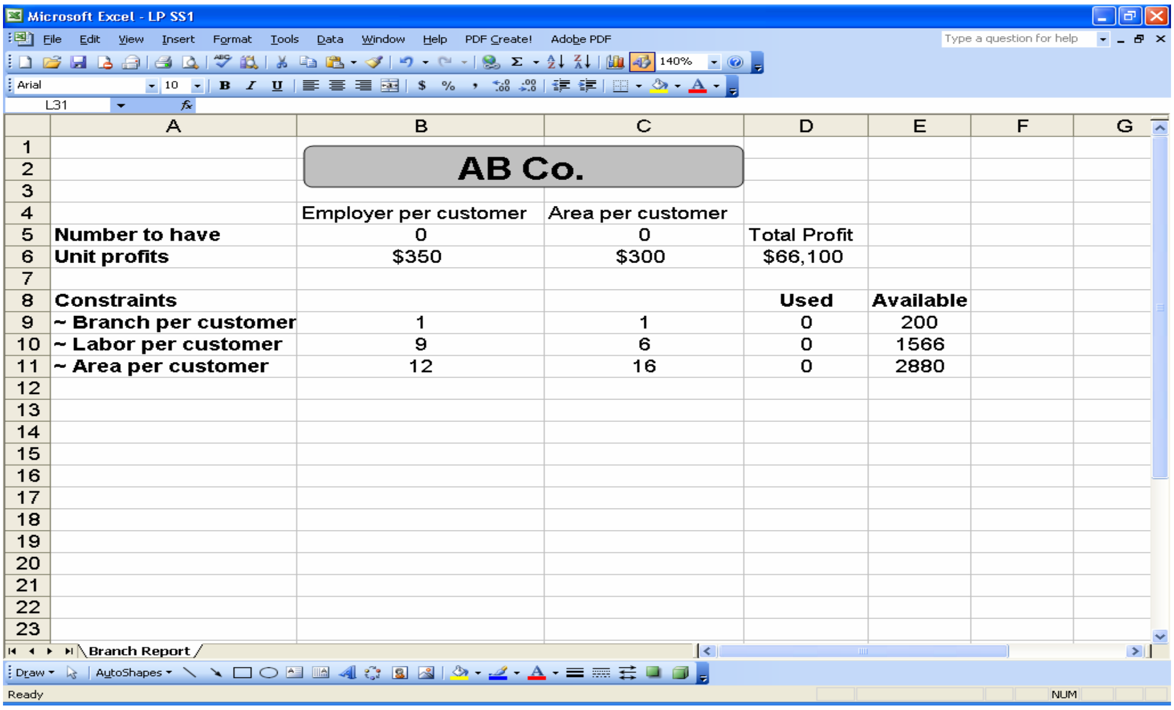


Figure A3.14 The Solver Options Dialogue Box



	A	B	C	D	E
2		AB Co.			
4		Employer per customer	Area per customer		
5	Number to have	0	0	Total Profit	
6	Unit profits	$350	$300	$66,100	
8	Constraints			Used	Available
9	~ Branch per customer	1	1	0	200
10	~ Labor per customer	9	6	0	1566
11	~ Area per customer	12	16	0	2880

Figure A3.15 The Optimal Solution

Implementing DEA through Spreadsheet Software

Spreadsheet add-ins such as Solver allow problem solving with ease because the mathematical computations are done by the program once the required equations are formulated into the spreadsheet. For a DEA type analysis however, the tedium comes from the numerous iterations required to find the optimal efficiency in terms of the input/output ratios for all DMUs and then to rank them accordingly. A simpler approach exists. For some popular mathematical models the preparation of the spreadsheet with the right equations in the right format has already been done by various authors. All that is required with these is the organisation and input of data into the specified cells as defined by the program authors. The program does the computations and all the iterations necessary and presents a comprehensively answered solution. See Zhu (2003), Ragsdale (2004), www.banxia.com, or www.saitech-inc.com for working and trial versions of these. Fully functional and more comprehensive versions of these are commercially available. One of these, DEA-Solver-PRO (Professional Version 4.1), is used in this thesis and its application is demonstrated in Chapter 5.

Appendix 2b DEA Solver-Pro 4.1

Version 4.1 consists of 130 models in 32 clusters. We can classify them into the three categories as displayed below.

Category	Cluster or Model
Radial	CCR, BCC, IRS, DRS, AR, ARG, NCN, NDSC, BNDCATSYSBilateralScale Elasticity, Congestion, Window, Malmquist-Radial, Adjusted Projection, FDH
Non-Radial and Oriented	SBM-Oriented, Super-efficiency-Oriented, Malmquist**Error! Bookmark not defined.**
Non-Radial and Non-Oriented	Cost, New-Cost, Revenue, New-Revenue, Profit, New-Profit, Ratio, SBM-NonOriented, Super-SBM-NonOriented, Malmquist-C (V, GRS), Undesirable Outputs

The abbreviated model names correspond to the following models.

1. CCR = Charnes-Cooper-Rhodes model
2. BCC = Banker-Charnes-Cooper model (Chapters 4, 5)
3. IRS = Increasing Returns-to-Scale model (Chapter 5)
4. DRS = Decreasing Returns-to-Scale model (Chapter 5)
5. GRS**Error! Bookmark not defined.** = Generalized Returns-to-Scale model (Chapter 5)
6. AR = Assurance Region model (Chapter 6)
7. ARG = Assurance Region GlobalNCN = Non-controllable variable model (Chapter 7)
8. NDSC = Non-discretionary variable model (See Page 7)
9. BND = Bounded variable model (Chapter 7)
10. CAT = Categorical variable model (Chapter 7)
11. SYS = Different Systems model (Chapter 7)
12. SBM-Oriented = Slacks-Based Measure model in input/output orientation (Chapter 4)
13. SBM-NonOriented = Slacks-Based Measure without orientation (Chapter 4)

14. Supper-SBM-Oriented = Super-efficiency model in input/output orientation
15. Super-SBM- NonOriented =Super-efficiency model without orientation. Cost = Cost efficiency model New-Cost = New cost efficiency model Revenue = Revenue efficiency model New-Revenue = New revenue modelProfit = Profit efficiency model New-Profit = New profit model Ratio = Ratio efficiency model (Chapter 8)
16. Bilateral = Bilateral comparison model (Chapter 7)
17. Window = Window Analysis (Chapter 9)
18. FDH = Free Disposal Hull model (Chapter 4)
19. Adjusted projection model
20. Malmquist-NonRadial= Malmquist productivity index model under the non-radial schemeMalmquist-Radial = Malmquist productivity index model under the radial scheme Scale Elasticity = Scale ElasticityCongestion = Congestion model Undesirable outputs = Undesirable outputs model DEA Models Included

The following 130 models in 32 clusters are included.

No.	Cluster	Model
1	CCR	CCR-I, CCR - O
2	BCC	BCC-I, BCC-O
3	IRS	IRS-I, IRS-O
4	DRS	DRS-I, DRS-O
5	GRS	GRS-I, GRS-O
6	AR (assurance region)	AR-I-C, AR-I-V, AR-I-GRS, AR-O-C, AR-O-V, AR-O-GRS
7	ARG (assurance region global)	ARG-I-C, ARG-I-V, ARG-I-GRS, ARG-O-C, ARG-O-V, ARG-O-GRS
8	NCN (non-controllable)	NCN-I-C, NCN-I-V, NCN-O-C, NCN-O-V
9	NDSC (non-discretionary)	NDSC-I-C, NDSC-I-V, NDSC-I-GRS, NDSC-O-C, NDSC-O-V, NDSC-O-GRS
10	BND (bounded variable)	BND-I-C, BND-I-V, BND-I-GRS, BND-O-C, BND-O-V, BND-O-GRS

11	CAT (categorical variable)	CAT-I-C, CAT-I-V, CAT-O-C, CAT-O-V
12	SYS (different systems)	SYS-I-C, SYS-I-V, SYS-O-C, SYS-O-V
13	SBM-Oriented (Slacks-based Measure)	SBM-I-C, SBM-I-V, SBM-I-GRS, SBM-O-C, SBM-O-V, SBM-O-GRS, SBM-AR-I-C, SBM-AR-I-V, SBM-AR-O-C, SBM-AR-O-V
14	SBM-NonOriented	SBM-C, SBM-V, SBM-GRS, SBM-AR-C, SBM-AR-V
15	Super-SBM-Oriented	Super-SBM-I-C, Super-SBM-I-V, Super-SBM-I-GRS, Super-SBM-O-C, Super-SBM-O-V, Super-SBM-O-GRS
16	Super-SBM-NonOriented	Super-SBM-C, Super-SBM-V, Super-SBM-GRS
17	Cost	Cost-C, Cost-V, Cost-GRS
18	New-Cost	New-Cost-C, New-Cost-V, New-Cost-GRS
19	Revenue	Revenue-C, Revenue-V, Revenue-GRS
20	New-Revenue	New-Revenue-C, New-Revenue-V, New-Revenue-GRS
21	Profit	Profit-C, Profit-V, Profit-GRS
22	New-Profit	New-Profit-C, New-Profit-V, New-Profit-GRS
23	Ratio (Revenue/Cost)	Ratio-C, Ratio-V
24	Bilateral	Bilateral
25	Window	Window-I-C, Window-I-V, Window-I-GRS, Window-O-C, Window-O-V, Window-O-GRS
26	FDH	FDH
27	Adjusted Projection	Adj-CCR-I, Adj-CCR-O, Adj-BCC-I, Adj-BCC-O, Adj-AR-I-C, Adj-AR-I-V, Adj-AR-O-C, Adj-AR-O-V
28	Malmquist-NonRadial	Malmquist-I-C, Malmquist-I-V, Malmquist-I-GRS, Malmquist-O-C, Malmquist-O-V, Malmquist-O-GRS, Malmquist-C, Malmquist-V, Malmquist-GRS
29	Malmquist-Radial	Malmquist-Radial-I-C, Malmquist-Radial-I-V,

