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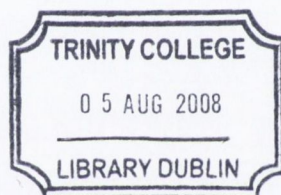
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ENVIRONMENTAL CONSIDERATIONS WITHIN MANUFACTURING STRATEGY

Déirdre Crowe

2008

This thesis is submitted for the degree of Ph.D. to University of Dublin, Trinity College.



THESIS
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ENVIRONMENTAL CONSIDERATIONS WITHIN MANUFACTURING STRATEGY

ABSTRACT

This thesis examines innovative entrepreneurial firms and their engagement in environmental management in the context of sustainable development. The interrelationships of environmental management with innovation and other strategic processes are studied in order to gain insights on current necessary resources, capabilities and motivations and to inform future orientation of firms towards sustainable development. The thesis begins with a discussion on sustainable development and the role of innovation. Environmental management in organisations is embedded in the concept of sustainable development. The central role played by organisations in sustainable development as well as in innovation is discussed. Approaches to study sustainable development include: ecological modernisation theory, industrial ecology, the systems approach and the role of innovation. These approaches are discussed. The role of innovation in reaching sustainable development is highlighted and, drawing on the literature on innovation and competitiveness, it suggests a possible framework to link societal and organisational level goals for sustainable development.

The focus of this research is at the level of the organisation/firm and the literature review discusses some theoretical perspectives from the organisation and strategic management literatures. These include institutional and strategic perspectives that provide a theoretical foundation for the research and analysis: institutional theory, stakeholder theory, contingency theory and the resource-based view. The combination of institutional and strategic perspectives provides a comprehensive framework which is compatible with the use of the innovation capability perspective and the production capability triad and the entrepreneurial firm.

This is a mixed-methods study and two sources of data are employed: international survey and case study. The first phase of this research, which employs data from the International Manufacturing Strategy Survey (IMSS), takes a resource-based view. The IMSS survey comprised 558 respondents from 17 countries. Innovation and performance related variables were identified and examined in conjunction with environmental considerations in manufacturing strategy.

The IMSS survey comprised 558 respondents from 17 countries. Innovation and performance related variables were identified based on the literature. A measure of the salience of the environment in manufacturing strategy was determined - the environment in strategy (ES) index. This was developed using the relative position of the environmental item within four key manufacturing strategy questions. Negative, neutral and positive ES groups are identified.

There are some significant relationships between the ES index and the innovation and performance variables. However, regression models identify only three variables predicting the ES index: R&D, influence of manufacturing on business/marketing strategies and ISO14001. The results also indicate that these are weak and account for small variances in the ES index meaning the innovation and performance variables have poor predictive capacity. The results of the comparative analyses indicate the same significant variables and they give a better picture of the relationships with the ES index. However, links between the ES index and the innovation and performance variables remain inconclusive.

Following this analysis four firms were selected for case study accompanied by two others recommended by experts in the field of environmental management. These six cases are then analysed individually followed by a cross-case analysis. The institutional perspectives complement the strategic perspectives to provide a more complete analysis of environmental management.

The cases illustrate that environmental management in these manufacturing firms can be leveraged for competitive advantage through innovation and cost savings in particular. However, the converse that innovation or other business requirements will be leveraged for environmental management, only sometimes applies even where a formal EMS is in place. Nevertheless, the prominence of environmental management is clearly linked to formalisation and to corporate policy and values. While environmental management is often aligned to quality and quality systems, environmental considerations are often subordinate to quality imperatives. The ability to link environmental management to business requirements such as cost savings and customer priorities is an effective way of achieving environmental improvements. Both regulations and individuals influence the direction and choice of many initiatives.

A model is developed to enable a comprehensive understanding of the complexities of environmental management strategy and implementation in organisations. an open system of activities and influences. In the broader context, innovation systems and production capability triad are possible models for sustainable development.

ACKNOWLEDGEMENTS

This thesis would not have been possible without the support and assistance from a great many people for which I will be eternally grateful.

Beforehand, I wish to acknowledge the financial support I received throughout my studies which enabled me to dedicate the time needed to complete my task. I received support from the following bodies: Irish-American Partnership / Enterprise Ireland: Partnership Scholars Programme, Trinity College Postgraduate Scholarship fund, Irish Research Council for the Humanities and Social Sciences (IRCHSS) and the Institute for International Integration Studies (IIIS). I also received travel grants from the Trinity Trust and the School of Business Studies to attend and present at conferences which were crucial elements of my learning experience.

I had been toying with the idea of doing a Ph.D. when I was approached by two colleagues at the IMI to work on a proposed project which would involve such work. While the project did not go ahead in the end, I am very grateful to John Mangan and Kevin Hannigan for their encouragement and support and for putting me on the path which has led to this thesis. I particularly thank them for putting me in contact with my supervisor Louis Brennan at the School of Business in Trinity.

Louis has been both a great supervisor and advisor to me over the years. He gave me the freedom to take the thesis in a direction very different from the original project plans and has always encouraged me in this. I cannot thank him enough for the support and assistance he has given me, especially for the many decisions in my personal and professional life which may have interfered with the progress of my thesis and with project work on the IMSS survey. His guidance and reading of my work has been invaluable but, above all, he has shown infinite patience and understanding and I will always be indebted to him for this.

Others in the School of Business have been very supportive and helpful over the years. I particularly wish to thank Valerie McCarthy who looks after postgraduates in the School with immense consideration and understanding, Joan Reidy in the School office who is always ready to help out with great will and humour, Gemma Donnelly-Cox who has been very kind to me in our shared experiences of motherhood and Alessandra Vecchi, my colleague on IMSS IV until I abandoned ship, however we have remained great friends. I also particularly wish to thank Paul Coughlan who has always been helpful as a colleague with the IMSS survey and associated work but, most especially, as a kind and insightful second reader for my thesis which was of extremely valuable assistance in the later stages of completion.

My current colleagues at the IMI have also been particularly helpful and supportive. I am especially grateful to Elaine McMahon and Mary Hogan for giving me the time and flexibility to complete this thesis and for their humorous goodwill, support and friendship. I also wish to thank all in the IMI Knowledge Centre for their friendly assistance and emergency backup.

My friends and family have been a constant source of support, inspiration and loving encouragement – that is when they weren't bemused by my undertaking. I apologise to them all for the missed celebrations and events over recent times as I've tried to complete this work – I will make up for it! I wish to particularly thank Deirdre and Leonie for their wonderful and constant friendship, they and their partners, KC and Dec, and families are my family too. My science friends have always been a wonderful group and I thank them for the great times and look forward to many more now that my weekends will be free again. With great love and fondness I remember Trisha and know how we all miss her.

My family have just been incredible with the support and encouragement I received throughout this process and particularly in the later years. I cannot ever thank my mum, Ena, enough for her endless generosity and energy in looking after my children. It is wonderful to see such a fun-and-loving bond between herself and Nuanna and I hope it will always continue like this. My brother, Louis, has been both a fantastic support and inspiration to me. His thoughtfulness and kindness in helping me over the last hurdles has been amazing and I will always remember this, Louis. My brother, Patrick and sister-in-law, Daniela, have also been so wonderful in their support and assistance since returning to Ireland last year. It is great to have you home again with Louis, Andreea and Kevin and I have no excuse now to miss get-togethers and parties anymore! I would also like to thank my Aunt Betty, who, as an academic herself, has always been particularly interested in my education and given me great support and encouragement. To my family and friends in Brazil – muito obrigada e que saudade!

I cannot find the words to thank Marcel who has been a rock solid support for me - full of love and consideration and endless patience. Particularly, in the last summer months when I spent all my time and every weekend in the attic, he fed me and supplied me with tea and entertained the children when we should have been out all together as a family. This enveloping love is indescribable and wonderful and has got me through to the end of this journey. Finally, Nuanna and Kian - who I couldn't imagine as I started this work and now I cannot imagine life without them – are such joyful and loving children. I cannot thank the two of them enough for waiting for me to finish so we could go for that walk in the park and, tonight, get dressed for Halloween without any worries about getting back to 'the book'. I look forward to catching up and having great fun with them now.

to my family and friends

both here and gone

thank you

I love you all

D.

31st October 2007

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INTRODUCTION

1. INTRODUCTION

1.1 Introduction

This thesis examines the connections between innovative firms and environmental management. Environmental management in this research means the inclusion of environmental concerns in a systematic and strategic manner throughout the organisation.

The thesis begins with a discussion on sustainable development and the role of innovation. Environmental management in organisations is embedded in the concept of sustainable development. Sustainable development is discussed and the central role of organisations. Approaches to study sustainable development include: ecological modernisation theory, industrial ecology, the systems approach and the role of innovation. These approaches are discussed. The role of innovation in reaching sustainable development is highlighted and, drawing on the literature on innovation and competitiveness, it suggests a possible framework to link societal and organisational level goals for sustainable development. The challenge to disentangle economic growth from environmental problems presents opportunities for innovation and competitiveness (CEC, 2000; Porter and van der Linde, 1995; Welford, 1998). New environmental regulations and paradigms change the competitive environment and in this context a firm's ability to innovate may be a factor in competitive advantage. Evidence shows that competitiveness through innovation and firm performance is compatible with and can be enhanced through environmental management.

The focus of this research is at the level of the organisation/firm and the literature review discusses some theoretical perspectives from the organisation and strategic management literatures. These include institutional and strategic perspectives that provide a theoretical foundation for the research and analysis: institutional theory, stakeholder theory, contingency theory and the resource-based view.

Institutional and strategic perspectives provide a comprehensive framework which is compatible with the use of the innovation capability perspective and the production capability triad and the entrepreneurial firm. Two sources of data are employed in this research, international survey and case study. The first phase, which employs data from the International Manufacturing Strategy Survey (IMSS), takes a resource-based view. The IMSS survey comprised 558 respondents from 17 countries. Innovation and performance related variables were identified and examined in conjunction with environmental considerations in manufacturing strategy. Following this analysis four firms are selected for case study accompanied by two others recommended by experts in the field of environmental management. These six cases are then analysed and the institutional perspectives can complement the strategic perspectives to provide a more complete analysis of environmental management. A model of environmental management provides a format for developing a comprehensive understanding of the complexities of environmental management in an open system.

1.2 Aims of the Research

The main aim of this work is to look at innovative and progressive manufacturing firms and their engagement in the realm of natural environmental management. It seeks to gain insights into firms which combine innovation and progressiveness with natural environmental management at both strategic and operations levels. The purpose is to learn from these firms in order to aid the promotion of environmental management in organisations, and manufacturing firms in particular, in the context of sustainable development.

1.3 Motivation for the Research

Coming from a background in the natural sciences and ecology I have always had an interest in environmental issues and in sustainable development. As my work developed I become more interested in the social, organisational and behavioural factors influencing sustainable development. I am particularly interested in the processes and capabilities in organisations for effective environmental management and innovation for sustainable development. While knowledge and technologies currently exist which could contribute towards sustainable development they are mostly not widely adopted voluntarily. Likewise, environmental considerations are not inherently integrated in innovation systems (Berkhout and Green, 2002).

Organisations are one of the key structures of modern society. In the case of sustainable development the collective effort of all society is required and therefore organisations play a central role in achieving sustainable development (Dunphy *et al.*, 2003; Robbins, 2001; Shrivastava, 1995). Similarly, organisations and industry are primary agents of innovation. Dynamic innovation is influenced by the institutions, collaboration and mutual support in the innovation system comprising a triple helix of public and private entities: industry, government, universities (Leydesdorff, 2006).

The roles of organisations, and more specifically manufacturing firms, in sustainable development and innovation are of special interest to me. Are they interrelated? Do generally innovative organisations also innovate in environmental management? What are the influences and drivers for environmental management? How does environmental management fit within the organisation? How is environmental management incorporated into innovation processes? Does environmental management drive innovation in the organisation?

It is widely accepted that firms need to continuously innovate to remain in business in the long-term (Tidd *et al.*, 2005 pp. 39-42). Firms which are currently innovating and leading in their fields of activity can provide good insights into processes and capabilities required to maintain success. I am particularly interested in examining environmental management in those firms which are considered to be innovative in general. These are the firms which are most likely to remain in business in the future. Consequently, their role in achieving sustainable development is more likely to be greater in the long-term. By examining what makes them successful in business and in innovation and, in particular, what drives them towards effective environmental management, we can learn how to best orientate them and other organisations to innovate and operate for sustainable development. Although regulations and the institutional environment are major driving forces in environmental management, why do some organisations choose to act 'beyond compliance' (Prakash, 2001)?

1.4 Contribution to Domains of Knowledge

This work contributes to the domains of knowledge in the innovation, business and environment, strategy, organisation science and environment policy literatures as well as contributing to research methodology.

Until recently the interaction between innovation management and environmental management has been limited (Berkhout and Green, 2002). This work contributes to the understanding of how innovation and environmental management can influence and contribute to each other. It examines the relationship between innovation and environmental management in manufacturing operations and innovation processes through

the unique use of a global manufacturing strategy survey and it further develops this theme through six case studies.

An index is developed to examine the position, or strategic salience, of environmental management in manufacturing strategy. While this contributes directly to the study and understanding of environmental management in manufacturing firms, it also contributes to the methodology of survey design, scale development and analysis. It develops a technique which reflects the relative position of environmental management rather than the absolute position as recorded in the survey responses. This technique could be more widely applied in the analysis of survey instruments relating to any subject matter.

This research looks at the strategic nature of environmental management and it provides insights into its contribution to organisational goals and how these may be best achieved. The case study data contribute particularly rich insights and learning in this regard especially in relation to the formalisation of environmental management and in its interaction with other strategic processes: innovation, quality, corporate policy and business requirements.

Regarding organisation science, one of the main contributions of this work is in the development of a model representing the organisation as an open system of activities and influences which interact with environmental management. It models environmental management in six case firms. It highlights the role of communication and the need for environmental management system to understand the requirements of the functional areas with which it interacts. It contributes to the understanding of how organisational structure and design influence strategic environmental management (Sharma, 2002). The model may be applied to any organisation and adapted to any system or strategy within the organisation.

The thesis makes a contribution to the theory of the firm and value of the various theoretical perspectives in examining environmental management. In particular it contributes to the literature on resource-based view of the firm and identifies some of its strengths and weaknesses. It stresses the benefits of combining institutional and strategic perspectives in research to reflect the complexities of environmental management and to gain a more comprehensive understanding of the role of organisations and manufacturing firms in particular in sustainable development.

This research contributes to environmental policy literature. It identifies the need for policy makers to develop resources and capabilities for strategy development and implementation. It highlights the role of regulations in promoting a collective and cooperative approach to sustainable development.

The thesis emphasises the collective societal approach to sustainable development and contributes insights into how organisations, and manufacturing firms in particular, may operate within a system. As an alternative to some espoused system models such as Industrial Ecology and Ecological Modernisation which are problematic in practice due to the lack of a social dimension, the thesis suggests drawing from models of innovation systems. It proposes the possibility of using the Capability Triad model (Best, 2001), in which entrepreneurial firms are key actors in economic development and innovation-led growth, as a model for sustainable development. Rather than viewing sustainable innovation as one possible outcome of the Capability Triad, sustainable development can form the core of the framework.

Finally, the thesis contributes to the literature on methodology, particularly to the arguments for the use of mixed methods and the philosophy of scientific enquiry.

1.5 Organisation of Thesis

The remainder of the thesis is structured in the six following chapters covering the literature, methodology, results and discussion:

Chapter 2: Literature Review

This review presents the context for examining environmental management in organisations which are viewed as central actors in sustainable development. After a discussion on sustainable development and approaches to its study the review deals with some theoretical perspectives from the organisation and strategic management literatures. Finally, the review examines environmental management in firms and the evidence from the literature of its role and performance.

Chapter 3: Methodology Part 1 – Philosophy and Paradigms

Following a brief outline of the research project I discuss research philosophies and paradigms, both from a personal perspective which led to the choice of subject matter and from the research perspective. Given the importance of his work in the debate about paradigms in the social sciences I present Kuhn's arguments. This is followed by a discussion on paradigms in the social sciences and how they are presented and debated in the literature particularly in relation to the scientific approach and critical realism. The chapter concludes with a discussion on paradigms and methodology with a focus on mixed methods and the elements of adaptive theory employed in this research.

Chapter 4: Methodology Part 2 – Methods

In this second methodology chapter, I present and discuss the details of the research methods involved in undertaking this thesis: data collection through survey and case studies, analysis and integration. After presenting a general introduction and outline I discuss triangulation, validity and reliability in the research. I then discuss the use of adaptive theory in the research process. Details of the empirical data collection and analysis follow: development, administration and analysis of the survey; development of measures and scores using both international data as well as Irish data; the identification and selection process of Irish based firms for case analysis; and finally, the processes involved in interviewing and analysing the cases.

Chapter 5: Results Part 1 – Survey Analyses

This chapter presents the results from the International Manufacturing Strategy Survey (IMSS). General results are given for the positioning of the environment in manufacturing strategy as well as for innovation and performance related variables. The results for all IMSS respondents and for the Irish based respondents are presented. Results pertaining to the development of the IMSS environmental index and subsequent analyses follow. The final section of this chapter presents some results exclusive to the Irish respondents relating to environmental management which, used in conjunction with the IMSS environment index and innovation variables, assist in the selection of cases for further analysis.

Chapter 6: Results Part 2 – Case Analyses

Complementing the survey, case analysis was chosen to further illuminate the role of environmental management in manufacturing firms and its relationships with innovation and other processes. This chapter briefly describes the selection of firms for case analysis and presents the six selected cases.

These are all Irish based firms, four of which were selected on the basis of the IMSS survey results and the remaining two were selected based on the recommendation of experts. The six cases are presented individually and the chapter concludes with a cross case analysis.

Chapter 7: Discussion

Discussion of survey and case results as well as implications for environmental management in organisations, for research and for policy.

LITERATURE REVIEW

2. LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of the literature which provides the context for, guides and informs this work. It is divided into three sections: the first section briefly discusses sustainable development which provides the context for this research. It discusses some of the approaches to sustainable development: ecological modernization theory, industrial ecology and a systems approach. It outlines the links between innovation and sustainable development, and, drawing on the literature on innovation and competitiveness, it suggests a possible framework to link societal and organisational level goals for sustainable development based on the concepts the production capability triad and the entrepreneurial firm (Best, 1998, 1999, 2000, 2001) and incorporating the Triple Helix. The focus of this research is at the level of the organisation/firm and the second section of this review deals with some theoretical perspectives from the organisation and strategic management literatures. These include institutional and strategic perspectives that provide a theoretical foundation for the research and analysis: institutional theory, stakeholder theory, contingency theory and the resource-based view. Together these perspectives provide a framework for examining the organisation and the influences, resources and capabilities for environmental management in the firm. The role of individuals as well as individual and organisational values and motivations are also considered. These perspectives also view the organisation as an open system and they provide a link to the entrepreneurial firm and the capability triad. Some limitations of these perspectives are also discussed. Finally, the third section of this review examines environmental management in firms and the evidence from the literature of its role and performance in firms.

2.2 Sustainable development

Environmental management in organisations is embedded in the concept of sustainable development. Sustainable development is defined in the 'Brundtland' Report, *Our Common Future*, as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, chaired by Gro Harlem Brundtland). This recognises the paradigm shift from the concept of zero-growth previously espoused by the environment agenda (Welford, 1998 p. 14). The focus in the economics literature on environmental sustainability is on the sustainability of people's quality of life and on environmental sustainability as an indicator of well-being that does not decline over time (Clinch, 2001). In practice, sustainable development requires policy makers to balance environmental protection and socio-economic development (Department of Environment and Local Government, 2001).

The 'Brundtland' definition of sustainable development was accepted by over 170 countries at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro - known as the Earth Summit. However, this definition has its critics - it is too vague, it does not define needs or describe the means to achieve sustainability and it is anthropocentric (Castro, 2004; Giddings *et al*, 2002; Starik and Rands, 1995). Particularly, the concept of growth implied in the focus on development is problematic as it is widely accepted that the earth's ecosystem has a limited capacity (Martin, 2006; Starik and Rands, 1995). As an example of common criticisms, I briefly refer to some of the works of John Ehrenfeld, Director of the Technology, Business and Environment Program at MIT (Ehrenfeld, 1998, 2000, 2005; Howard *et al*, 2000;

Korhonen *et al.*, 2004). Ehrenfeld (2000), for example, argues that the Brundtland definition is tied to a particular economic model which foresees endless capacity for growth and progress similar to Solow's view that 'there is no reason that we should not think of the productivity of natural resources as increasing more or less exponentially over time' (Solow, 1973 p. 51, cited in Ehrenfeld, 2000). Ehrenfeld has a valid point considering that the concept of sustainable development arose when it was collectively realized that current levels of economic growth, resource exploitation and population growth could not be maintained (World Conservation Strategy, 1981) leading many environmentalists to argue that the Brundtland definition is an oxymoron - economic development itself compromises the needs of future generations therefore undermining the essence of sustainability (Best, 2001 p. 243). Ehrenfeld proposes that sustainability is merely the *possibility* 'that human and other life will flourish on the Earth forever' arguing that the term sustainable development is 'politically correct' and that it implies sustainability is a 'technological characteristic of the global system' (Ehrenfeld, 2000). However, he goes on to say that 'flourishing means not only the survival but the realization of whatever we humans declare makes life meaningful – justice, freedom and dignity', which seems to itself allow for improvement, growth and development in some form. Based on numerous existing definitions, Ehrenfeld then offers a new definition of sustainability as 'a possible way of living or being in which individuals, firms, governments, and other institutions act responsibly in taking care of the future as if it belonged to them today, in equitably sharing the ecological resource on which the survival of humans and other species depends, and in assuring that all who live today and in the future will be able to satisfy their needs and human aspirations'. This definition, essentially, is a lengthy way of removing the word 'development' from the Brundtland definition. However, development is not the same as growth. Economic and social development is not the same as environmental or ecological development. Ecological and environmental growth does not exist - matter is merely changed in a closed system with no such thing as waste and energy is freely inputted (solar) and is converted and conserved with minimum dissipation. Ehrenfeld highlights the use of the word 'responsibly' in his article however this is implied in the Brundtland definition in its deference to future generations. Despite his criticisms of sustainable development Ehrenfeld concludes that we possibly can have both modern living and sustainability through a radical transformation of our economic and social system and proposes industrial ecology as a vehicle for achieving this (see below) (Ehrenfeld, 2000). This is typical of many critics of sustainable development who argue for change of the current system of growth while at the same time using definitions of sustainability which incorporate terms such as 'flourishing' and acknowledge a desire to improve the human condition (Starik and Rands, 1995). All of these are also subject to further criticisms of being anthropocentric and reflecting a human-nature dualism which traces its roots to the Era of Enlightenment and which supposes humans to be separate from nature which they can freely exploit and dominate and that, even if humans may choose sustainable development, it still does not recognise their essential position *within* nature (Gladwin *et al.*, 1995; Purser *et al.*, 1995). On the other hand an eco-centric view focussing on ecological issues can cause issues of social concern and questions about the nature of society to be overlooked (Giddings *et al.*, 2002). Sustainable development recognises the need for change and that a trade-off exists between growth (in its current form) and sustainability which requires that society should not impose any permanent damage while at the same time strive to create the physical and social infrastructures to facilitate world population growth (Welford, 2000 p. 6). While the concept of growth in sustainable development elicits many criticisms, the Brundtland definition neatly encompasses environmental, social and economic issues in a manner which is widely understood and accepted (Dunphy *et al.*, 2003; Gladwin and Kennelly, 1997; Welford, 2000). This widespread acceptance can

be both a weakness and a strength - it is difficult for anyone to disagree with it while, at the same time, it is easy to interpret to suit one's own meaning, for example, many large corporations claim to embrace sustainable development without ever changing their fundamental *modus operandi* and without affecting their economic power (Castro, 2004; Giddings *et al*, 2002). The essential issues in the debate on sustainable development are: *what kinds* of progress and development are acceptable which will improve quality of life equitably and will not endanger or limit the potential of the current or future generations; and *how* do we achieve such progress and development without further damaging the natural environment upon which we depend?

2.2.1 Sustainable Development and the firm

Sustainable development encompasses all aspects of human interaction: economic, social and environmental, at all levels of human activity: individual, organisational and societal. Significantly, these aspects and levels are interconnected, mutually dependent and demand that sustainable development be approached in a comprehensive holistic manner (Giddings *et al*, 2002). While recognising that it cannot be disconnected from the other levels, the primary focus of this work is at the level of the organisation/firm and, where individual and societal aspects are considered, the context is the firm. Commercial organisations, corporations or firms, are not only one of the dominant institutions of society (Robbins, 2001 p. 41), they are 'fundamental cells of modern economic life and their phenomenal success in transforming the earth's resources into wealth has shaped the physical and social world we live in' (Dunphy *et al*, 2003 p. 3). As well as being the primary engines of economic growth, corporations/firms have the technical and financial resources as well as the capabilities to implement solutions for sustainable development (Shrivastava, 1995b). Therefore, the role of firms in achieving sustainable development is critical and, consequently, firms are subject to extensive research and scrutiny. In sustainable development the firm has a triple bottom-line: environmental, social and economic (Savitz and Weber, 2006).