		Malmquist-Radial-I-GRS, Malmquist-Radial-O-C, Malmquist-Radial-O-V, Malmquist-Radial-O-GRS
30	Scale Elasticity	Elasticity-I, Elasticity-O
31	Congestion	Congestion
32	Undesirable Outputs	BadOutput-C, BadOutput-V, BadOutput-GRS, NonSeparable-C, NonSeparable-V, NonSeparable-GRS

The meanings of the extensions -C, -V and –GRS are as follows. Every DEA model assumes a returns to scale (RTS) characteristics that is represneted by the ranges of the sum of the intensity vector λ, i.e. , $L \leq \lambda_1 + \lambda_2 + \cdots + \lambda_n \leq U$. The *constant* RTS (-C) corresponds to $(L = 0, U = \infty)$, and the variable RTS (-V) to $(L = 1, U = 1)$, respectively. In the models with the extension GRS, we have to supply *L* and *U* from keyboard, the defaults being *L*=0.8 and *U*=1.2. The *increasing* RTS corresponds to $(L = 1, U = \infty)$ and the *decreasing* RTS to $(L = 0, U = 1)$, respectively. It is recommended to try several sets of (*L*, *U*) in order to identify how the RTS chracteristics exerts an influence on the efficiency score.

Appendix 3 Summary of Business Units-Average Scores

No. of DMUs = 6

No. of Input items = 8 No. of Output items = 7

Input(1) = StakId	Output(1) = CorpImg
Input(2) = StakMgt	Output(2) = Trust
Input(3) = Value	Output(3) = Commn
Input(4) = Dialog	Output(4) = Opness
Input(5) = Ethic	Output(5) = T/over
Input(6) = EthicAtm	Output(6) = OrgID
Input(7) = SocAc	Output(7) = EmpInv
Input(8) = SocRptg	

Statistics on Input/Output Data

	StakId	StakM	Value	Dialog	Ethic	EthicA	SocAc	SocRp	CorpIn	Trust	Comm	Opnes	T/over	OrgID	EmpInv
Max	2.70	5.67	5.73	4.87	4.99	5.88	4.00	5.46	3.93	3.61	4.31	5.67	2.83	4.05	0.00
Min	2.28	5.38	5.41	4.68	4.14	5.57	3.78	5.04	3.57	3.24	3.55	4.24	2.40	3.33	0.00
Average	2.52	5.59	5.63	4.78	4.72	5.73	3.86	5.30	3.77	3.40	3.97	5.33	2.60	3.75	0.00
SD	0.15	0.10	0.11	0.08	0.27	0.09	0.10	0.13	0.13	0.12	0.22	0.50	0.14	0.22	0.00

Correlation

	StakId	StakM	Value	Dialog	Ethic	EthicA	SocAc	SocRp	CorpIn	Trust	Comm	Opnes	T/over	OrgID	EmpInv
StakId	1.00	0.33	0.53	0.75	0.08	-0.18	-0.58	0.01	-0.43	-0.67	-0.88	-0.06	0.27	-0.72	0.00
StakMgt	0.33	1.00	-0.42	0.69	0.83	0.83	0.26	0.89	-0.49	-0.85	-0.27	0.82	-0.63	-0.23	0.00
Value	0.53	-0.42	1.00	0.28	-0.21	-0.85	-0.72	-0.69	-0.31	-0.09	-0.52	-0.35	0.50	-0.45	0.00
Dialog	0.75	0.69	0.28	1.00	0.67	0.18	-0.05	0.28	-0.56	-0.91	-0.66	0.50	-0.40	-0.62	0.00
Ethic	0.08	0.83	-0.21	0.67	1.00	0.63	0.36	0.67	-0.59	-0.76	-0.08	0.97	-0.82	-0.13	0.00
EthicAtm	-0.18	0.83	-0.85	0.18	0.63	1.00	0.56	0.96	-0.13	-0.42	0.19	0.72	-0.66	0.19	0.00
SocAc	-0.58	0.26	-0.72	-0.05	0.36	0.56	1.00	0.30	0.36	0.09	0.56	0.37	-0.78	0.36	0.00
SocRptg	0.01	0.89	-0.69	0.28	0.67	0.96	0.30	1.00	-0.33	-0.57	0.01	0.76	-0.54	0.07	0.00
CorpImg	-0.43	-0.49	-0.31	-0.56	-0.59	-0.13	0.36	-0.33	1.00	0.77	0.67	-0.51	0.05	0.68	0.00
Trust	-0.67	-0.85	-0.09	-0.91	-0.76	-0.42	0.09	-0.57	0.77	1.00	0.68	-0.65	0.37	0.64	0.00
Commn	-0.88	-0.27	-0.52	-0.66	-0.08	0.19	0.56	0.01	0.67	0.68	1.00	0.08	-0.36	0.95	0.00
Opness	-0.06	0.82	-0.35	0.50	0.97	0.72	0.37	0.76	-0.51	-0.65	0.08	1.00	-0.82	0.07	0.00
T/over	0.27	-0.63	0.50	-0.40	-0.82	-0.66	-0.78	-0.54	0.05	0.37	-0.36	-0.82	1.00	-0.26	0.00
OrgID	-0.72	-0.23	-0.45	-0.62	-0.13	0.19	0.36	0.07	0.68	0.64	0.95	0.07	-0.26	1.00	0.00
EmpInv	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

DMUs with inappropriate Data with respect to the chosen Model

No.	DMU
	None

		No. of DMUs in Data =	6	Frequency in Reference Set	
		No. of DMUs with inapp	0	3	0
No. of DM	6	No. of evaluated DMUs	6	4	0
Average	1			5	0
SD	0	Average of scores =	1	6	0
Maximum	1	No. of efficient DMUs =	6		
Minimum	1	No. of inefficient DMUs	0		
		No. of over iteration DM	0		

Appendix 4 All Business Units-Reversed

No. of DMUs = 6
No. of Input items = 7 No. of Output items = 8

Input(1) = CorpImg	Output(1) = StakId
Input(2) = Trust	Output(2) = StakMgt
Input(3) = Commn	Output(3) = Value
Input(4) = Opness	Output(4) = Dialog
Input(5) = T/over	Output(5) = Ethic
Input(6) = OrgID	Output(6) = EthicAtm
Input(7) = EmpInv	Output(7) = SocAc
	Output(8) = SocRptg

	CorpIn	Trust	Comm	Opnes	T/ove	OrgID	EmpIn	StakI	StakM	Value	Dialo	Ethic	EthicAt	SocAc
Max	3.93	3.61	4.31	5.67	2.83	4.05	6.08	2.70	5.67	5.73	4.87	4.99	5.88	4.00
Min	3.57	3.24	3.55	4.24	2.40	3.33	4.71	2.28	5.38	5.41	4.68	4.14	5.57	3.78
Average	3.77	3.40	3.97	5.33	2.60	3.75	5.23	2.52	5.59	5.63	4.78	4.72	5.73	3.86
SD	0.13	0.12	0.22	0.50	0.14	0.22	0.43	0.15	0.10	0.11	0.08	0.27	0.09	0.10

Correlation

	CorpIn	Trust	Comm	Opnes	T/ove	OrgID	EmpIn	StakI	StakM	Value	Dialo	Ethic	EthicAt	SocAc
CorpImg	1.00	0.77	0.67	-0.51	0.05	0.68	0.88	-0.43	-0.49	-0.31	-0.56	-0.59	-0.13	0.36
Trust	0.77	1.00	0.68	-0.65	0.37	0.64	0.92	-0.67	-0.85	-0.09	-0.91	-0.76	-0.42	0.09
Commn	0.67	0.68	1.00	0.08	-0.36	0.95	0.51	-0.88	-0.27	-0.52	-0.66	-0.08	0.19	0.56
Opness	-0.51	-0.65	0.08	1.00	-0.82	0.07	-0.80	-0.06	0.82	-0.35	0.50	0.97	0.72	0.37
T/over	0.05	0.37	-0.36	-0.82	1.00	-0.26	0.42	0.27	-0.63	0.50	-0.40	-0.82	-0.66	-0.78
OrgID	0.68	0.64	0.95	0.07	-0.26	1.00	0.48	-0.72	-0.23	-0.45	-0.62	-0.13	0.19	0.36
EmpInv	0.88	0.92	0.51	-0.80	0.42	0.48	1.00	-0.42	-0.83	-0.01	-0.73	-0.85	-0.50	0.09
StakId	-0.43	-0.67	-0.88	-0.06	0.27	-0.72	-0.42	1.00	0.33	0.53	0.75	0.08	-0.18	-0.58
StakMgt	-0.49	-0.85	-0.27	0.82	-0.63	-0.23	-0.83	0.33	1.00	-0.42	0.69	0.83	0.83	0.26
Value	-0.31	-0.09	-0.52	-0.35	0.50	-0.45	-0.01	0.53	-0.42	1.00	0.28	-0.21	-0.85	-0.72
Dialog	-0.56	-0.91	-0.66	0.50	-0.40	-0.62	-0.73	0.75	0.69	0.28	1.00	0.67	0.18	-0.05
Ethic	-0.59	-0.76	-0.08	0.97	-0.82	-0.13	-0.85	0.08	0.83	-0.21	0.67	1.00	0.63	0.36
EthicAtm	-0.13	-0.42	0.19	0.72	-0.66	0.19	-0.50	-0.18	0.83	-0.85	0.18	0.63	1.00	0.56
SocAc	0.36	0.09	0.56	0.37	-0.78	0.36	0.09	-0.58	0.26	-0.72	-0.05	0.36	0.56	1.00
SocRptg	-0.33	-0.57	0.01	0.76	-0.54	0.07	-0.66	0.01	0.89	-0.69	0.28	0.67	0.96	0.30

DMUs with inappropriate Data with respect to the chosen Model

No.	DMU
	None

		No. of DMUs in Data =	6
		No. of DMUs with inapprop	0
No. of DMU	6	No. of evaluated DMUs =	6
Average	1		
SD	0	Average of scores =	1
Maximum	1	No. of efficient DMUs =	6
Minimum	1	No. of inefficient DMUs =	0
		No. of over iteration DMUs	0

Frequency in Reference Set

Peer set	Frequency to other DMUs
1	0
2	0
3	0
4	0
5	0
6	0

[CCR-I] LP started at 10-05-2005 19:45:08 and completed at 10-05-2005 19:45
Elapsed time = 1 seconds
Total number of simplex iterations = 37

Appendix 5 Sample with 48 DMUs

Appendix 5 Table 5.9

No. of DMUs = 48

No. of Input items = 23
- Input(1) = ComOpn
- Input(2) = Comacc
- Input(3) = Humanst
- Input(4) = EmpInv
- Input(5) = Intethics
- Input(6) = Mgteth
- Input(7) = EthclCzn
- Input(8) = sesiCSP
- Input(9) = OrgComt
- Input(10) = OrgId
- Input(11) = Trust
- Input(12) = Pos
- Input(13) = Corpimg
- Input(15) = Justce
- Input(16) = Stkeng
- Input(17) = Accbty
- Input(18) = tenure
- Input(19) = Socldes
- Input(20) = Ethbusbhvr
- Input(21) = manfin

No. of Output items = 8
- Output(1) = StakID
- Output(2) = Stakman
- Output(3) = Valu
- Output(4) = dialog
- Output(5) = eticCom
- Output(6) = EthicATm
- Output(7) = SocAcy
- Output(8) = Socrptg

	Huma	EmpInv	Inteth	Mgtet	EthclC	sesiC	OrgC	OrgId	Trust	Pos	Corpir	Tover	Justce	Stkeng
Max	5.00	9.00	5.00	5.00	5.00	5.00	5.00	5.00	4.33	5.00	5.00	5.00	5.00	7.00
Min	1.44	1.75	1.00	1.13	2.00	2.60	2.40	2.33	2.33	1.00	2.00	1.00	1.33	3.17
Average	3.46	5.10	2.76	3.10	4.15	4.19	4.00	3.79	3.40	3.29	3.66	2.67	3.36	5.60
SD	0.74	1.55	1.16	0.92	0.59	0.63	0.62	0.69	0.42	0.92	0.68	1.11	0.94	0.90

Correlation

	Huma	EmpInv	Inteth	Mgtet	EthclC	sesiC	OrgC	OrgId	Trust	Pos	Corpir	Tover	Justce	Stkeng
ComOpn	0.50	0.20	0.34	0.42	0.43	0.25	0.38	0.23	-0.04	0.71	0.49	-0.37	0.16	0.36
Comacc	0.48	0.28	-0.06	0.27	0.27	0.42	0.44	0.33	0.11	0.49	0.28	-0.44	0.20	0.29
Humanst	1.00	0.36	0.26	0.55	0.48	0.39	0.39	0.05	-0.02	0.55	0.55	-0.44	0.26	0.45
EmpInv	0.36	1.00	0.38	0.47	0.33	0.37	0.46	0.33	0.19	0.41	0.53	-0.42	0.27	0.37
Intethics	0.26	0.38	1.00	0.24	0.52	0.22	0.19	0.18	0.21	0.38	0.38	-0.31	0.25	0.25
Mgteth	0.55	0.47	0.24	1.00	0.32	0.49	0.49	0.19	0.12	0.63	0.40	-0.16	0.20	0.60
EthclCzn	0.48	0.33	0.52	0.32	1.00	0.27	0.36	0.23	0.27	0.50	0.71	-0.38	0.23	0.42
sesiCSP	0.39	0.37	0.22	0.49	0.27	1.00	0.40	0.25	0.14	0.44	0.28	-0.13	0.17	0.40
OrgComt	0.39	0.46	0.19	0.49	0.36	0.40	1.00	0.61	0.26	0.52	0.37	-0.55	0.26	0.44
OrgId	0.05	0.33	0.18	0.19	0.23	0.25	0.61	1.00	0.20	0.33	0.24	-0.36	-0.11	0.16
Trust	-0.02	0.19	0.21	0.12	0.27	0.14	0.26	0.20	1.00	0.15	0.26	-0.32	0.18	0.03
Pos	0.55	0.41	0.38	0.63	0.50	0.44	0.52	0.33	0.15	1.00	0.47	-0.37	0.23	0.50
Corpimg	0.55	0.53	0.38	0.40	0.71	0.28	0.37	0.24	0.26	0.47	1.00	-0.48	0.19	0.38
Tover	-0.44	-0.42	-0.31	-0.16	-0.38	-0.13	-0.55	-0.36	-0.32	-0.37	-0.48	1.00	-0.27	-0.13
Justce	0.26	0.27	0.25	0.20	0.23	0.17	0.26	-0.11	0.18	0.23	0.19	-0.27	1.00	0.22
Stkeng	0.45	0.37	0.25	0.60	0.42	0.40	0.44	0.16	0.03	0.50	0.38	-0.13	0.22	1.00
Accbty	0.65	0.34	0.32	0.53	0.58	0.31	0.45	0.17	0.13	0.50	0.62	-0.42	0.47	0.62
tenure	0.21	0.07	0.23	0.09	-0.03	0.02	0.15	0.14	0.11	0.15	0.04	-0.34	0.07	-0.15
Socldes	0.10	0.06	0.10	0.12	-0.03	0.14	-0.09	0.10	-0.16	-0.04	-0.03	0.11	-0.22	0.08
Ethbusbh	0.69	0.51	0.51	0.61	0.66	0.46	0.50	0.18	0.20	0.64	0.57	-0.41	0.26	0.59
manfin	0.20	-0.01	-0.12	0.58	-0.04	0.12	0.22	0.08	-0.12	0.10	0.10	0.02	-0.13	0.31
csrmc	0.73	0.48	0.36	0.71	0.54	0.47	0.51	0.18	0.07	0.58	0.59	-0.32	0.34	0.84
discitiz	0.37	0.46	0.59	0.37	0.63	0.33	0.23	0.11	0.28	0.39	0.52	-0.32	0.37	0.47
StakID	0.32	0.39	0.40	0.59	0.49	0.37	0.47	0.29	0.08	0.44	0.38	-0.14	0.15	0.88
Stakman	0.47	0.25	0.03	0.46	0.24	0.33	0.30	-0.02	-0.04	0.43	0.28	-0.09	0.23	0.87
Valu	0.35	0.31	0.13	0.44	0.10	0.45	0.39	0.21	0.27	0.29	0.25	-0.12	0.40	0.46
dialog	0.77	0.37	0.32	0.58	0.40	0.30	0.24	-0.01	-0.09	0.40	0.50	-0.24	0.20	0.63
eticCom	0.63	0.36	0.43	0.54	0.62	0.38	0.50	0.13	0.33	0.60	0.54	-0.40	0.20	0.58
EthicATm	0.61	0.52	0.47	0.54	0.56	0.43	0.40	0.18	0.06	0.55	0.48	-0.34	0.25	0.47
SocAcy	0.66	0.31	0.31	0.49	0.58	0.32	0.42	0.07	0.11	0.56	0.58	-0.44	0.49	0.61
Socrptg	0.51	0.31	0.26	0.46	0.47	0.22	0.38	0.24	0.12	0.32	0.53	-0.32	0.34	0.50

	Accbt	tenure	Socld	Ethbu	manfi	csrmc	disciti	StakI	Stakm	Valu	dialog	eticCo	EthicA	SocA	Socrptg
Max	7.00	442.00	5.00	6.80	5.00	6.55	4.67	7.00	7.00	7.00	6.57	6.80	7.00	7.00	7.00
Min	3.18	0.00	2.33	1.53	2.00	3.64	1.67	3.00	3.33	3.44	2.57	1.80	1.25	1.75	3.40
Average	5.38	148.94	4.19	4.67	4.28	5.12	3.60	5.45	5.74	4.70	4.75	5.63	3.70	5.19	5.57

Appendix 6 Minimum Average Maximum Scores

No. of DMUs = 18
No. of Input items = 6
Input(1) = R
Input(2) = S
Input(3) = U
Input(4) = V
Input(5) = AB
Input(6) = AE
No. of Output items = 1
Output(1) = AM

Returns to Scale = Constant (0 =< Sum of Lambda < Infinity)

Statistics on Input/Output Data

	R	S	U	V	AB	AE	AM
Max	7	5	5	5	5	5	5
Min	1	1.44	1	1	1	1	1.33
Average	4.110815	3.440129	2.836569	3.094416	3.132614	3.248451	3.554064
SD	2.061796	1.243274	1.571148	1.39564	1.486525	1.516603	1.222962