With regard to the study of organisations and management, Gladwin *et al* (1995) articulate the two paradigmatic extremes in the debate which are incompatible and neither of which can provide the basis to attain sustainable development: techno-centric and eco-centric. The techno-centric paradigm which holds a human-nature dualism viewpoint focuses on the ability of science and 'green' technology to deal with any possible problems and does not see the human social connections with sustainability or a need to be preoccupied with the future. The eco-centric paradigm emphasises harmony in nature and sees the interconnections and the role of humans in it. However, it sees the role of humans as another biological species and does not acknowledge human wisdom or intellect nor can it provide any guidance to sustainability other than population reduction and a vision of an idealised primal lifestyle. Neither extreme provides a realistic means to achieve sustainability and to this end the authors propose that the sustaincentrism paradigm which is centred on sustainable development itself as an organising principle for mankind is the way forward for organisation and management studies (Gladwin *et al*, 1995). This is a development somewhat of the eco-centric responsibility paradigm described by Purser *et al* (1995), which, although it places humans within the natural ecosystem and views nature as intrinsically valuable in its own right and not in relation to human needs, it is a paradigm which gives humans a citizenship role in nature, it is about responsibility and is concerned with finding the best sustainable match between socio-cultural organisation and natural ecosystems (Purser *et al*, 1995) - it is a 'logic of the home' (Rolston, 1987 p. 71, cited in Purser *et al* 1995).

Many firms themselves recognise their role in sustainable development and this is reflected in the organisation of groups and networks as well as in the actions of individual firms. For example, the World Business Council for Sustainable Development (WBCSD) was established by CEOs of major multinational corporations in 1991 to become an advocate for, and present, the business case for sustainable development and, similarly, the Business in the Community (BITC) organisation is also member based network to promote corporate social responsibility (CSR) including environmental management. However, these types of networks also bring criticisms as they do not necessarily change the fundamental way in which business is conducted and they represent powerful forces in their own interest (Welford, 2000 p. 61). Ehrenfeld, for example, argues that the current trend towards corporate environmental management and citizenship is dangerous - at best, slowing the arrival of the inevitable environmental catastrophe, and at worst, contributing to it while seemingly taking positive action (Ehrenfeld, 2005; Howard *et al*, 2000) in what is known as 'greenwashing' (Dunphy *et al*, 2003 p. 42). The main problem really is that we may be only 'shifting the burden' and dealing with the symptoms of unsustainability rather than the root causes which demand a radical change in the way we operate (Ehrenfeld, 2005). The business community espouses voluntary approaches to sustainable environmental management implying that society must trust firms to provide and implement solutions (Welford, 2000 p. 51) and there are many examples of individual firms which have taken on the mantle of sustainable development from The Body Shop to IKEA which has adopted The Natural Step programme (Natrass and Altomare, 1999). However, there is little evidence to suggest that industry as a whole will change substantially of its own initiative (Welford, 2000 p. 51). And, while any efforts by individual firms are laudable, the attainment of sustainable development requires a collective effort due to the cumulative massive impact of firms and their decision-makers on the environment and on global society (Dunphy *et al*, 2003 p. 10; Giddings *et al*, 2002; World Commission on Environment and Development, 1987). Furthermore, since firms are supported by consumers who reward them by purchasing goods and services sustainable development requires a collective responsibility and an integrated effort in society as a whole (Drake *et al*, 2004; Dunphy *et al*, 2003 p. 10).

The central role of organisations to sustainable development is reflected in approaches to its study including: ecological modernisation theory, industrial ecology, the systems approach and the role of innovation. These approaches are discussed in the following sections.

2.2.2 Ecological Modernization Theory

Ecological Modernization Theory (EMT) is concerned with the way in which modern society is responding to environmental issues and the risks associated with industrial development (Murphy and Gouldson, 2000). It particularly examines economic and environmental measures and how these can jointly provide solutions for sustainable development with the view that they are not necessarily intrinsically in conflict (Buttel, 2000). EMT takes the perspective that sustainable development depends on technological advances (York and Rosa, 2003) and that innovative firms will lead the way inspiring win-win solutions (Drake *et al*, 2004). Proponents of EMT see the only way out of environmental/ecological crisis is to go further into the process of modernization and economic development (Robbins, 2001 pp. 23-26). Capitalism and modern social institutions are deemed sufficiently flexible to incorporate and integrate ecological and economic concerns (Gibbs, 2000). EMT relies on the expectation that, encouraged by regulations and government policies, an industrial switch over to environmentally friendly technologies and processes will be profitable and attractive for commercial development and therefore economic and market mechanisms will be enough to attain

sustainable development (Dunphy *et al*, 2003 p. 48). Rather than radical break from the path of industrial development EMT represents a continuation of it with an environmental dimension which does not significantly alter its path (Welford, 2000 pp. 52-64). However, as Starik (2004a) points out, the notion of "inventing our way out" of serious socio-environmental problems does not address the complexities inherent in sustainability and innovation challenges which are fraught with paradoxes and dilemmas 'such as whether or not biotechnologies should be developed, used, and regulated, or, how far ahead in the future or how widely beyond the human species should impacts from technological development be assessed'. In this regard EMT is overly optimistic about the capacity of science and technology without paying attention to risks of industrial development (Murphy, 2000). While institutional learning may be a part of EMT, the evidence shows that only some organisations are pursuing sustainable environmental management strategies, and, that learning predominantly occurs following an environmental crisis or accident or only when it is linked to economic interests (Robbins, 2001 pp. 132-133). On the other hand the EMT perspective highlights an important issue which is the role of innovation in assisting the attainment of sustainable development.

Sustainable development not just about ecology and economics but about ideology and politics – it is value laden (Gibbs, 2000). While the origins of EMT were in the technological capacity to find solutions to sustainable development, EMT theorists now recognise that politics and institutional structures play central roles in facilitating the necessary technological development (Buttel, 2000). To this end EMT focuses on societal matters to some degree although it is mainly restricted to national level solutions, industrial countries, particularly Europe, and use of environmental regulations (Murphy, 2000; Murphy and Gouldson, 2000). A cultural politics view of ecological modernization can partially explain the differing responses of firms to sustainable development and environmental management, however a fuller understanding can only be provided when EMT is used in conjunction with organisation/management theory (Robbins, 2001 pp. 134-135).

Despite its recent rise in popularity EMT remains 'indistinct as a social theory' (Buttel, 2000) and cannot satisfactorily explain many observed phenomena either at macro-level policy making or at micro-level decision-making in organizations (Lundqvist, 2000), or lack of consumer demands and the dominance of compliance-driven over market-driven innovation (Drake *et al*, 2004), or the lack of radical innovations and long-term solutions (Drake *et al*, 2004; Murphy and Gouldson, 2000). Drake *et al* (2004) point out that targeting one sector of society - firms - for regulation does not advance the notion that environmental management is good for business and that a broader societal approach is required where environmental responsibility at the societal level will stimulate demand for 'green' business. Furthermore, arguments that the move towards a knowledge-based and services economy is a natural development of ecological modernization do not consider the increasing consumption of goods and greater demands in these economies (Robbins, 2001 p. 137) which are becoming isolated from the production of those goods. In addition, the lack of concern with issues of social justice or equity, and their disassociation from environmental issues, limits the potential of EMT to provide solutions for global sustainable development (Murphy and Gouldson, 2000).

2.2.3 Industrial Ecology, eco-efficiency and eco-effectiveness

Industrial Ecology (IE) provides a scientific basis for the implementation of ecologically sustainable industrial production. Ecology is a science of living systems – it focuses on the interconnections and community character of a system and seeks to identify and describe the energy and material flows and

discover the rules which govern and give resilience to the system (Ehrenfeld, 2000). Ecosystems use only solar energy and release only infra-red radiation back into space as 'waste'. They have a cyclical flow of materials, waste does not exist as it is nutrient for another element in the system. Industrial systems on the contrary use non-renewable energy sources and exhibit a linear flow of materials which depletes resources and generates waste and emissions which cannot be assimilated into the surrounding system without creating imbalance (Korhonen *et al*, 2004). Industrial ecology seeks to create material and energy flows which emulate the natural ecosystem model. For example, eco-industrial parks have been established where firms collaborate with use of materials, by-products and energy. One of the most cited examples is in Kalundborg Denmark where the by-product from an oil refinery is used by the others to reduce energy consumption (Dunphy *et al*, 2003 p. 150; Korhonen *et al*, 2004). However, eco-industrial ideals in such parks are often compromised (Deutz and Gibbs, 2004) as the case of Kalundborg and the central role of the oil refinery shows.

A limitation of IE is the particular focus on eco-efficiency, that is achieving more from resources used and reducing the environmental burden (Ehrenfeld, 2005). This can be achieved through recycling, reducing energy inputs and reducing material inputs – a process known as dematerialisation. Eco-efficiency is an appealing concept as firms can identify its with efficiency goals to reduce costs and waste in lean production (King and Lenox, 2001; Pil and Rothenberg, 2003). Additionally, approximately one-third of economic growth in the USA between 1929 and 1982 can be attributed to increases in efficiency and productivity achieved through innovation and technological progress (Davis, 1994).

However, a focus on eco-efficiency does not address the fundamental issues of choice of materials used and the design of production. In their thesis, *A World of Abundance*, McDonagh and Braungart (2000) argue that a focus on eco-efficiency creates tensions between industry and environment and is in fact an unsustainable model applied to current production systems. They propose an eco-effectiveness model based on three principles drawn from natural ecosystems: waste equals food, use current solar supply and respect diversity. Essentially they argue that basic changes in the design of products, processes and business models can free industry of limitations and constraints and dispense with the notion of a trade-off between growth and sustainability. For example, rather than trying to dematerialise and perhaps compromise on some feature such as quality, designers should focus on using different non-toxic non-polluting materials and therefore eliminate worries about use of the materials e.g. the elimination of PVC from Nike shoes. Also, rather than trying to find a one-for-all universal design, diversity in all forms should be encouraged for solutions to sustainable products and designs. New business models include the leasing of products to customers which can be reused/recycled upon return e.g. Interface carpets leasing programme. McDonagh and Braungart have worked closely with some large firms in progressing towards sustainable manufacturing, including Nike and Interface Carpets, and they appreciate the practical implications of attaining an eco-effectiveness model. The first step is about values and making the commitment to transform.

Interface Carpets, one of the world's largest producers of commercial carpets, have adopted The Natural Step (TNS) programme which is scientifically based programme aimed at attaining sustainable production. Perhaps the most famous example of a TNS organisation is IKEA. The Swedish furniture manufacturer has many critics however it was the first major corporation to adopt the TNS programme. The TNS was devised by Dr. Karl-Henrick Robert whose experience as a cancer specialist caused him to question the way society was managing its environment (Robert, 1999).

The TNS identifies four system conditions in its frameworks which are based on the principles of materials and energy flows in natural ecosystems. 'In a sustainable society nature is not subject to increasing: 1. concentrations of substances extracted from the Earth's crust; 2. concentrations of substances produced by society; 3. degradation by physical means; and that in society 4. human needs are met worldwide' (Natrass and Altomare, 1999 pp. 22-42). These conditions provide the framework for organisations to progress towards sustainable production. Natrass and Altomare show in their case studies, which include Interface and IKEA, that this is achievable although the case studies also illustrate that it is not an easy process. There are many organisational learning and cultural issues involved. And, while the cases illustrate the achievements and how sustainable production is compatible with highly successful business models, in all cases strong leadership commitment, values and strategic vision play significant roles. The framework itself does not provide the organisation with an model of implementation and, in this sense, it is compatible to use with environmental management systems, such as ISO14001, which do not typically provide the goals and specific measures to guide the organisation (Natrass and Altomare, 1999 pp. 170-173).