Correlation

	R	S	U	V	AB	AE	AM
R	1	0.969309	0.979878	0.957972	0.974405	0.971889	0.942641
S	0.969309	1	0.975387	0.955563	0.975468	0.957473	0.939266
U	0.979878	0.975387	1	0.954547	0.969979	0.945905	0.908205
V	0.957972	0.955563	0.954547	1	0.965488	0.965427	0.918503
AB	0.974405	0.975468	0.969979	0.965488	1	0.974538	0.95863
AE	0.971889	0.957473	0.945905	0.965427	0.974538	1	0.975303
AM	0.942641	0.939266	0.908205	0.918503	0.95863	0.975303	1

DMUs with inappropriate Data with respect to the chosen Model

No. of DMUs in Data =	18
No. of DMUs with inappropriate Data =	0
No. of evaluated DMUs =	18

Average of scores =	0.741354
No. of efficient DMUs =	4
No. of inefficient DMUs =	14
No. of over iteration DMUs =	0

[CCR-O] LP started at 03-05-2006 16:14:29 and completed at 03-05-2006 16:14:30
Elapsed time = 0 seconds
Total number of simplex iterations = 88

No. of DMU	18
Average	0.741354
SD	0.152827
Maximum	1
Minimum	0.560961

Frequency in Reference Set

Peer set	Frequency to other DMUs
A1	14
B1	6
E1	4
F1	1

Appendix 7 Service History of More than Five Years

Appendix 7A Unit A Table 5.10ii

No. of DMUs = 6

No. of Input items = 6
Input(1) = Comopen
Input(2) = Comacc
Input(3) = Integeth
Input(4) = Manageth
Input(5) = Pos
Input(6) = Justice

No. of Output items = 1
Output(1) = Csrmc

	Comopen	Comacc	Integeth	Manageth	Pos	Justice	Csrmc
Max	5.6	5.2	3.33	4.88	4.2	5	6.29
Min	3.4	2	1	1.13	2	2	3.78
Average	4.2	4.066667	2.331667	2.815	3.066667	3.721667	4.976667
SD	0.730297	1.214724	0.881919	1.355566	0.861523	1.038756	0.886541

Correlation

	Comopen	Comacc	Integeth	Manageth	Pos	Justice	Csrmc
Comopen	1	0.135271	0.725085	0.133338	0.593377	0.277265	0.210059
Comacc	0.135271	1	-0.4771	0.733818	0.12316	0.172681	0.760411
Integeth	0.725085	-0.4771	1	-0.56377	0.263083	0.160806	-0.47523
Manageth	0.133338	0.733818	-0.56377	1	0.380185	-0.11439	0.86219
Pos	0.593377	0.12316	0.263083	0.380185	1	0.044945	0.166134
Justice	0.277265	0.172681	0.160806	-0.11439	0.044945	1	0.336036
Csrmc	0.210059	0.760411	-0.47523	0.86219	0.166134	0.336036	1

DMUs with inappropriate Data with respect to the chosen Model
No. of DMUs in Data = 6
No. of DMUs with inappropriate Data = 0
No. of evaluated DMUs = 6

Average of scores = 0.961873
No. of efficient DMUs = 3
No. of inefficient DMUs = 3
No. of over iteration DMUs = 0

[CCR-O] LP started at 10-17-2005 21:03:25 and completed at 10-17-2005 21:03:26
Elapsed time = 0 seconds
Total number of simplex iterations = 27

No.	DMU
	None

No. of DMU	6
Average	0.961873
SD	0.04775
Maximum	1
Minimum	0.866812

Frequency in Reference Set

Peer set	Frequency to other DMUs
108	1
152	3
182	3

Appendix 7B Unit B Table 5.10ii

No. of DMUs = 46
No. of Input items = 6 No. of Output items = 1
Input(1) = Comacc Output(1) = Csrmc
Input(2) = Humanist
Input(3) = Integeth
Input(4) = Manageth
Input(5) = Pos
Input(6) = Justice

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	7	5	5	5	5	5	6.55
Min	1.6	1.44	1	1.5	1	1.33	3.64
Average	4.056522	3.593913	2.912826	3.162391	3.382609	3.36587	5.176957
SD	1.257093	0.734541	1.186758	0.830964	0.919193	0.911088	0.724736

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.478104	0.027871	0.161072	0.470434	0.185077	0.398387
Humanist	0.478104	1	0.352832	0.486114	0.573084	0.303296	0.727088
Integeth	0.027871	0.352832	1	0.354343	0.414637	0.305204	0.497427
Manageth	0.161072	0.486114	0.354343	1	0.695647	0.25985	0.649165
Pos	0.470434	0.573084	0.414637	0.695647	1	0.276993	0.654406
Justice	0.185077	0.303296	0.305204	0.25985	0.276993	1	0.342135
Csrmc	0.398387	0.727088	0.497427	0.649165	0.654406	0.342135	1

DMUs with inappropriate Data with respect to the chosen Model
No. of DMUs in Data = 46
No. of DMUs with inappropriate Data = 0
No. of evaluated DMUs = 46

Average of scores = 0.915673
No. of efficient DMUs = 20
No. of inefficient DMUs = 26
No. of over iteration DMUs = 0

[CCR-O] LP started at 10-17-2005 20:32:52 and completed at 10-17-2005 20:32:52
Elapsed time = 1 seconds
Total number of simplex iterations = 524

No.	DMU	Frequency in Reference Set Peer set	Frequency to other DMUs	Frequency in Reference Set Peer set	Fcy to other DMUs
	None	38	1	170	3
		52	17	171	0
No. of DMU	46	72	8	186	5
Average	0.915673	96	2	190	0
SD	0.095818	134	9	202	4
Maximum	1	138	10	203	4
Minimum	0.701832	145	4	205	1
		147	19	207	0
		148	1	213	0
		168	1	215	12

Appendix 7C Unit C Table 5.10 ii

No. of DMUs = 49

No. of Input items = 6 No. of Output items = 1

Input(1) = Comacc Output(1) = Csrmc

Input(2) = Humanist

Input(3) = Integeth

Input(4) = Manageth

Input(5) = Pos

Input(6) = Justice

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	6.8	5	5	5	5	5	6.62
Min	1	1.89	1	1.25	1	1	3.24
Average	4.32449	3.754898	3.107347	3.285102	3.22449	3.23449	5.171224
SD	1.34233	0.729059	1.108481	0.843501	0.857745	1.241464	0.695817

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.335538	0.033894	0.397614	0.433387	0.170148	0.466966
Humanist	0.335538	1	0.089566	0.429848	0.432874	0.35525	0.532886
Integeth	0.033894	0.089566	1	0.331736	0.21454	0.000599	0.173951
Manageth	0.397614	0.429848	0.331736	1	0.501182	0.2255	0.626762
Pos	0.433387	0.432874	0.21454	0.501182	1	0.463731	0.517921
Justice	0.170148	0.35525	0.000599	0.2255	0.463731	1	0.450246
Csrmc	0.466966	0.532886	0.173951	0.626762	0.517921	0.450246	1

DMUs with inappropriate Data with respect to the chosen Model

No. of DMUs in Data = 49

No. of DMUs with inappropriate Data = 0

No. of evaluated DMUs = 49

Average of scores = 0.794361

No. of efficient DMUs = 9

No. of inefficient DMUs = 40

No. of over iteration DMUs = 0

[CCR-O] LP started at 10-17-2005 22:13:27 and completed at 10-17-2005 22:13:28

Elapsed time = 0 seconds

Total number of simplex iterations = 471

No.	DMU
	None

No. of DMU	49
Average	0.794361
SD	0.132886
Maximum	1
Minimum	0.563387

Frequency in Reference Set

Peer set	Frequency to other DMUs
19	10
39	5
42	35
44	1
46	5
68	37
78	25
109	19
204	4

Appendix 7D Unit D Table 5.10ii

No. of DMUs = 48
No. of Input items = 6   No. of Output items = 1
Input(1) = Comacc   Output(1) = Csrmc
Input(2) = Humanist
Input(3) = Integeth
Input(4) = Manageth
Input(5) = Pos
Input(6) = Justice

	Com	Huma	Intege	Manag	Pos	Justice	Csrmc
Max	6.80	5.00	5.00	4.38	5.00	5.00	6.69
Min	1.60	1.44	1.00	1.13	1.00	1.00	2.32
Average	4.27	3.56	2.69	2.68	2.71	2.88	4.86
SD	1.37	0.89	1.05	0.76	1.07	1.02	0.87

Correlation

	Com	Huma	Intege	Manag	Pos	Justice	Csrmc
Comacc	1.00	0.28	0.23	0.29	0.40	0.49	0.31
Humanist	0.28	1.00	0.39	0.56	0.66	0.40	0.58
Integeth	0.23	0.39	1.00	0.39	0.30	0.24	0.53
Manageth	0.29	0.56	0.39	1.00	0.62	0.28	0.62
Pos	0.40	0.66	0.30	0.62	1.00	0.55	0.68
Justice	0.49	0.40	0.24	0.28	0.55	1.00	0.44
Csrmc	0.31	0.58	0.53	0.62	0.68	0.44	1.00

DMUs with inappropriate Data with respect to the chosen Model
No. of DMUs in Data = 48
No. of DMUs with inappropria 0
No. of evaluated DMUs = 48

Average of scores = 0.67
No. of efficient DMUs = 3
No. of inefficient DMUs = 45
No. of over iteration DMUs = 0

[CCR-O] LP started at 10-17-2005 21:27:01
Elapsed time = 0 seconds
Total number of simplex iterations = 346

No.	DMU
	None

No. of DMU 48
Average 0.7
SD 0.2
Maximum 1
Minimum 0.4

Frequency in Reference Set

Peer set	Frequency to other DMUs
95	4
135	38
231	45

Appendix 7E Unit E Table 5.10

No. of DMUs = 41
No. of Input items = 6
Input(1) = Comacc
Input(2) = Humanist
Input(3) = Integeth
Input(4) = Manageth
Input(5) = Pos
Input(6) = Justice
No. of Output items = 1
Output(1) = Csrmc

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	7	5	5	4.63	5	5	6.87
Min	2	2.33	1	1.63	1	1.83	3.98
Average	4.362195	3.675122	2.553171	3.097561	3.378049	3.44122	5.255122
SD	1.307053	0.669817	1.040388	0.672269	0.904059	0.854173	0.667321

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.254881	0.084038	0.174642	0.086402	0.05505	0.232806
Humanist	0.254881	1	0.642261	0.442728	0.573779	0.466535	0.727082
Integeth	0.084038	0.642261	1	0.36146	0.492691	0.447781	0.576618
Manageth	0.174642	0.442728	0.36146	1	0.406074	0.278548	0.533143
Pos	0.086402	0.573779	0.492691	0.406074	1	0.464705	0.625206
Justice	0.05505	0.466535	0.447781	0.278548	0.464705	1	0.478716
Csrmc	0.232806	0.727082	0.576618	0.533143	0.625206	0.478716	1

DMUs with inappropriate Data with respect to the chosen Model

No. of DMUs in Data =	41
No. of DMUs with inappropriate Data =	0
No. of evaluated DMUs =	41

Average of scores =	0.918811
No. of efficient DMUs =	16
No. of inefficient DMUs =	25
No. of over iteration DMUs =	0

[CCR-O] LP started at 10-17-2005 20:49:32 and completed at 10-17-2005 20:49:33
Elapsed time = 0 seconds
Total number of simplex iterations = 438

No.	DMU	Frequency in Reference Set			
	None	Peer set	Frequency to other DMUs		
		28	3	198	20
No. of DMl	41	56	2	216	12
Average	0.918811	64	1	218	0
SD	0.086784	83	8	221	8
Maximum	1	98	9	241	0
Minimum	0.671345	107	11	242	8
		113	0		
		119	8		
		146	5		
		187	0		

Appendix 7F Unit F Table 5.10ii

No. of DMUs = 18
No. of Input items = 6 No. of Output items = 1
Input(1) = Comacc Output(1) = Csrmc
Input(2) = Humanist
Input(3) = Integeth
Input(4) = Manageth
Input(5) = Pos
Input(6) = Justice

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	6.2	5	5	4.88	5	5	6.6
Min	1.6	2.44	1	2	2	1.33	3.58
Average	4.055556	3.986667	3.203333	3.353333	3.444444	3.685556	5.148889
SD	1.188473	0.728415	1.031908	0.676814	0.725888	0.976651	0.690595

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.207239	0.241569	0.427707	0.164571	0.336401	0.217626
Humanist	0.207239	1	0.553998	0.631764	0.478139	0.128457	0.656446
Integeth	0.241569	0.553998	1	0.612359	0.546718	0.318239	0.530139
Manageth	0.427707	0.631764	0.612359	1	0.519869	0.280443	0.805996
Pos	0.164571	0.478139	0.546718	0.519869	1	0.380973	0.327473
Justice	0.336401	0.128457	0.318239	0.280443	0.380973	1	0.204202
Csrmc	0.217626	0.656446	0.530139	0.805996	0.327473	0.204202	1

DMUs with inappropriate Data with respect to the chosen Model
No. of DMUs in Data = 18
No. of DMUs with inappropriate Data = 0
No. of evaluated DMUs = 18

Average of scores = 0.939812
No. of efficient DMUs = 9
No. of inefficient DMUs = 9
No. of over iteration DMUs = 0

[CCR-O] LP started at 10-17-2005 22:25:41 and completed at 10-17-2005 22:25:42
Elapsed time = 0 seconds
Total number of simplex iterations = 129

No.	DMU
	None

No. of DMU	18
Average	0.939812
SD	0.084472
Maximum	1
Minimum	0.721608

Frequency in Reference Set

Peer set	Frequency to other DMUs
174	6
27	1
31	5
128	1
223	2
65	5
92	4
183	5
123	1

Appendix 8 Trial 1

Appendix 8 Table 5.11
No. of DMUs = 231
No. of Input items = 6 No. of Output items = 1
Input(1) = Comacc Output(1) = Csrmc
Input(2) = Humanist
Input(3) = Integeth
Input(4) = Manageth
Input(5) = Pos
Input(6) = Justice

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	7	5	5	5	5	5	6.87
Min	1	1	1	1	1	1	2.32
Average	4.231255	3.621169	2.825801	3.04697	3.164935	3.270173	5.082641
SD	1.296303	0.797445	1.109515	0.833567	0.979279	1.036071	0.776499

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.311849	0.096127	0.283826	0.307914	0.236923	0.345104
Humanist	0.311849	1	0.385503	0.509241	0.555474	0.319591	0.620671
Integeth	0.096127	0.385503	1	0.385806	0.388135	0.230713	0.422233
Manageth	0.283826	0.509241	0.385806	1	0.596198	0.282781	0.642059
Pos	0.307914	0.555474	0.388135	0.596198	1	0.461684	0.620413
Justice	0.236923	0.319591	0.230713	0.282781	0.461684	1	0.421486
Csrmc	0.345104	0.620671	0.422233	0.642059	0.620413	0.421486	1

DMUs with inappropriate Data with respect to the chosen Model

No.	DMU
	None

No. of DMUs in Data =	231
No. of DMUs with inappropriate Data =	0
No. of evaluated DMUs =	231

No. of DMU	231
Average	0.623105
SD	0.154181
Maximum	1
Minimum	0.395617

Average of scores =	0.623105
No. of efficient DMUs =	11
No. of inefficient DMUs =	220
No. of over iteration DMUs =	0

Frequency in Reference Set

Reference	Frequency to other DMUs
C109	6
C129	40
C42	48
C44	18
C68	73
D135	113
D2	36
D231	216
D95	4
E242	28
E83	4

[CCR-I] LP started at 11-11-2005 20:02:48
Elapsed time = 3 seconds
Total number of simplex iterations = 1509

Appendix 9 Trial 2

Appendix 9 Table 5.14

Problem = DMU

No.	DMU
	None

No. of DMUs = 6
No. of Input items = 6
Input(1) = Comacc
Input(2) = Humanist
Input(3) = Integeth
Input(4) = Manageth
Input(5) = Pos
Input(6) = Justice
No. of Output items = 1
Output(1) = Csrmc

Returns to Scale = Constant (0 =<

No. of DMU	6
Average	0.943051
SD	0.064369
Maximum	1
Minimum	0.847943

Frequency in Reference Set

Reference	Frequency to other DMUs
A108	2
A152	3
A182	3

Statistics on Input/Output Data

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	5.2	4	3.33	4.88	4.2	5	6.29
Min	2	2	1	1.13	2	2	3.78
Average	4.283333	2.998333	2.331667	2.815	3.066667	3.721667	4.976667
SD	1.117164	0.654177	0.881919	1.355566	0.861523	1.038756	0.886541

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.893475	-0.51913	0.752834	0.389048	0.239728	0.718163
Humanist	0.893475	1	-0.37341	0.801392	0.38937	0.462873	0.917361
Integeth	-0.51913	-0.37341	1	-0.56377	0.263083	0.160806	-0.47523
Manageth	0.752834	0.801392	-0.56377	1	0.380185	-0.11439	0.86219
Pos	0.389048	0.38937	0.263083	0.380185	1	0.044945	0.166134
Justice	0.239728	0.462873	0.160806	-0.11439	0.044945	1	0.336036
Csrmc	0.718163	0.917361	-0.47523	0.86219	0.166134	0.336036	1

DMUs with inappropriate Data with respect to the chosen Model

No. of DMUs in Data =	6
No. of DMUs with inappropriate Data =	0
No. of evaluated DMUs =	6
Average of scores =	0.943051
No. of efficient DMUs =	3
No. of inefficient DMUs =	3
No. of over iteration DMUs =	0

[CCR-O] LP started at 11-13-2005 14:13:13 and completed at 11-13-2005 14:13:13
Elapsed time = 0 seconds
Total number of simplex iterations = 39

Appendix 9 Table 5.14

Problem = ID

No. of DMUs = 46
No. of Input items = 6
Input(1) = Comacc
Input(2) = Humanist
Input(3) = Integeth
Input(4) = Manageth
Input(5) = Pos
Input(6) = Justice
No. of Output items = 1
Output(1) = Csrmc

Returns to Scale = Constant (0 =< Sum of Lambda < Infinity)

Statistics on Input/Output Data

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	7	5	5	5	5	5	6.55
Min	1.6	1.44	1	1.5	1	1.33	3.64
Average	4.056522	3.593913	2.912826	3.162391	3.382609	3.36587	5.176957
SD	1.257093	0.734541	1.186758	0.830964	0.919193	0.911088	0.724736

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.478104	0.027871	0.161072	0.470434	0.185077	0.398387
Humanist	0.478104	1	0.352832	0.486114	0.573084	0.303296	0.727088
Integeth	0.027871	0.352832	1	0.354343	0.414637	0.305204	0.497427
Manageth	0.161072	0.486114	0.354343	1	0.695647	0.25985	0.649165
Pos	0.470434	0.573084	0.414637	0.695647	1	0.276993	0.654406
Justice	0.185077	0.303296	0.305204	0.25985	0.276993	1	0.342135
Csrmc	0.398387	0.727088	0.497427	0.649165	0.654406	0.342135	1