Industrial Ecology has some other limitations in that, apart from a handful of practical examples, these are idealised systems and any wider application would require massive industrial adjustment and, for this to occur, social and organisational factors needs to be accommodated. IE emerged from the scientific and engineering communities, however, IE theorists are moving towards the inclusion of the social dimension (Korhonen *et al*, 2004). As with the example of The Natural Step at firm level, limiting IE to the biophysical and the scientific can only bring about scientific, technological solutions and, even then, without insights from the social sciences, these will be difficult to achieve. Ehrenfeld argues for an alternative paradigmatic use of the natural ecosystem, as a metaphor, to provide a possible solution for sustainable development. This focuses on the interconnectedness and community aspects of natural ecosystems as well as the balance between competition and cooperation (Ehrenfeld, 2000). Hoffman (2003) cautions against trying to produce a 'grand theory' to cover all elements of the industrial ecosystem, rather, he suggests linking the technical analysis of industrial ecology with the social systems analysis from other disciplines. Korhonen *et al* (2004) elaborate on this and make three points to link IE to management and policy studies: 1. the systems and network approach of IE is compatible with the systems approach to study both inter- and intra- organisation dynamics; 2. management and policy studies can complement IE material and energy flows to produce prescriptive suggestions for wider societal application of IE; and 3. IE as a powerful metaphor is a source of inspiration for management and strategic vision of a sustainable society.

2.2.4 Systems Approach

A system is a set of interrelated and interdependent parts which operate as a unified whole (Robbins, 2001 pp. 10-15): a closed system is self-contained and an open system interacts with its environment through inputs and outputs as well as influences and responses. At the level of the organisation, elements of the environment with which the organisation interacts include government, labour force, financial institutions, suppliers, and customers as well as raw material inputs and energy and outputs of finished products/services or waste. Internally, the organisation itself is composed of many interdependent elements and sub-systems - processes, functional areas and social dimensions - people, culture and structure. Key characteristics of an open system are (adapted from Katz and Khan, 1978 cited in; Robbins, 2001 p. 13):

- environmental awareness – the organisation constantly interacts with its environment

- feedback – the system adjusts to information from its environment
- cyclical character – the system consists of cycles of events
- tendency towards growth – without active intervention the system runs down or disintegrates
- steady state – there is an input or energy to counteract the winding-down properties
- movement towards growth and expansion – the more sophisticated the system the more likely it is to grow
- balance of maintenance and adaptive activities – to be effective the system must ensure the subparts are in balance and that it maintains its ability to adapt to its environment
- equifinality – there are a number of ways to achieve the same objective

A collective and integrated approach to sustainable development can be operationalised, for example, through a multi-level, multi-system process (Starik, 2004b; Starik and Rands, 1995). Each of three levels, individual, organisational and societal, has multiple interconnected systems (inputs, processes, outputs, feedback). The individual can choose to take action and assume responsibility for environmental actions. The organisational level involves group activities, teamwork, management systems, networks and leadership for environmental action. At the societal level, collective efforts of individual and organisational levels are manifest through social, cultural or political actions and governance. Ultimately, these levels are encompassed by an ecological level (Starik and Rands, 1995). The systems approach recognises many interactions and relationships and that fit will be dependent on many contingencies and organisational characteristics. The implications for organisations are that multiple internal and external factors and relationships need to be examined, defined and prioritised. Strategies need to be developed to support an environmental orientation for managerial and functional decisions and choices.

System and system capabilities are also important in management for innovation and for sustainable development. In describing the evolution of industrial structure in dynamic regions, Best (2001 pp. 54-58) identifies the production capabilities to achieve competitive advantage. These are knowledge intensive and are the capabilities to not just integrate different elements of the system but to integrate different systems and sub-systems. Best (2001 p. 262) describes systems integration as 'a fundamental principle of production and organization ... operating at the technical and organisational levels ... it means the organizational capability to redesign production to exploit design changes in sub-systems in ways that take advantage of interactive effects'.

At the individual level the ability to think in terms of systems has been identified as an important skill in the practice of sustainable development as well as a core skill for organisational learning (Sweet *et al*, 2003). Systems-thinking recognises that choices and actions are context dependent and that in complex, open systems there is a mutual causality and interdependence between the economic, social and environment elements and it seeks for deeper patterns and structures. Systems-thinking enables managers to move the organisation toward sustainable production through recognising the social and environmental consequences of actions and outputs (Dunphy *et al*, 2003 p. 114). Organisation and management theories which view the organisation from an open systems perspective are further discussed below in section 2.4

Innovation too occurs in systems of public and private organisations at national, regional and industry levels (Davis, 1994) and the role of innovation and innovation systems in sustainable development is discussed below.

2.2.5 Conclusion an EMT, IE and Systems Approaches

I have discussed ecological modernization theory and industrial ecology and their limitations for the study of sustainable development in organisations – mainly their lack of a social dimension. Systems theory offers a more suitable vehicle. However, it is difficult to operationalise either as a research tool or as a mechanism for achieving sustainable development. It seems that the insistence on including the environment itself causes difficulties from both a research perspective and from economic and societal perspectives. Although it may be a driving force, the environment is not an active, conscious agent in bringing about economic or social changes for sustainable development. It does not make economic or strategic choices or hold its own values and in this sense it is passive. Therefore its inclusion in models for sustainable development is sometimes a confusing and complicating factor. This does not mean that it cannot be the subject matter or theme or an informant or stakeholder, particularly by proxy. I look to innovation as a comparable concept because, firstly, innovation and sustainable development are intertwined and, secondly, innovation systems and models for driving economic growth can provide a model for sustainable development. The next section looks at the relationship between sustainable development, innovation and competitiveness.

2.3 Sustainable development and innovation

The role of innovation in reaching sustainable development has been evident throughout the discussion to this point. Both ecological modernization theory and industrial ecology highlight the pivotal role of new technologies and processes in reaching a sustainable production system and society. Even modest sustainability targets require substantial innovation (Rennings, 1998). Whether it is the development of new products or the reprocessing and recycling of old materials or the development of new business models, the primary agents of innovation are organisations and commercial firms.

'Innovation is broadly defined as the generation and application of new ideas and skills to produce new products, processes and services that improve economic and social prosperity' (Dodgson, 2006). From a sustainable development perspective environmental improvement could be included to this definition. A broad definition of innovation is appropriate since, rather than just referring to the first commercial application of a product or process, the greater the technological change inherent in the innovation, the more likely organizational or social innovations are also involved (Davis, 1994).

Sustainable development may bring a powerful agenda to direct innovation, however, the most dominant force in the economy driving innovation has been the competitiveness agenda. While in the past the competitiveness and sustainability had few linkages, their mutual sensitivity to technological innovation is bringing about a new 'techno-economic' paradigm (Davis, 1994). The perception of a trade-off between the environment and economic growth is changing and they are increasingly being seen as mutually supportive goals (Best, 2001; Davis, 1994; Porter and van der Linde, 1995a; UNCSD, 2001).

At the level of the firm, a study on large electronic firms found that complex environmental design tools are not enough to diffuse design-for-environment (DfE) principles and knowledge into product development teams - what is required is complexity & knowledge sharing in companywide networks with concentrated

centres of expertise (Lenox *et al*, 2000). Hall and Vredenburg, (2004) contend that it is precisely because innovation for sustainable development is so difficult that it can be the grounds for competitive advantage. They found that traditional risk management techniques and innovation strategies in the agricultural biotechnology and oil and gas industries are insufficient to deal with the complexities of sustainable development, especially the social dimension and that effective sustainable development innovation requires embedded organizational capabilities.

While innovation is essential for sustainable development it is also essential for firm growth and comparative advantage. Innovation, the creative and entrepreneurial resources of the firm and its organisational capabilities, rather than size, drive its growth (Foss, 1993; Penrose, 1955). The organisational abilities to generate and gain from innovation, rather than command over a particular technology, are the source of a firm's competitive advantage (Nelson, 1991) where competence lies in the process of learning and not in the content of what is learned (Dosi and Marengo, 1994). Innovation and competitiveness and the links with economic growth and sustainable development are discussed next.

2.3.1 Competitiveness and innovation

The capacity to innovate and to adopt new technologies is seen as an essential driver of economic growth and competitiveness (NESC, 1993 p. 105). Innovation has become both a key indicator of and a top priority for competitiveness and competitive advantage (Cooke, 1998; Fites *et al*, 1999; NCC, 2000a; Porter, 1990a; Porter, 1990b). Definitions of competitiveness vary (Faberberg, 1988; Jacquemin & Pench, 1997; O'Donnell, 1992) but essentially they incorporate the concept of firms, regions or nations producing and trading in open international markets while improving living standards and incomes e.g.:

Competitiveness refers to the ability of companies, industries and regions or supranational regions to generate, while being and remaining exposed to international competition, relatively high factor income and factor employment levels on a sustainable basis (OECD, 1996).

This definition illustrates how competitiveness is applicable from firm level to supranational level. However, it is not explicit what is meant by each of these. It is also true that these levels of competitiveness can be intertwined, interdependent (Buckley, Pass, & Prescott, 1988; Porter, 1990a) and even confused (O'Donnell, 1992). At the core of national competitiveness is the competitiveness of firms, where their role is to create economic value added and, in turn, their performance depends on their regional/national performance (IMD, 1997; WEF, 2001).

While the extensive array of factors believed to influence competitiveness means that measurement can be extremely complex and it can be easier to recognise competitiveness performance than to specify its causes (NESC, 1993 p.105), in practice it has often been measured, for simplicity, by the single factor of relative change in unit labour costs of production (Boyle *et al*., 1992; O'Donnell, 1992). As noted earlier, one-third of economic growth in the USA between 1929 and 1982 is attributed to increased efficiency and productivity brought about by technological changes and innovation (Davis, 1994).

Differences in technology have long been attributed as possible explanations of comparative advantage and trade power (Best, 1990; CEC, 2000; Deardoff, 1984; Fites *et al*., 1999; O'Donnell, 1992; Solow, 1957). Furthermore, the importance of technological variables in determining trade has been endorsed by empirical studies (Deardoff, 1984; Dosi & Soete, 1988). Competitiveness is related to technological change and the

capacity to innovate and to adopt new innovations (NESC, 1993 p.104). In his review of competitiveness, O'Donnell concludes that "the research on Ireland's competitive advantage should have as one of its chief elements a focus on innovation and technological ownership advantages" (O'Donnell, 1992 p.48). Cooke (1998) notes that, internationally, the priority tool to gain competitive advantage is innovation.

2.3.2 Sustainable development, innovation and competitiveness

Environmental sustainability is inextricably linked to innovation and competitiveness in many national and international policies. For example, the European Union agreed the strategic goal for the EU (CEC, 2000):

"to become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion (p.4)."

And in the Laeken Declaration (EU, 2001) the EU aspired to ensuring globalisation was embedded in sustainable development:

"Now that the Cold War is over and we are living in a globalised, yet also highly fragmented world, Europe needs to shoulder its responsibilities in the governance of globalisation. The role it has to play is that of a power ... seeking to set globalisation within a moral framework, in other words to anchor it in solidarity and sustainable development."

It is not just at the level of nations or regions that competitiveness, innovation and environmental sustainability are intertwined but also at the level of industries and firms (Porter and van der Linde, 1995a). However, it has proven difficult to conceptually link economic performance at national or regional level with performance at firm level and internal firm dynamics (Best, 2000).

It has been argued that the challenge to decouple economic growth from environmental problems actually presents opportunities for innovation and consequently competitiveness (CEC, 2000; Porter and van der Linde, 1995a). Porter and van der Linde (1995a; 1995b) brought this thinking into the mainstream management and competitiveness debate. They maintained that the new paradigm, defining international competitiveness as dynamic and based on innovation, gives rise to the possibility that environmental regulation can trigger innovations that may off-set costs of compliance and lower the total cost of a product or improve its value. They argued that many econometric studies did not account for the dynamic innovation effects and consequently viewed compliance with regulations as raising costs and harming competitiveness. Presenting a counter-argument in the same journal issue, Palmer *et al* (1995) argued that environmental regulations reduce profits – since, if the relevant technology/innovation brings benefits that are worth the investment then, driven by competition, complying firms would have implemented it anyway. They surmise that the environmental innovations are not pursued out of choice, there being better options, whereas Porter and van der Linde argue that they are often not pursued out of ignorance.

Palmer *et al* contend that traditional cost-benefit analysis, which includes the benefits to society not addressed by Porter and van der Linde, should be the basis for economic attractiveness of regulations and not the premise of 'cost-free' regulation. They also point to the lack of empirical evidence presented by Porter and van der Linde who cite numerous case studies in support of their thesis. In an analysis of manufacturing survey data at industry level, Jaffe and Palmer (1997) found no significant relationship between environmental regulatory compliance expenditures and patenting activity but they did find a positive relationship between compliance expenditures and R&D expenditures. In general, Porter's arguments have

received support for the use of well designed regulatory framework to stimulate innovation for sustainability (Dunphy *et al.*, 2003 p. 46). This conforms with ecological modernization theory (EMT) that a strong regulatory framework will stimulate innovation and lead to sustainable development.