DMUs with inappropriate Data with respect to the chosen Model
No. of DMUs in Data = 46
No. of DMUs with inappropriate Data = 0
No. of evaluated DMUs = 46

Average of scores = 0.915673
No. of efficient DMUs = 20
No. of inefficient DMUs = 26
No. of over iteration DMUs = 0

[CCR-O] LP started at 11-13-2005 14:15:53 and completed at 11-13-2005 14:15:54
Elapsed time = 0 seconds
Total number of simplex iterations = 731

Appendix 9 Table 5.14

Problem = BusUnit

No. of DMUs = 63
No. of Input items = 6
Input(1) = Comacc
Input(2) = Humanist
Input(3) = Integeth
Input(4) = Manageth
Input(5) = Pos
Input(6) = Justice
No. of Output items = 1
Output(1) = Csrmc

Returns to Scale = Constant (0 =< Sum of Lambda < Infinity)

Statistics on Input/Output Data

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	7	5	5	5	5	5	6.62
Min	1	1.89	1	1	1	1	3.24
Average	4.287302	3.685873	3.072857	3.206349	3.238095	3.245556	5.175873
SD	1.348308	0.774209	1.106293	0.853587	0.918838	1.181787	0.712805

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.367051	0.102874	0.41715	0.387838	0.209508	0.479135
Humanist	0.367051	1	0.218223	0.459416	0.464515	0.318698	0.519284
Integeth	0.102874	0.218223	1	0.401472	0.281187	0.092014	0.246786
Manageth	0.41715	0.459416	0.401472	1	0.547419	0.311318	0.633697
Pos	0.387838	0.464515	0.281187	0.547419	1	0.518882	0.544082
Justice	0.209508	0.318698	0.092014	0.311318	0.518882	1	0.472724
Csrmc	0.479135	0.519284	0.246786	0.633697	0.544082	0.472724	1

DMUs with inappropriate Data with respect to the chosen Model
No. of DMUs in Data = 63
No. of DMUs with inappropriate Data = 0
No. of evaluated DMUs = 63

Average of scores = 0.785799
No. of efficient DMUs = 11
No. of inefficient DMUs = 52
No. of over iteration DMUs = 0

[CCR-O] LP started at 11-13-2005 14:25:01 and completed at 11-13-2005 14:25:02
Elapsed time = 0 seconds
Total number of simplex iterations = 712

Appendix 9 D Table 5.14

No. of DMUs = 57
No. of Input items = 6
Input(1) = Comacc
Input(2) = Humanist
Input(3) = Integeth
Input(4) = Manageth
Input(5) = Pos
Input(6) = Justice
No. of Output items = 1
Output(1) = Csrmc

Returns to Scale = Constant

No.	DMU
	None

No. of DMU	57
Average	0.668046
SD	0.161485
Maximum	1
Minimum	0.397331

Frequency in Reference Set

Reference	Frequency to other DMUs
D135	42
D2	7
D231	52
D81	12
D95	4

Statistics on Input/Output Data

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	6.8	5	5	4.38	5	5	6.69
Min	1.6	1	1	1.13	1	1	2.32
Average	4.26614	3.482982	2.637193	2.668947	2.677193	2.918421	4.769649
SD	1.291311	0.913493	1.05246	0.755854	1.048142	0.984053	0.87505

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.217326	0.234172	0.277186	0.366321	0.459955	0.296494
Humanist	0.217326	1	0.424169	0.530985	0.640006	0.289585	0.582043
Integeth	0.234172	0.424169	1	0.471315	0.382045	0.178921	0.546796
Manageth	0.277186	0.530985	0.471315	1	0.642871	0.207441	0.580079
Pos	0.366321	0.640006	0.382045	0.642871	1	0.481039	0.67552
Justice	0.459955	0.289585	0.178921	0.207441	0.481039	1	0.394491
Csrmc	0.296494	0.582043	0.546796	0.580079	0.67552	0.394491	1

DMUs with inappropriate Data with respect to the chosen Model

No. of DMUs in Data =	57
No. of DMUs with inappropriate Data =	0
No. of evaluated DMUs =	57
Average of scores =	0.668046
No. of efficient DMUs =	5
No. of inefficient DMUs =	52
No. of over iteration DMUs =	0

[CCR-O] LP started at 11-13-2005 14:27:10 and completed at 11-13-2005 14:27:10
Elapsed time = 1 seconds
Total number of simplex iterations = 389

Appendix 9 Table 5.14

Problem = ID

No. of DMUs = 18
No. of Input items = 6
Input(1) = Comacc
Input(2) = Humanist
Input(3) = Integeth
Input(4) = Manageth
Input(5) = Pos
Input(6) = Justice
No. of Output items = 1
Output(1) = Csrmc

Returns to Scale = Constant (0 =< Sum of Lambda < Infinity)

Statistics on Input/Output Data

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Max	6.2	5	5	4.88	5	5	6.6
Min	1.6	2.44	1	2	2	1.33	3.58
Average	4.055556	3.986667	3.203333	3.353333	3.444444	3.685556	5.148889
SD	1.188473	0.728415	1.031908	0.676814	0.725888	0.976651	0.690595

Correlation

	Comacc	Humanist	Integeth	Manageth	Pos	Justice	Csrmc
Comacc	1	0.207239	0.241569	0.427707	0.164571	0.336401	0.217626
Humanist	0.207239	1	0.553998	0.631764	0.478139	0.128457	0.656446
Integeth	0.241569	0.553998	1	0.612359	0.546718	0.318239	0.530139
Manageth	0.427707	0.631764	0.612359	1	0.519869	0.280443	0.805996
Pos	0.164571	0.478139	0.546718	0.519869	1	0.380973	0.327473
Justice	0.336401	0.128457	0.318239	0.280443	0.380973	1	0.204202
Csrmc	0.217626	0.656446	0.530139	0.805996	0.327473	0.204202	1

DMUs with inappropriate Data with respect to the chosen Model
No. of DMUs in Data = 18
No. of DMUs with inappropriate Data = 0
No. of evaluated DMUs = 18

Average of scores = 0.939812
No. of efficient DMUs = 9
No. of inefficient DMUs = 9
No. of over iteration DMUs = 0

[CCR-O] LP started at 11-13-2005 19:09:43 and completed at 11-13-2005 19:09:44
Elapsed time = 0 seconds
Total number of simplex iterations = 168

Appendix 10 Trial 3

Appendix 10 Trial 3 Table 5.16

No. of DMUs = 231	No. of Output items = 8
No. of Input items = 6	Output(1) = STAKID
Input(1) = COMMACC	Output(2) = STAKMAN
Input(2) = HUMANIST	Output(3) = VALUEATT
Input(3) = INTEGETH	Output(4) = DIALOGUE
Input(4) = MANAGETH	Output(5) = ETHICCOM
Input(5) = POS	Output(6) = ETHICATM
Input(6) = JUSTICE	Output(7) = ACCTYID
	Output(8) = ACCTYREP

Returns to Scale = Constant (0 =< Sum of Lambda < Infinity)

Statistics on Input/Output Data

	COM	HUM	INTE	MAN	POS	JUST	STAK	STAK	VALU	DIAL	ETHI	ETHI	ACC	ACCTYREP
Max	7.00	5.00	5.00	5.00	5.00	5.00	7.00	7.00	7.00	7.00	6.80	7.00	7.00	7.00
Min	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.14	1.80	1.00	1.25	2.40
Average	4.24	3.62	2.83	3.04	3.16	3.27	5.43	5.55	4.72	4.71	5.68	3.76	5.20	5.37
SD	1.30	0.80	1.11	0.83	0.98	1.04	1.08	1.11	0.95	1.01	0.96	1.37	1.18	1.05

Correlation

	COM	HUM	INTE	MAN	POS	JUST	STAK	STAK	VALU	DIAL	ETHI	ETHI	ACC	ACCTYREP
COMMA	1.00	0.31	0.10	0.28	0.31	0.24	0.27	0.25	0.18	0.25	0.25	0.31	0.34	0.23
HUMAN	0.31	1.00	0.39	0.51	0.56	0.32	0.47	0.25	0.39	0.56	0.54	0.51	0.58	0.39
INTEGE	0.10	0.39	1.00	0.39	0.39	0.23	0.42	0.17	0.27	0.38	0.45	0.37	0.38	0.23
MANAG	0.28	0.51	0.39	1.00	0.60	0.28	0.55	0.29	0.47	0.54	0.51	0.49	0.52	0.40
POS	0.31	0.56	0.39	0.60	1.00	0.46	0.56	0.32	0.41	0.50	0.47	0.60	0.50	0.35
JUSTICE	0.24	0.32	0.23	0.28	0.46	1.00	0.34	0.26	0.30	0.35	0.26	0.35	0.34	0.29
STAKID	0.27	0.47	0.42	0.55	0.56	0.34	1.00	0.45	0.56	0.64	0.46	0.52	0.59	0.51
STAKMA	0.25	0.25	0.17	0.29	0.32	0.26	0.45	1.00	0.39	0.43	0.33	0.23	0.44	0.31
VALUEA	0.18	0.39	0.27	0.47	0.41	0.30	0.56	0.39	1.00	0.61	0.43	0.40	0.51	0.55
DIALOG	0.25	0.56	0.38	0.54	0.50	0.35	0.64	0.43	0.61	1.00	0.51	0.55	0.69	0.56
ETHICC	0.25	0.54	0.45	0.51	0.47	0.26	0.46	0.33	0.43	0.51	1.00	0.45	0.56	0.42
ETHICA	0.31	0.51	0.37	0.49	0.60	0.35	0.52	0.23	0.40	0.55	0.45	1.00	0.48	0.39
ACCTYI	0.34	0.58	0.38	0.52	0.50	0.34	0.59	0.44	0.51	0.69	0.56	0.48	1.00	0.59
ACCTYF	0.23	0.39	0.23	0.40	0.35	0.29	0.51	0.31	0.55	0.56	0.42	0.39	0.59	1.00

DMUs with inappropriate Data with respect to the chosen Model

No.	DMU
	None

No. of DMUs in Data = 231
No. of DMUs with inap 0
No. of evaluated DMU 231

[CCR-I] LP started at 02-16-2006 21:58:
Elapsed time = 16 seconds
Total number of simplex iterations = 489

No. of D	231
Average	0.9
SD	0.1
Maximur	1
Minimun	0.5

Average of scores =	0.9
No. of efficient DMUs	58
No. of inefficient DMU	173
No. of over iteration D	0

Frequency in Reference Set

Referenc Frequency to other DMUs

2	21	90	0	51	11	153	44
4	0	95	9	55	0	155	0
6	0	105	0	56	3	168	0
8	4	109	2	58	9	179	1
16	6	112	1	61	4	182	10
19	1	113	1	64	10	187	17
21	11	119	2	68	83	190	31
24	0	129	21	70	10	203	0
25	9	134	0	75	0	204	20
28	4	135	27	78	25	205	2
31	0	138	6	81	48	207	0
33	11	139	0	83	35	216	32
39	6	145	37	89	49	219	0
42	128	147	4			231	152
44	3	152	107			242	0

Appendix 11 The Balanced Scorecard of Kaplan and Norton (1992)

A major consideration in performance improvement involves the creation and use of performance measures as indicators of goal achievement. These indicators should be the measurable characteristics of products, services, processes and operations that the company can use to align all its activities in improving customer, operational and financial performance.

First published in the *Harvard Business Review* in 1992 and followed by the book The Balanced Scorecard: Translating Strategy into Action in 1996, Robert Kaplan and David Norton drew attention to a new approach to performance measurement.

Financial performance is essential for business success and even non-profit organisations need to consider how to use funds effectively. However, there are two major drawbacks to the purely financial approach as detailed below.

1) The accounting and financial approach is historical telling only what has happened to the organisation in the past. It does not tell us about the present and is not a good indicator of future performance.
2) It is too low level. Commonly, the current market value of an organisation is greater than simply the value of its assets. For example, Tobin's q measures the ratio of the value of a company's assets to its market value. The excess value comes from intangible assets. It is the intangibles' contribution to performance that are not included, therefore not reported, in normal financial reporting.

The Balanced Scorecard addresses the limitations of the financial approach by introducing four perspectives which enable a company to translate vision into a strategic performance management system. The system measures the past, monitors present performance, and captures information which indicates how well the organisation is positioned for the future.

The 4 perspectives aredetailed below.

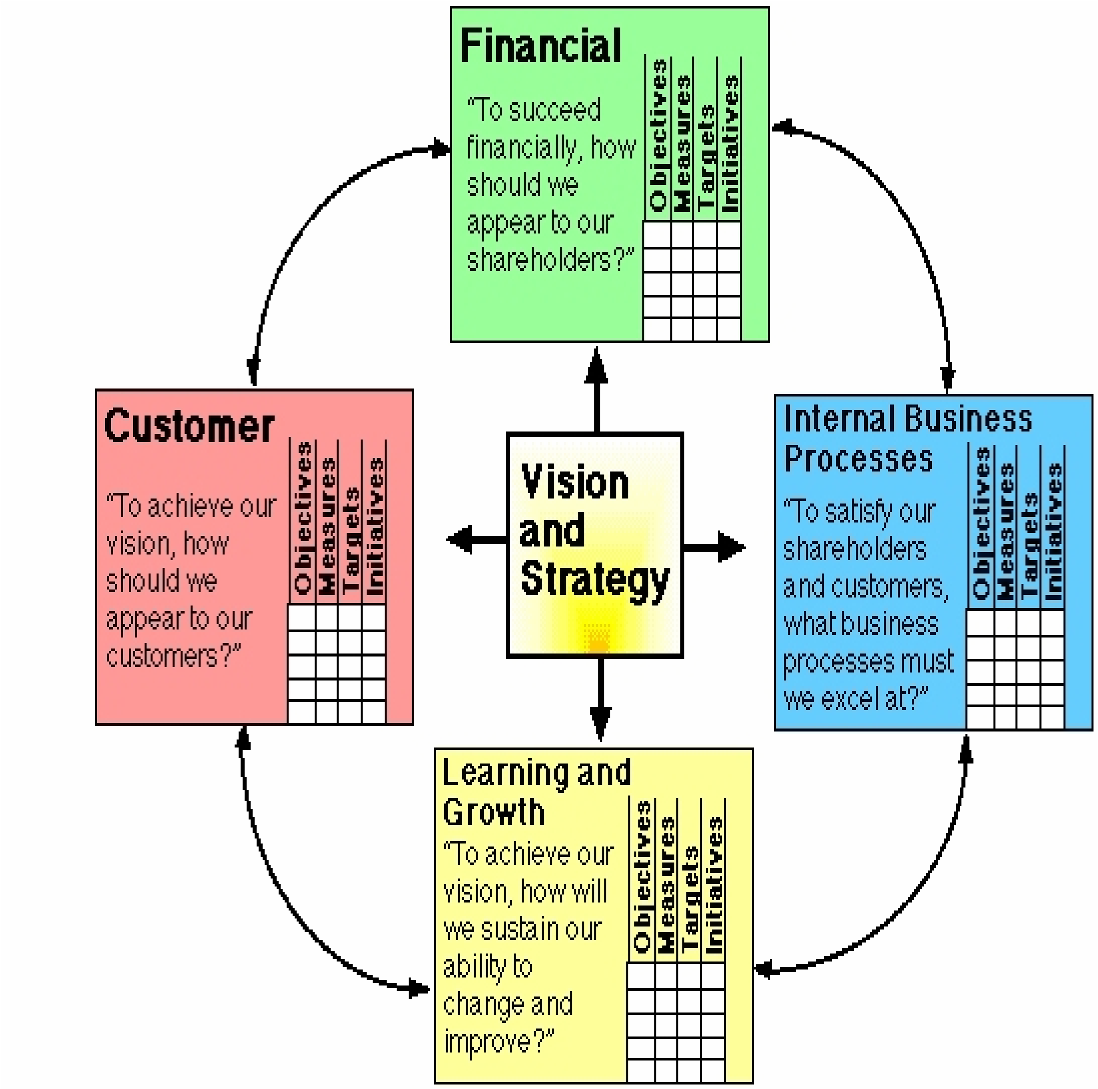
1) **Financial Perspective** This is the traditional financial approach maintained for the timely and accurate funding data, always regarded as a high priority by managers who need it. In fact, there is often more than necessary handling and processing of financial information. The implementation of corporate databases and the accessibility of

centralised automated data would suggest that financial issues may lead to an emphasis on financial performance at the expense of the other perspectives.

2) **Customer Perspective** Recent management thinking has shown an increasing realisation of the importance of customer focus and customer satisfaction in any company. As leading indicators, if customers are not satisfied they will find other suppliers that meet their needs and furthermore let others know of their dissatisfaction. Poor performance from this perspective is therefore a good indicator of future decline, even though the current financial picture may still seem good. In developing metrics for satisfaction, customers should be analysed in terms of their demographics, the products and services they require, and what gives our company the advantage.

3) **Business Process Perspective** This refers to the internal operational processes and the measures related to these. It shows managers how well their business is doing and whether the products and services conform to customer requirements. Performance is dissected into two business processes; mission oriented processes, and support processes. Support processes are those that being repetitive in nature, are easier to measure and benchmark using generic techniques. The other reflects the problems unique in achieving company mission.

4) **Learning and Growth Perspective** This perspective includes employee training and corporate culture, those attitudes that relate to individual and corporate self improvement. In knowledge based companies, people are the main resource. In a time of rapid technological change people are required to learn quickly and continuously. Kaplan and Norton caution that learning is more than training and should include coaching and mentoring, and should include communication among workers with facilities such as the Internet.



Objectives, Measures, Targets and Initiatives

Each perspective has four factors that are monitored and scored:

1) **Objectives** These are the major objectives that need to be achieved. Profit growth may be an example.
2) **Measures** these are the observable parameters that can be used to measure progress toward achieving the stated objective. In the above example the profit growth may be measured by growth in net margin.
3) **Targets** These are specific targets for the measures. For example, the target net profit margin may be set at 5%.
4) **Initiatives** These are the projects or programs initiated to meet the objective.

Benefits of the Balanced Scorecard

Kaplan and Norton cite the following benefits of a balanced scorecard methodology for performance improvement.

1) Focusing the whole organisation on only a few key issues will create breakthrough performance.
2) The BSC invigorates corporate programs such as six sigma, lean thinking, TQM and BPR.
3) Breaking down strategic measures into lower order metrics allows managers and employees understand what is required at their own levels to achieve superior performance.

Value of Metrics

'It cannot be improved if it cannot be measured' is a performance idiom which many adhere to. Metrics must be developed on the priorities of the strategic plan so that the key business drivers can be monitored according to specified criteria. Processes are then designed to collect pertinent information in numerical form for storage, display and analysis. The value of these metrics is in their ability to provide feedback:

1) Strategic feedback. This shows the present status of the organisation from the various perspectives.
2) Diagnostic feedback. This allows an analysis of process variation for continuous improvement.
3) Trends. Movement over time.
4) Measurement feedback. This tracks the metrics themselves and may indicate which should be changed, and how.
5) Quantitative inputs. Input for forecasting and decision support systems.