Advocating the need for a specific theory and policy of eco-innovation, Rennings (1998) states: 'a carefully designed, forward-looking eco-innovation policy may be able to cut the costs of a policy toward sustainability dramatically. It requires close coordination with environmental policy in all innovation phases. Environmental and eco-innovation policy can be regarded as complementary. However, an environmental policy neglecting the potentially beneficial effects of a specific eco-innovation policy (especially in the invention phase) may lead to excessive economic costs'.

Given the importance of innovation to the competitiveness agenda it has been subject to extensive institutional support and development and the insights from innovation in this regard can be of particular use for sustainable development. Furthermore, the innovation systems may be harnessed for sustainable development.

2.3.3 Innovation systems

Schmideiny (1993) highlights the importance of technology cooperation for sustainable development stating that it is now 'a major focus of business, governments, and multilateral organizations. Such cooperation is complex and is best seen as an interconnected chain of 5 links: competitive advantage, long-term partnerships, training, innovation, and sustainability'. This reflects the fact that collaboration is a key element in fostering innovation (Kiston & Michie, 1998; Roper, 2000). This gives rise to the ideas of innovation networks and national innovation systems and national innovative capacity. These describe the social institutions of innovation and a social system of innovation which can encompass financial flows, legal and policy links, and flows of information, science, technology, and people (Davis, 1994).

A supportive environment is acknowledged as a key element for successful innovation (Oliver & Blakeborough, 1998) and several particularly successful regional models have been widely reported, for example, Denmark, Singapore, Baden-Württemberg (Germany), and Emilia-Romagna (Italy) (Best, 1999; Cooke, 1998; Dunning, Bannerman, & Lundan, 1998; Oliver *et al.*, 1998). NESC (1993 p.106) recognised that while "innovation was essentially a matter for individual firms ... the capacity for innovation can be stimulated or inhibited by the institutional and policy framework within countries". The converse is also true, where organisational capabilities of firms influence the growth and competitive strength of national industries and economies, which require co-operation in a wide variety of facilities and skills for markets to be effective (Chandler, 1992a, b). Inputs to a firm's innovation process can be acquired through networking as an alternative to in-house R&D (Roper, 2000). In Ireland, for example, both internal firm organisation of MNCs and their inter-firm linkages may provide a basis for the development of indigenous capabilities (O'Sullivan, 2000). While innovation systems may function well in national frameworks due to cultural and language background the notion that a system is bounded by geography and politics does not match well with the modern globalised information society which gave rise to the concept of a knowledge-based economy by the OECD (Leydesdorff, 2006).

Innovation systems are complex and dynamic and it can be difficult to operationalise the concept. The Triple Helix is a three-dimensional model describing and examining the system and refers to the mutual information sharing by university, industry and government to bring about successful innovations

(Leydesdorff, 2006). For example, international studies show that the effect of government and university research on productivity is positive and it outweighs the cost of public research and, in countries where the business R&D intensity is higher, the effect of public research is greater as the business sector is better able to seize opportunities raised by public research (Guellec and van Pottelsberge de la Potterie, 2001). I suggest that the sustainable development agenda harness the insights and learning from innovation and the technological and social dynamic of innovation systems to achieve its goal. A model of innovation-led economic growth is proposed by Best in the innovation and capability perspective which I outline below and discuss as a possible framework for sustainable development.

2.3.4 *The Capability & Innovation Perspective and the Entrepreneurial Firm*

Best (1990; 1998; 1999; 2000; 2001) draws on the Penrosian idea of the *entrepreneurial firm* for his capability and innovation perspective of economic growth. The internal growth dynamic of entrepreneurial firms lies at the core of national/regional growth dynamics (Best, 2000).

While the entrepreneurial firm has taken some different forms (for example Best discusses Japanese and American variants) a common feature is the integration of design and manufacturing. The fully developed entrepreneurial firm:

1. pursues product-led (not price-led) competitive strategies and depends upon high performance work systems (HPWS¹)
2. integrates design and manufacturing - necessary for compression of new product development cycle times
3. is part of internal/external dynamic based on *open systems networking*. This dynamic fosters the decentralisation and diffusion of design and thereby enhances regional innovation.

Best's capability and innovation perspective is a framework for integrating technology and innovation into growth processes by defining resource creation in terms of production and organisational capabilities. The framework also provides a suitable vehicle to link both firm level and national/regional level competitiveness. This is particularly appropriate in the Irish context where national policies have often needed to adapt to the requirements of firms operating in the global environment (Bradley, 2001). In Best's Capability Triad² (Best, 2000) three interactive domains shape a region's capability development processes – Business Model, Production Capabilities and Skill Formation (Figure 2.1). Technology-led growth involves the synchronised advances in all three overlapping and interconnected elements of the triad (Table: 2.1).

¹ HPWS – high performance work systems - are bundles of practices in which workers have greater autonomy over their tasks and production methods, greater opportunities to upgrade skills and to participate in design and manufacturing and have pay incentive schemes linked to system performance.

² Best has also called it the Productivity Triad with the term *production systems* replacing *production capabilities*, however, both are essentially the same.

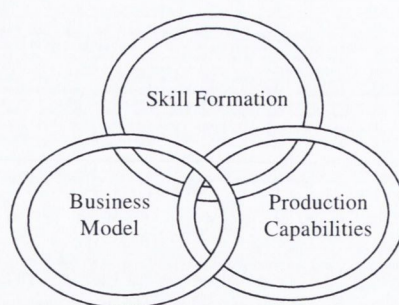


Figure 2.1: Best's Capability Triad - Technology-led growth involves the synchronised advances in all three overlapping and interconnected elements of the triad. Source: Best, 2001

Table 2.1: Description of the Three Interconnected Domains in Best's Capability Triad

<i>Business Model</i>	refers to "enterprise organization for processes of capability development." The <i>entrepreneurial firm</i> is at the centre of the business model and is driven by a capability/market opportunity dynamic. Open-systems networks are the mediating link between firms and the region. New market opportunities motivate changes in productive capabilities, setting in motion a new technology and market dynamic (Best, 2000). A virtuous circle is generated whereby entrepreneurial firms, in advancing their own capabilities also advance those of the region and, in turn, regional technological capabilities will spawn more entrepreneurial firms (Best, 2001).
<i>Production Capabilities</i>	are an expression of the underlying and unifying principle of production and organisation. The integration of design and manufacturing, as well as technology management rather than simply technology, are key production capabilities of entrepreneurial firms. Best (2001) identifies five models of production systems in which competitive strategy and production systems are bound together. These each represented in their time innovative performance in technology management, production principles and associated capabilities: 1.interchangability (Amory), 2.single-product flow (Ford), 3. multi-product flow (Toyota), 4. new product development (Canon), 5. systems integration (Intel). Best discusses each of these models and their regional implications in terms of manufacturing throughput efficiency, incremental innovation, new product development, design modularisation and technology management.
<i>Skills Formation</i>	represents the dynamic between firms and regional supply of skills and is a critical component in growth-oriented industrial policy. Growth depends on skills that match advances in production capabilities. Regions that invest in skills formation are in a better position to anticipate, respond to and benefit from change. Three conditions for success exist: characterisation of the demand for specific skills; investment in technical education; and skill formation in the workplace.

Source: Best, 2001

From the perspective of the firm the capability triad identifies several characteristics which may contribute to a region's capability development and growth (Table2.1):

business model - The *entrepreneurial firm* is at the centre of the business model and is driven by a capability/market opportunity dynamic Open-systems networks are the mediating link between firms and the region. New market opportunities motivate changes in productive capabilities, setting in motion a new technology and market dynamic (Best, 2000).

Production Capabilities are an expression of the underlying and unifying principle of production and organisation. The integration of design and manufacturing, as well as technology management rather than simply technology, are key production capabilities of entrepreneurial firms.

Skills Formation - the importance of regional investment in skills, technical education and skills formation in the workplace.

I propose that we may draw inspiration from the literature on innovation and competitiveness for the best use of organisations in attaining of sustainable development, in particular the innovation and capability perspective, the Capability Triad and incorporating the Triple Helix (Leydesdorff, 2006).

2.3.4.1 *Sustainable development as a social and technological innovation system for growth*

Best (2001 pp. 243-256) briefly addresses the issue of sustainable development and suggests that the production innovation and capabilities perspective provides a conceptual framework for engaging in the issues of sustainable development rather than being an economics of sustainable development. However, Best was applying this in the context of technological developments and the process by which firms can apply innovation and production capabilities to sustainable development. He did not present the triad as possibly a structure for sustainable development in itself in the same way he uses it as a tool to examine technology-led growth but rather as a vehicle for firms in the system to deliver sustainable innovation and production capabilities. However, I propose that the system itself could be transformed into system for analysing sustainable development to identify challenges and opportunities and ultimately for achieving it.

While innovation and organisational capabilities have been identified as key factors for competitiveness these are also being identified as key requirements for environmentally sustainable manufacturing. As discussed earlier, these common factors give rise to the argument that environmentally sustainable initiatives, through innovation, may be a source of competitiveness both at firm level and national level. The capability and innovation perspective can place these in a production and economic growth framework.

Best contends that the capabilities and innovation perspective denies trade-off between growth and environment in sustainable development based on the principle of design for sustainability (Best, 2001 p.244). In his discussion he encapsulates the principles of Industrial Ecology production design to improve productivity and the elimination of waste, design for manufacturability and energy efficiency. He gives examples of industry and university cooperation guided and supported by government policies which led to breakthrough innovations in sustainable products such as biodegradable polymers, micro-technologies and renewable energy. He outlines how a focus on process and quality underpins productive capabilities, continuous improvement and innovation.

The innovation and capability perspective may provide a suitable framework to link Industrial Ecology to the social facets of innovation systems and production (Korhonen *et al*, 2004) which is compatible with the design led eco-effective vision of McDonagh and Braungart (2000) for achieving sustainability which also denies that a trade-off need exist between growth and environment. The three interconnected and overlapping areas of the Best's Capability Triad also reflect the interconnectedness of economic, social and environment in sustainable development: the business model, production capability and skills formation. Development in these three areas is mutually reinforcing and occurs simultaneously to achieve technology-led growth. These three areas can each be enabled for sustainable development-led growth. There is no need to include environment as a separate element in the model as it is not an active agent and all the necessary considerations can be captured by the economic and social elements of production, skills and business models.

First of all, Best describes the regional business model for innovation-led growth. This can easily be altered to become innovation for sustainable development. Best places the entrepreneurial firm at the centre of a region's business model. In turn, by placing it at the centre of the business model for sustainable development the entrepreneurial firm:

1. pursues sustainable product-led competitive strategies and depends upon high performance work systems (HPWS) – both key elements of successful innovation, productivity and HR management in sustainable enterprises
2. integrates sustainable design and manufacturing – essential for sustainable processes and products
3. is part of internal/external dynamic based on *open systems networking*. This dynamic will aid the diffusion of design and associated capabilities for sustainable innovation and production. The open systems model will include cooperation with government and universities for innovation breakthroughs and skills formation.

Furthermore, the firm's own business model can take on new sustainable forms such as leasing of products instead of selling them. A recent example of how a business model can change on a grand scale in the recycling and reuse of electrical and electronic goods in the EU which entails significant cooperation between consumer, distributor and manufacturer (see glossary for a description of WEEE). Also, industrial ecology and eco-effectiveness models are more likely to be attainable on a grander regional scale than via a series of small scale initiatives because a greater diversity of enterprises will facilitate the alignment and matching of inputs/outputs and innovation to that end.

The second area of the Capability Triad, production capabilities - technology management and the integration design and manufacturing - can be specifically oriented towards sustainable production. Examples of how this can be achieved on large scale through cooperative development in production capabilities are the removal of CFC from fridges and other products and, more recently, the removal of lead and the move towards reduction in greenhouse gas emissions through improved energy efficiency. This also highlights the role of governments and societal institutions in guiding production capabilities towards sustainable development whether they are competitive or not.

The third area of the Capability Triad is skills formation. This also can be geared towards sustainable development. The societal institutions responsible for skills formation can focus on sustainable development opportunities and education. In conjunction with industry, skills formation for sustainable production can be tried and experimentation for production and business can be conducted. Skills formation also includes education skills for sustainable living and changing consumer habits to match the new business models.

The cumulative effect of skills formation, technology development, production capabilities can all be oriented to sustainable development. The role for government, as in the Triple Helix, is to support all elements of this triad through enterprise development and education institutions. The government has a role in the nurturing of expertise and the creation of opportunities, for example, through financial support. Policies and regulations can use the Triad to guide the process of sustainable development.