Limitations of the BSC

People tend to work to achieve specific targets as set. If such targets are not on the BSC or they are disproportionably weighted, as in an over emphasis on financial performance, then actions and thinking may be short term and the mechanisms developed could limit the attainment of longer term strategy. The choice of measures is crucial (Meyer 2002). Criticism of the BSC has also often revolved around the view that there is no specific mention of employees, suppliers, alliance partners, intermediaries and regulators, nor the community or pressure groups (Neely, Adams and Crowe, 2001).

Conclusion

The BSC has been so influential that it has been the most cited measurement system over a number of years (deWaal 2003). Such pervasiveness naturally brings profilicacy. Cobbold and Lawrie (2004) trace its development and classify its design by the intended method of use by the organisation. They note that it has now evolved into a third generation performance measurement system.

Appendix 12 The Performance Prism of Cranfield University

The **Performance Prism** is an innovative second generation performance measurement and management framework. Its advantage over other frameworks is that it addresses *all* of an organisation's stakeholders-principally investors, customers and intermediaries, employees, suppliers, regulators and communities. It does this in two ways:

1) by considering what the wants and needs ***of the stakeholders*** are, and
2) what the organisation wants and needs ***from its stakeholders***.

In this way, the reciprocal relationship with each stakeholder is examined.

There are five facets of the Performance Prism:

1) Stakeholder Satisfaction
2) Stakeholder Contribution
3) Strategies
4) Processes
5) Capabilities

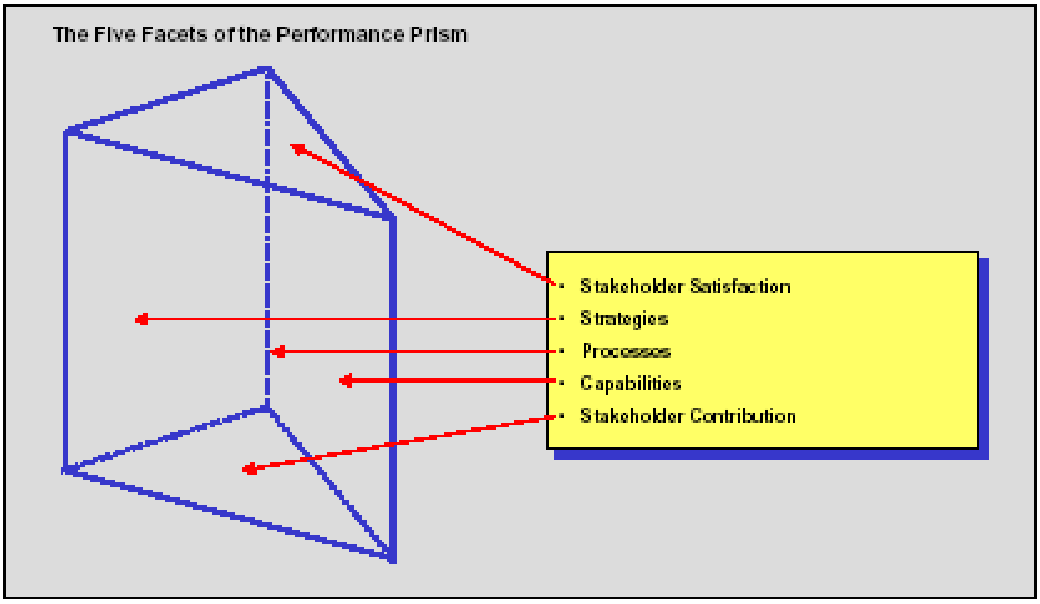


Figure A12a The Five Facets of the Performance Prism

The Performance Prism is based on the belief that those organisations aspiring to be successful in the long term within today's business environment have an exceptionally clear picture of who their key stakeholders are and what they want. They have defined what strategies they will pursue to ensure that value is delivered to these stakeholders and they understand what processes the enterprise requires if these strategies are to be delivered. They also define what capabilities they need to execute these processes. The more sophisticated organisations have also thought carefully about what it is that the organisation wants from its stakeholders – employee loyalty, customer profitability, long term investments, etc. In essence they have a clear business model and an explicit understanding of what constitutes and drives good performance.

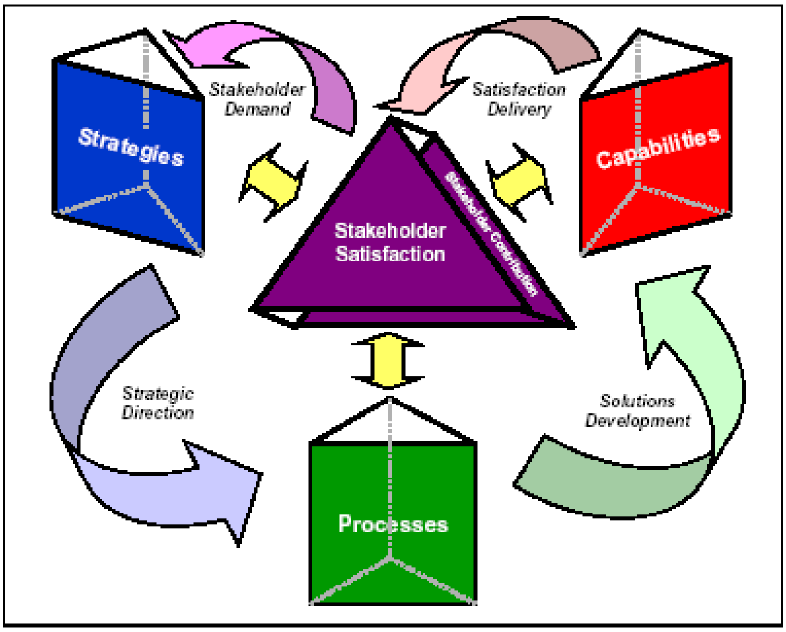


Figure A12b Stakeholder Satisfaction

Approach: Starting with Stakeholders, not with Strategy

According to the Performance Prism, vision is one of the great fallacies of performance measurement because it is measures that should be derived from strategy. Listen to any conference speaker on the subject. The statement often made – 'derive your measures from your strategy', is such a conceptually appealing notion, that nobody stops to question it. Yet to derive measures from strategy is to misunderstand fundamentally the purpose of measurement and the role of strategy. The Performance Prism starts its process with thinking about the Stakeholders and what they want.

Five key questions for measurement design are listed below.

1) Stakeholder Satisfaction – who are the key stakeholders and what do they want and need?
2) Strategies – what strategies do we have to put in place to satisfy the wants and Aneeds of these key stakeholders?
3) Processes – what critical processes do we require if we are to execute these strategies?
4) Capabilities – what capabilities do we need to operate and enhance these processes, and
5) Stakeholder Contribution – what contributions do we require from our Astakeholders if we are to maintain and develop these capabilities?

The Performance Prism is designed to illustrate the hidden complexity of the corporate world. Single dimensional, traditional frameworks pick up only elements of this complexity, and while each of them offers a unique perspective on performance. It is essential to recognise that this is all they offer – a myopic view. Performance, however, is not uni-dimensional, so to understand it in its entirety, it is essential to view performance from the multiple and interlinked perspectives offered by the Performance Prism (Neely et al. 2001).

Appendix 13 The Construct of CSR Management Capacity

Black (2004) hypothesised that there are antecedent variables which are predictive of an organisation's capability to be socially responsive and to behave in a manner which displays corporate citizenship. She found that a firm's cultural context can influence managerial initiatives which explain how organisations choose to become socially responsive. The culture which is based on shared values and assumptions underpins organisational structure, behaviour and thinking, and is reflective of a humanistic culture where the organisation is managed in a participative fashion such that people support each other in an environment which promotes ethical business behaviour. She labelled this as the 'corporate social responsiveness management capacity' construct (CSRMC).

She tested the existence of such a construct with traditional hypothesis testing. The fourteen hypotheses are summarised below.

The antecedents to CSRMC:

1. A humanistic culture will be positively related to CSRMC.
    a. The humanistic culture will be more strongly related to dialogue, ethical business behaviour and accountability than to the other dimensions of CSRMC.
2. Management commitment to ethics will be positively related to CSRMC.
3. Integrated ethics practice will be positively related to CSRMC.
4. Perceived distributive justice be positively related to CSRMC.
5. Perceived organisational support be positively related to CSRMC.
6. Communication accuracy be positively related to CSRMC.

The consequences of CSRMC:

7. CSRMC is positively related to human resources and communication outcomes.
8. CSRMC will be related positively to organisational identification
9. CSRMC will be related positively to organisational commitment.
10. CSRMC will be related negatively to turnover intention.
11. CSRMC will be related positively to trust
12. CSRMC will be related positively to organisational image.
13. CSRMC will be related positively to employer investment in employees.

14. CSRMC will be related positively to communication openness.

All hypotheses, except for 3 and 6, were supported with humanistic culture and a management commitment to ethics, strongly and significantly, contributing to an organisational environment supporting the development of corporate social responsiveness.

The results of her tests revealed five dimensions of the CSRMC construct, with significant positive correlations for most of the eight factors that comprise it. These factors are: stakeholder identity, stakeholder management, value attuned public relations, dialogue, ethics (compliance), ethics (caring atmosphere), accountability (reporting) and accountability (sense of). She concluded that there exists an eight factor structure within a five dimensional framework that adequately reflects her claim to the CSMRC construct. However, at no stage was her intent or her finding a comparison on which of the business entities were most efficient on the dimensions she espoused.