The Capability Triad provides a framework for the necessary collective, integrated action by all actors for sustainable development without having to rely excessively on individual firms (Drake *et al*, 2004; Dunphy *et al*, 2003 p. 10; Giddings *et al*, 2002; World Commission on Environment and Development, 1987) while at

the same time facilitating individual firms and actors to provide a diversity of solutions through competitive innovation (McDonough and Braungart, 2000; Porter and van der Linde, 1995a, 1995b).

2.3.4.2 *The application of Capability Triad in this research*

From the perspective of this research which takes a firm level look at environmental management the Capability Triad is useful: it will aid the identification of innovative entrepreneurial firms in a global manufacturing context with the International Manufacturing Strategy Survey (IMSS) and in six case studies; it will assist in linking innovation and environmental management capabilities; it will enable an open systems theoretical approach to be adopted whereby organisational environmental management is seen in the context of its institutional environment; and it will assist in the identification of organisational characteristics and capabilities as well as institutional factors in environmental management. The next section of this review looks at some theoretical perspectives from the organisation and strategic management literatures.

2.4 **Theoretical Perspectives**

This section of the literature review deals with the theoretical perspectives of the firm. It outlines some theories of the firm and how they apply to the study of environmental management. Where a theoretical perspective is adopted to studying environmental management in organisations three theoretical approaches dominate in the organisation and strategic management literatures: institutional theory, stakeholder theory and the resource-based view - these are outlined below. Also, many researchers adopt a combination of these and other approaches. Examples of the many other research approaches and frameworks which have been adopted, in many cases to complement one or more of the main three just mentioned, are: systems approach (Starik and Rands, 1995), contingency theory (Aragón-Correa and Sharma, 2003), co-evolution (Blum-Kusterer and Hussain, 2001; Rennings, 1998), leadership (Egri and Herman, 2000), use of Morgan's metaphors (Jorgensen, 2000), strategic issue interpretation (Bansal, 2003; Sharma, 2000), individual champions (Andersson and Bateman, 2000; Bansal, 2003), decision styles theory (Sweet *et al*, 2003), the theory of reasoned action (Marshall *et al*, 2005) and congruence theory (Russo and Harrison, 2005).

The perspectives may be broadly categorised according to whether they emphasise the role of the organisation's institutional environment in determining policies, strategies and actions or whether they emphasise the organisation's freedom to choose strategies. Some of these perspectives are discussed below. The common feature of these institutional and strategic perspectives is that they view the organisation as an open system where the organisation is embedded in its environment (e.g. business, social, political and economic), a view which is consistent with sustainable development (Starik and Rands, 1995).

2.4.1 **Institutional Perspectives**

Two perspectives which emphasise the influence of the organisation's institutional contexts in determining strategies, including environmental management, are institutional theory and stakeholder theory.

2.4.1.1 *Institutional Theory*

Jennings and Zandbergen (1995) first proposed institutional theory as a means of explaining and understanding environmentally sustainable organisations. Since then institutional theory has been applied by various authors to explain the adoption of environmental management in organisations.

Institutional theory focuses on the pressures the institutional environment exerts on firms' policies and actions. Institutions are defined as 'cognitive, normative and regulative structures and activities that provide stability and meaning to social behaviour. Institutions are transported by various carriers – cultures, structures and routines – and they operate at multiple levels of jurisdiction' (Scott, 1995 p. 33). Each firm/organisation operates within an organisational field – a diversified or multinational organisation may operate in several fields. The organisational field consists of 'those organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resources and product customers, regulatory agencies, and other organizations that produce similar services or products ... the totality of relevant actors ... the field idea comprehends the importance of both connectedness and structural equivalence' (DiMaggio and Powell, 1991). While organisations in the same industry, market or those sharing a common technology may operate in the same organisational field, the field can revolve or evolve around an issue or issues upon which interaction and dialogue are based and for which consensus is reached (Hoffman, 1999). This consensus reflects the relative power of disparate and often competing institutions engaged in the field in determining an issue's meaning. Whereas the organisational field may be viewed as a source of knowledge and information providing unlimited choice and giving discretion at individual and firm level, institutional theory views the organisational field as providing choice from a 'narrowly defined set of legitimate options' (Hoffman, 1999).

Institutional pressures in the organisational field provide the context for managerial decisions, actions and change (Marshall *et al*, 2005). Over time responses to these pressures become institutionalised and repetitive and organisations that face the same institutional conditions begin to resemble one another – a process known as isomorphism. Three types of pressures influence isomorphic change in organisations: coercive, mimetic and normative (DiMaggio and Powell, 1991).

- Coercive pressures are exerted by the institutions upon which the organisation depends e.g. regulatory authorities and market forces as well as cultural expectations in society.
- Normative pressures are experienced through professionalisation of employees, professional relationships, networks and industry associations etc.
- Mimetic pressures are the conscious and unconscious efforts made by organisations to imitate or model other organisations in response to uncertainty.

Institutions wielding pressure for environmental actions and management in organisations include governments, regulatory authorities, customers, suppliers, community groups, environmental organisations, media, industry associations and competitors. Governments and regulators exert pressures at local, national and international levels through policies, endorsement of practices and ultimately legislation as well as providing less coercive pressures such as information and technical, financial and other forms of support and incentives such as voluntary programmes (Angell and Rands, 2002; Clark, 2005; Corbett and Kirsch, 2001; Darnall, 2002; Delmas and Toffel, 2004; Hoffman, 1999; Jaffe *et al*, 1995; Marshall *et al*, 2005; Porter and van der Linde, 1995a).

Competitors, industry associations and networks also help define issues and their meanings and to determine acceptable practice. Associations and networks are sources of information for organisations including the sharing of best practices and they also play roles as industry advocates with regulatory authorities and the media (Delmas and Toffel, 2004; Marshall *et al*, 2005). The media influence organisations through

highlighting issues and activities of organisations, both negative and positive, as well as informing debate and providing a forum for confirmatory and/or dissenting voices (Darnall, 2003; Hoffman, 1999). Community environmental groups and other non-governmental organisations (NGOs) may exert pressure directly or indirectly through political or media channels (Delmas and Toffel, 2004; Hoffman, 1999). They may influence all levels e.g. the corporate, regional and plant or local (Marshall *et al*, 2005). Environmental policies adopted in response to pressures from external institutions confer legitimacy on organisations and may enhance their reputations (Delmas and Toffel, 2004; Henriques and Sharma, 2004). In effect, institutional theory posits that these pressures cause organisations to become increasingly aligned with the relevant institutions and to resemble each other in structure and practices (Starik and Marcus, 2000).

However, some authors deviate from the isomorphism hypothesis and suggest that institutionalism can also stimulate heterogeneity (Delmas and Toffel, 2004). Different responses to the institutional environment may be due to: organisations' different perceptions, filters and interpretations; conflicting institutional pressures which must be prioritised; and exposure of multinational and diversified organisations to different institutional fields (Levy and Rothenberg, 2002). In addition, the focus on isomorphism implies a stability which does not reflect the changing nature of the institutional environment and organisational change. Citing examples in the chemical industry Hoffman promotes an evolutionary approach where institutional and organisational changes are stimulated by disruptive events resulting in a reconfiguration of field members and/or patterns of interactions (1999). Jennings and Zandbergen (1995) proposed extending institutional theory to allow for the role of individuals in sense-making and acting contrary to normative systems and in innovation processes.

While these authors try to accommodate organisational diversity and change within its framework, institutional theory does not satisfactorily explain differences in responses to similar pressures by organisations in the same organisational field (Bansal and Roth, 2000; Delmas and Toffel, 2004) given that it is the institutional pressures which are supposed to shape organisations and their activities. Therefore, in order to account for other sources of influence e.g. stakeholders, individuals, resources and capabilities, many authors have opted to combine institutional theory with other approaches in striving to provide a more complete depiction of organisations and environmental management. And, while there is broad agreement on the institutional forces on organisations to adopt environmental management practices, there is a considerable variety of models and frameworks in the literature to accommodate these other factors. On the other hand, institutional factors and pressures are regularly identified in papers which do not explicitly adopt an institutional theory approach (Bailey and Rupp, 2006; Melnyk *et al*, 2003; Porter and van der Linde, 1995a, 1995b; Rondinelli and Vastag, 1996; Senge *et al*, 2001). Environmental management is an all encompassing subject matter which recognises the interaction and mutual dependency between organisations and their environment in its entirety – natural, social, economic etc. In this context institutional theory sits well with the sustainable development and corporate social responsibility frameworks and authors examining environmental management in organisations may naturally encompass institutional factors.

Where institutional theory looks at entities in a field which may influence an organisation, stakeholder theory looks at those entities which affect *or are affected* by the organisation's activities and performance and which consequently, from an institutional perspective, exert a particular type of pressure.

2.4.1.2 Stakeholder Theory

Stakeholders are persons or groups that have or claim ownership, rights or interests in an organisation and its activities (Clarkson, 1995). Stakeholders include shareholders and investors, employees, customers and suppliers as well as local communities and authorities such as governments, regulators and taxation authorities. Non-human nature/the environment may also be a considered stakeholder (Mitchell *et al*, 1997; Starik, 1995). Stakeholders influence or affect and/or are influenced or affected by organisations (Clarkson, 1995).

Stakeholders were originally defined and brought to prominence in the management literature by Freeman in the mid-1980s (Freeman, 1984). Observations in 1997, that there are inconsistencies in the definitions and classifications of stakeholders (Mitchell *et al*, 1997), still apply today. Stakeholder theory lacks consensus and some conflicting views of the theory's scope exist (Kassinis and Vafeas, 2006; Steurer, 2006). The debate begins with the definition of stakeholders and who or what they are. For example, Clarkson (1995) defines primary stakeholders as those without whom the organisation cannot survive such as shareholders, employees, community and regulatory authorities. Secondary stakeholders are those who influence or affect the organisation but who are not engaged in direct transactions with the organisation and are not essential for its survival such as the media and special interest groups. However, Donaldson and Preston (1995) argue that a clear distinction must be made between influencers and stakeholders and, for example, they explicitly exclude the media from stakeholder groups precisely because, although they may affect the organisation, they are not affected by it. Other studies also exclude the media from analysis of stakeholders (Delmas and Toffel, 2004; Marshall *et al*, 2005) while some explicitly include the media (Henriques and Sharma, 2004; Lesourd and Schilizzi, 2001). Moreover, the latter authors use very different definitions and classifications of stakeholders. Henriques and Sharma classify stakeholders according to the organisation's resource dependency on them. Conversely, Lesourd and Schilizzi (2001 p. 26), define stakeholders as those who are affected by the firm and classify them according to whether they are directly affected such as employees, shareholders and taxation authorities or indirectly affected, such as NGOs, the media and the general public. Neither classification includes the environment as a stakeholder of any kind.

Stakeholders have also been classified according to three attributes - power, legitimacy and urgency – which explain stakeholder salience and the attention given by managers to various stakeholders (Mitchell *et al*, 1997). These attributes are not static and those with little or no salience can affectively increase managerial attention by acquiring missing elements. This highlights the manager-stakeholder relationship and the importance of managerial perceptions (Henriques and Sharma, 2004). The organisation needs to respond simultaneously to multiple stakeholders with competing interests (Rowley, 1997) and reconcile these with multiple objectives in complex decision making processes (Winn, 2001). The institutional environment may change and develop around issues (Hoffman, 1999) and, similarly, issues and social issues change (Husted, 2000) and may also determine new or different stakeholders or change their legitimacy, power and salience. Furthermore, just as stakeholders are dynamic, so too is the organisation and managerial/organisational values can also change given new information and/or circumstances which will consequently change the nature of stakeholder relationships, for example, the acceptance of environmental values for the production of the first dolphin-friendly tuna fish (Winn, 2001).

Steurer (2006) identifies three stakeholder theory perspectives in the literature: the corporate, the stakeholder and the conceptual. The latter often incorporates the former two and includes examinations of stakeholder

relationships from the perspective of sustainable development and environmental management. Henriques and Sharma (2004) adopt a clearly corporate perspective and base their reclassification of primary and secondary stakeholders on a study of the Canadian forestry industry. According to their framework primary stakeholders are those on whom the organisation is dependent for critical resources. There may be a mutual dependency such as with shareholders and customers, or the stakeholders themselves may resource independent, such as regulators. Stakeholders on whom the organisation is not resource dependent usually have social and/or ecological purposes such as the media and environmental NGOs. They may enhance their power over an organisation and influence its strategy through exerting indirect pressure by affecting the behaviour of other stakeholders such as customers, local communities and shareholders on whom the organisation is resource dependent. Kassinis and Vafeas (2006) also use resource dependency to show how stakeholder pressures lead to improved environmental performance as measured by toxic emissions. Stakeholder power varies according to the organisation's resource dependency and managers respond and shape policies accordingly.

However, the resource dependency framework has some limitations. Henriques and Sharma acknowledge that it is from the perspective of the organisation and does not account for the stakeholder perspective. Also, resource dependence theory considers resource control as the source of power (Rowley, 1997) and, despite arguments that stakeholders on whom the firm has little or no resource dependency can exert influence indirectly (Henriques and Sharma, 2004), this perspective does not account for ethical decisions, moral actions and the role values play in organisations (Freeman, 2004) or the legitimacy and urgency attributes which also account for managerial attention (Mitchell *et al*, 1997). This further illustrates lack of consensus among stakeholder theorists. If strategy is related solely to the organisation-stakeholder resource dependency relationship, this does not accommodate the moral and ethical arguments of normative stakeholder theory which assumes that values play an essential and explicit role in organisations (Freeman, 2004). If power is the only relevant attribute than this leads to an amoral theory of organisation/manager-stakeholder relationships (Mitchell *et al*, 1997). On the other hand, while managers 'must take into account the legitimate interests' of stakeholders (Freeman *et al*, 2004), if legitimacy is the only focus then stakeholder theory is no more explanatory about an organisation's performance than the moral arguments of corporate social responsibility (Mitchell *et al*, 1997).

The corporate social responsibility and sustainable development perspectives assert that nature/the environment be counted as a stakeholder in its own right (Gladwin *et al*, 1995; Mitchell *et al*, 1997; Shrivastava, 1995b; Starik, 1995). However, many authors including those examining environmental management from a stakeholder perspective (Buysse and Verbeke, 2003; Christmann, 2004; Delmas and Toffel, 2004; Lesourd and Schilizzi, 2001) and the corporate/resource dependency perspective (Henriques and Sharma, 2004; Kassinis and Vafeas, 2006) do not include nature/the environment as a stakeholder in its own right (Starik, 1995) but rather include environmental groups, regulators and NGOs.

From the organisation's point of view, the environment may be directly influential, as a primary stakeholder, if the organisation is dependent on it (e.g. agriculture, forestry, fisheries, natural resources and tourism) or it may be indirectly influential through other primary or secondary stakeholders such as shareholders and NGOs (Buysse and Verbeke, 2003; Kassinis and Vafeas, 2006; Lesourd and Schilizzi, 2001). While the environment usually depends on representatives or proxies to voice and articulate its stakes and exert influence on its behalf, it is directly affected by the organisation and its activities (Gladwin *et al*, 1995;

Mitchell *et al.*, 1997; Sherman *et al.*, 2002; Starik, 1995). The nature and degree of the effect will vary according to the nature and degree of the organisation's activities. The organisation's influence on the environment can be extensive as it permeates the actions of its customers and suppliers etc. and, even where an organisation takes an environmental initiative, it may not be effective, e.g. the production of recyclable electrical goods does not mean that the end consumer will recycle a product and it may end up disposed in landfill. From a sustainable development perspective, the environment is clearly a stakeholder in its own right (Starik, 1995). A moral and legitimate responsibility is exerted on the organisation to treat the environment as a stakeholder. Furthermore, due to the pervasive nature of the interactions of an organisation with the environment, all levels of an organisation's operations are affected by environmental management (Bansal and Roth, 2000; Cordano and Frieze, 2000; Henriques and Sadorsky, 1999; Porter and van der Linde, 1995a) and, therefore, the environment becomes a stakeholder from the organisation's perspective also.

However, as with institutional theory, stakeholder theory does not fully explain why firms vary in response to different pressures or why some adopt beyond-compliance practices which exceed regulatory requirements (Delmas and Toffel, 2004; Prakash, 2000 pp. 4-6). Nor does it explain why some firms adopt, but choose not to disclose, positive environmental initiatives (Heller and Mroczko, 2002). While managerial decisions, values and perceptions play a role in stakeholder theory (Henriques and Sharma, 2004; Winn and Keller, 2001) the organisation is primarily treated as a single unit rather than a composite actor (Prakash, 2000). In addition, positive organisational values and motivations towards environmental management do not necessarily translate into successful performance (Bansal, 2003) and basic environmental capabilities are required in order to achieve higher level proactive and preventive management (Hart, 1995). The stakeholder literature also presents problems of 'mismatching', such as trying to link performance measures of one stakeholder, e.g. profitability for shareholders, with the influence of other stakeholders e.g. environmental activists (Russo and Fouts, 1997).

Stakeholder theory is an institutional perspective which focuses on the pressures exerted by particular entities in the organisational field which affect, or are affected, by the organisation. These pressures influence the organisation's policies, strategies and actions. Institutional perspectives advance our understanding of the context and influences but they do not contribute to our understanding of how the organisation itself and its internal attributes contribute to policies, strategies and actions.

2.4.2 Strategic Perspectives

While institutional and stakeholder theories focus on the pressures exerted on organisations to take action, strategic perspectives focus on organisational discretion and the issues, decisions and choices which influence the channelling of resources and capabilities for achieving a lasting competitive advantage (Foss and Knudsen, 2003; Teece *et al.*, 1997; Wheelwright, 1984). Competitive advantage may be described as the firm's ability to create and sustain superior performance relative its competitors (Porter, 1985).

Strategic perspectives may examine the organisation's attention (Ocasio, 1997), strategic reference points (Fiegenbaum *et al.*, 1996) and interpretations (Sharma, 2000). For example, sustainable development and environmental management may be interpreted as either threats or opportunities (Aragón-Correa and Sharma, 2003). They may become strategic issues or reference points resulting in the attention of decision makers and influencing the choice of strategy and performance, for example, for pro-activity or regulatory compliance. Even in the context of strong institutional pressures, such as in the petroleum industry, some firms make

strategic choices to perform differently to common industry practices and beyond environmental regulations (Sharma, 2000). Reference points which the organisation may choose to establish can be internal inputs (e.g. particular capabilities, functions, quality), internal outputs (e.g. profitability, growth and value creation), or external (e.g. competitors, customers and stakeholder) (Fiegenbaum *et al*, 1996). Decisions on which reference points matter and how they are communicated affect the alignment or fit between internal resources and external demands influencing the organisation's performance and adaptability. The concept of fit is also central to contingency theory.

2.4.2.1 Contingency Theory

Contingency theory focuses on the organisation's structure-environment fit (Burns and Stalker, 1961; MacKechnie, 2006) and strategic fit (Ghoshal and Nohria, 1995) and asserts that organisations achieving the best fit will perform most effectively. However, there exists no 'one best way' to organise and achieve fit - contingencies exist which are contextual and specific and which aid the choice of a suitable fit (Birkinshaw *et al*, 2002). Consequently, contingency theory has been called a 'horses for courses' theory where different structural forms (horses) perform well under different circumstances (courses) (Ghoshal and Nohria, 1995; MacKechnie, 2006). Strategic choices are made which reflect the organisation's circumstances, such as environmental/market stability, and the organisation's characteristics such as structure, size, technology and knowledge (Birkinshaw *et al*, 2002). The organisation's ability to cope with information is also central to the theory (MacKechnie, 2006). For example, the appropriate choice for successful supply chain strategy (e.g. market, network or hierarchy) is dependent on both the variability of activities and the ease of analysing activities in the supply chain (Brennan, 2006).

Although contingency theory proposes that an optimal fit will exist for each situation, this is not done in a deterministic manner (MacKechnie, 2006). And, where institutional theorists argue that options are limited and dependent on the organisational field (Hoffman, 1999), contingency theory recognises that strategic choice exists. The chosen strategy leads to the design of relevant tasks which, when analysed, will aid the identification of an appropriate structure. However, choices of strategy and tasks are not easily achieved – the organisation must interpret the situation and decide how best to exploit the given circumstances – environment, technology etc. (MacKechnie, 2006) Furthermore, strategic choice is also subjective and dependent on managerial interpretations of the situation (Aragón-Correa and Sharma, 2003; Sharma, 2000). Congruence theory, a variant of contingency theory, stresses the fit between an organisation's strategies and design and improved performance (Russo and Harrison, 2005). Individuals are included in the congruence framework of Nadler and Tushman (1997) which identifies four organisational dimensions that interact with each other to achieve fit: work, formal organisation, informal organisation and individual. (Some further comments on the role of individuals are given below). The concepts of fit and of best exploiting circumstances are also central to the resource-based view of the firm for achieving competitive advantage (Russo and Fouts, 1997).

2.4.2.2 Resource-based View

The resource-based view (RBV) of the firm is a way of identifying and explaining the internal resources and capabilities which differentiate firms and provide a source of competitive advantage and which can explain why some firms outperform others in a given external environment (Barney, 2001). Since its first formal articulation in 1984 (Wernerfelt, 1984) the RBV has become one of the most widely adopted approaches in

strategic management (Foss and Knudsen, 2003; Newbert, 2006). It has been also been adopted by many authors examining environmental management in organisations (e.g. Aragón-Correa and Sharma, 2003; Darnall and Edwards Jr., 2006; Hart, 1995; Russo and Fouts, 1997).

The original idea of viewing the firm as a bundle of resources was pioneered by Penrose (1980) who argued that it is the heterogeneity, or diversity, of the capabilities³ available from its resources that gives each firm its unique character. By looking internally at the firm, Penrose introduced the idea of organisational capabilities, rather than firm size, as a basis for the growth of the firm (Foss, 1993). She also stressed the creative and entrepreneurial resources of the firm which drive its growth and introduced the idea of the entrepreneurial firm used in Best's (2000; 2001) innovation and capability perspective and Capability Triad (Penrose, 1955).

The link between firm level innovation and national competitiveness has been noted above (Section 2.3), however differences in emphasis exist in the literature. For example, Porter (1990a) emphasises the role of the national environment in the diamond theory as a driver of innovations and consequent growth and competitiveness. While Porter recognises the importance of a firm's capabilities in sustaining competitive advantage he studies how firm behaviour is "catalysed by circumstances within a nation" (p.53). Nelson (1991), on the other hand, while recognising the role of the environment in "constraining and moulding what firms do", as well as the role of chance in determining differences between firms, stresses the lack of a full appreciation in economic theory of the differences between firms, namely the sources and implications of these differences. He argues in favour of the evolutionary theory perspective of economic progress in which firm diversity is an essential element and which gave rise to the theory of dynamic firm capabilities. Kostopoulos *et al* (2002) define capabilities as a firm's capacity to deploy and coordinate different resources, usually in combination, by adopting organisational processes, to affect a desired outcome. These capabilities are information-based, intangible processes that are specific and are developed over time through complex interactions among the firm's resources. Capabilities are a collection of knowledge sets and are considered 'core' if they differentiate a company strategically (Leonard-Barton, 1992).

The RBV asserts that a firm's competitiveness potential depends on the value, rareness, and inimitability of its resources and capabilities (Barney, 1995). In order to fully realize this potential, a firm must be organized to exploit its resources and capabilities with complementary resources which include formal reporting structures, explicit management control systems and compensation policies (Barney, 1991; Barney *et al*, 2001; Wernerfelt, 1984). The central assumption of RBV is that firms are heterogeneous in terms of strategic resources that they own and control. Resources in this context can be defined as those assets that are semi-permanently tied to the firm and they include financial, physical, human, commercial, technological, and organisational assets used by firms to develop, manufacture as well as deliver products and services to its customer (Barney, 1991; Wernerfelt, 1984). The development of unique resources and capabilities in technology and manufacturing may be achieved through monopoly over resources, unique embedded routines and processes, as well as the changing of routines and processes emphasising the role of innovation (Ghosh, 2001). An ability to institutionalise new behaviours gives a firm competitive advantage (Ghoshal *et al*, 2000). In a changing environment, firms must continuously acquire, develop and upgrade their resources and capabilities if they want to maintain competitiveness and growth. Unless a firm can adapt and change, its

³ Penrose used the term 'productive service' for capability (Best M. 2001. *The New Competitive Advantage*. Oxford University Press: Oxford. p. 64).

core capabilities, which may be inappropriate in some situations, will become 'core rigidities' which inhibit development (Leonard-Barton, 1992). This stresses the importance of dynamic capabilities which enable the firm to 'integrate, build and reconfigure, internal and external competences to address rapidly changing environments' (Teece *et al*, 1997). Contingency theory suggests a particular structure (organic management systems) may be suited to rapidly changing environments by facilitating management to quickly respond and take action (MacKechnie, 2006). The *dynamic capabilities* approach of RBV suggests that it is the ability to adapt to new environments that matters and that it is the organisational and strategic routines which enable firms to reconfigure resources for new environments (Eisenhardt and Martin, 2000). This highlights the difference between resource possession and resource exploitation, and that it is the ability to fully realise the potential of the resources they possess which can give firms competitive advantage (Newbert, 2006). As Ketchen *et al* (2007) note, RBV has evolved into a contingency theory of organisations where, in order to realise their potential value, strategic resources must be aligned with 'other important organisational elements' (Ketchen *et al*, 2007). This is termed an *organizing approach* of RBV where the focus is on the relationships, routines, knowledge flows and organisation of resources which enable their exploitation (Galunic and Rodan, 1998; Newbert, 2006).

Despite its popularity the RBV is not without problems and critics (Foss and Knudsen, 2003; Lado *et al*, 2006; Newbert, 2006; Priem and Butler, 2001a, 2001b). For example, the definition of RBV – *that valuable, rare and inimitable resources lead to competitive advantage* – is arguably tautological if 'valuable' and 'competitive advantage' are defined in similar ways i.e. relating to performance/efficiency/effectiveness (Priem and Butler, 2001b). Furthermore, many researchers use competitive advantage and performance interchangeably or examine the relationship of particular resources with performance and not with competitive advantage (Newbert, 2006). Another criticism is that the rarity of a resource does not necessarily confer competitive advantage but, rather, it is its value which is the critical attribute, and that a resource's value is determined by the external market which is not included in the RBV model (Priem and Butler, 2001a). This is interesting from the perspective of environmental management – a resource such as a new environmentally-friendly product may be valuable in environmentally sustainable terms but if it is not valued in the market place, e.g. if it is too expensive, is it of any use to the firm? This is a dilemma for manufacturers – they need to sell their products and they must match, or create, the market demand. Other authors acknowledge the role of external factors and many combine RBV with an institutional perspective to examine institutional influences on resource selection and exploitation including the social, economic and technological environment, industry structure, buyer and supplier power as well as competitors' behaviour (Darnall, 2003; Darnall and Edwards Jr., 2006; Kostopoulos *et al*, 2002; Oliver, 1997).

In responding to these criticisms Peteraf and Barney (2003), two of RBV's key authors and proponents, state that the value of resources relates to the effect, or potential effect, they have on a product's costs and benefits whereas the value in competitive advantage is relative to competitors in the industry and is exogenous. Resources may be treated as 'indicators of a potential for greater profitability' but many other factors also influence performance. Ketchen *et al* (2007) counter the tautology criticism by stressing the contingent nature of modern RBV which acknowledges that possession of resources does not directly lead to competitive advantage and performance but rather they are mediated by strategic actions to realise their potential (Figure 2.2). However, despite their apparent importance in determining a resource and its

competitive advantage value, the RBV exclusively does not provide the means for examining exogenous factors.



Figure 2.2 The core concepts of the resource-based view (Ketchen et al, 2007).

While many RBV authors try to identify and describe critical/strategic resources through establishing links with competitive advantage and performance, Figure 2.2 illustrates that strategic action is the determinant of the best exploitation of these resources, in which case, organisational attributes and strategy related competencies and capabilities become in themselves strategic/critical resources. Strategy-making resources and capabilities contribute to sustainable competitive advantage (Hart and Banbury, 1994). The organising and dynamic capabilities approaches in RBV are still in their infancy and such contributions may 'enhance our understanding of how and to what degree resources, capabilities and core competencies facilitate the attainment and sustainability of a firm's competitive advantage and subsequent level of performance' (Newbert, 2006). However, Figure 2.2 does not show how RBV can increase our understanding of how resources are chosen or how strategies and capabilities are decided.

Finally, in an interesting revision of her original thesis (Fiol, 1991) on corporate identity as a source of competitive advantage, Fiol (2001) concludes that sustained competitive advantage cannot be gained from any fixed set of core competencies but rather continuous changes bring about temporary advantages in a continuously changing environment. Therefore with regard to identities and culture which may change in a sequence with temporary advantages, confusion and fragmentation will ensue in the absence of a stable core. Fiol proposes that an organisation's members' identification with core values brings coherence and stability e.g. the identification with excellence and devotion to a set of outcomes by GE throughout multiple identities and culture changes. These values, timeless principles and shared goals which bind organisations and provide organisational coherence are the hallmarks of leading firms and will become increasingly important in the future e.g. HP-way, Johnson & Johnson credo, Intel's creative conflict (Collins, 2006; Nadler and Tushman, 1999).

Recent literature is trying to gain a greater understanding on environmental management than the pure RBV and, in practice, many authors use RBV in combination with institutional perspectives or other strategic perspective which emphasise choice and decision criteria. For example (Aragón-Correa and Sharma, 2003) draw on RBV, contingency and dynamic capabilities views of environmental strategy which is an interesting and insightful development and helps to explain characteristics in the general business environment interact with internal dynamic capabilities and firms characteristics to influence environmental management outcomes and explain different outcomes from firms with similar resources or similar strategies.

The RBV is useful for this research as it can show how new resources and capabilities can be developed for production of a new technology as shown in a fascinating case study of Analog Devices by Coates and McDermott (2002). This study emphasised how the firm was able to capitalise on existing knowledge competencies and facilitate the development of new competencies in technology, market and integration - all of which could apply to sustainable development. The authors also demonstrate how RBV could be used to

view managing a manufacturing firm based on a competency based strategy rather than on competitive priorities. This is a more complex and long-term strategy which entails the accumulation of capabilities and the discovery of new ones. The competencies in turn may provide the outcomes of competitive priorities but they are better outcomes. This approach could also contribute to the framework for sustainable development based on the Production Capability Triad.

2.4.3 Conclusions on Theoretical Perspectives

The common feature of these institutional and strategic perspectives is that they view the organisation as an open system where the organisation is embedded in its environment (e.g. business, social, political and economic), a view which is consistent with sustainable development (Starik and Rands, 1995) and with the open systems model of the entrepreneurial form (Best, 2001). Though these perspectives each have considerable contribution to make none can on, its own, provide a complete approach to the study of environmental management in firms. However, taken together the institutional and strategic perspectives provide a very comprehensive framework which is compatible with the use of the innovation capability perspective and the production capability triad and the entrepreneurial firm.

The next section of the literature review presents some results on the performance and role of environmental management in firms and the relationships with innovation and other variables.

2.5 Environmental Management in Firms

This section looks at some of the literature relating to environmental management in firms. It highlights some relevant points and items of interest. It is written with a to provide a general overview of how environmental management relates to innovation and organisational capabilities, firm performance and competitive advantage as well as how firms differ in their decision and choices.

2.5.1 Motivations

In studying motivations and their contexts, Basnal & Roth (2000) identified three types of motivations for corporate ecological responsiveness: competitive, legitimacy and environmental responsibility. Each type of motivation results in particular initiatives. Competitiveness motivated initiatives include green products and marketing. Legitimacy motivated responses lead to initiatives such as regulatory compliance or networking with environmental groups. Initiatives motivated by environmental responsibility include donations to relevant causes, lifecycle analyses as well as unpublicised initiatives.

The contexts influencing these types of motivations are ecological, organisational and individual. Ecological context refers to the prominence or salience of an issue, for example, whether the issue is definite, transparent and emotive such as toxic waste, noise pollution and oil spills killing wildlife or whether the issue is vague or seemingly innocuous such as global warming, odourless/colourless gas leaks and minor spills at petrol stations. Issues of high salience result in competitiveness or legitimacy motivated responses such as efforts to act on prominent issues valued by customers or to deflect negative public attention or avoid penalties. Individual concerns lead to initiatives motivated by legitimacy and environmental responsibility.

The organisational context in this model is the cohesion of "formal and informal network ties between constituents in an organizational field". Firms operating in fields with high cohesion were motivated less by competitiveness or unique propositions and innovations diffused rapidly. Superior environmental

performance was negatively viewed and discouraged as it increased standards for other organisations in the field (Bansal and Roth, 2000). However, this view of organisational context is restricted to the organisational field and might be better termed the institutional context as it does not include organisational level values, concerns, resources or capabilities.

It is widely reported that positive attitudes of individuals towards the environment do not necessarily translate into practice (Derksen and Gartrell, 1993). The same can apply to business and there have been varied and conflicting results in the literature on the organisational influences on environmental initiatives. In a study of Small and Medium Sized Enterprises (SMEs) three characteristics of environmentally proactive firms which support organisational learning were identified: individual champions in the organisation; positive attitudes; and an open approach to, and empowerment of, employees (Petts *et al*, 1998).

2.5.1.1 Role of Individuals

Managerial attitudes have been identified as key drivers in organisations with proactive environmental practices (Cordano and Frieze, 2000; Marshall *et al*, 2005). Individuals as issue champions or sellers are essential in attaining a positive organisational response to environmental issues (Bansal, 2003) and champions who frame issues in businesslike non-emotive language achieve most success (Andersson and Bateman, 2000).

Prakash (2001) examined the selective adoption of environmental policies which surpassed the demands of regulations. These beyond-compliance policies were greatly influenced by the individuals in each firm who championed the policies and Prakash identified two internal firm processes: power based and leadership based. He illustrates with examples of policies adopted following managerial conflict e.g. following considerable managerial debate, Ely Lily adopted beyond compliance policy of providing the most expensive and environmentally safest storage tanks at all its facilities. However, a similar managerial debate/conflict resulted in the rejection of a proposal to adopt ISO14001. Supporters of ISO14001 failed to convince top management of potential long-term benefits despite the relatively low investment in comparison to the storage tanks. Elsewhere, Melynk *et al* (2003) found that management decisions to adopt ISO14001 were based on qualitative criteria and decision not to adopt were based on economic criteria.

However, individuals alone are not sufficient to achieve successful organisational actions and the environmental issues need to be consistent with organisational values before they become strategic (Andersson and Bateman, 2000; Bansal, 2003). Organisational core values are critical in giving individuals a sense of identity (Fiol, 2001) as well as providing a vision for sustainable development and environmental management (McDonough and Braungart, 2000; Nattrass and Altomare, 1999). Where organisational values are not environmentally oriented, education and training, couched in the language of cost efficiencies, employee welfare and quality, can encourage the implementation of environmental practices (Marshall *et al*, 2005).

Employing the congruence framework of Nadler and Tushman (1997), Russo and Harrison (2005) examine fit between the organisational dimensions of work, formal organisation and informal organisation. Contrary to the notion of improved fit leading to improved performance, the direction of affect was reversed in their study - environmental performance influenced organisational design: firms were reactive rather than proactive and poor performance (higher toxic emissions) triggered organisation design changes (reporting structures, inclusiveness in strategic decisions and compensation). They speculate that overall firm

performance and environmental performance may require different organisational design or that the role of individual-informal organisation fit, which they did not examine, may be a key element in successful environmental management (Russo and Harrison, 2005).

2.5.1.2 Regulations and Other Drivers

Some countries have mandatory publication by firms of environmental reports, some others require reporting to environmental agencies on specific practices. In Ireland, apart from government departments and local authorities, responsibility for the relevant environmental compliance lies with two main bodies: the Environmental Protection Agency (EPA) and Repak. The EPA is responsible for the licensing and regulation of large/complex industrial and other processes on the basis of integrated pollution control (IPC) as well as the licensing and regulation of all significant waste disposal and recovery activities, including landfills. It prepares national monitoring programmes (which in practice are the responsibility of local authorities). Repak implements EU waste packaging regulations and operates the EU Green Dot Scheme in Ireland which is obligatory for 'major producers' i.e. firms with a turnover of more than euro1.27million and placing 25 tonnes of packaging on the Irish market. Non-major producers may voluntarily participate in the Green Dot scheme. Both EPA and Repak operate national databases such as the Pollution Emissions Register (EPA) and the National Waste Database (Repak), develop environmental quality objectives and standards and publish reports.

An example of major legislation from the EU is the Directive on Waste Electrical and Electronic Equipment (WEEE) (CEC, 2001). This establishes measures for the prevention of waste from electric and electronic equipment as well as collection of WEEE for recycling and recovery. The overall aim is to reduce disposal of such waste. The proper treatment, recovery and disposal of WEEE is financed by producers. Consumers are able to return their equipment free of charge. This was introduced in Ireland in 2005 and has been very successful.

The Federation of Electronics Industries in the UK has estimated that this directive will cost the industry £5bn in the first year and £1bn annually thereafter (Bennet, 2002). Clearly this regulation has a significant impact on the manufacturers of electric and electronic equipment (e.g. organisation, supply chain management, product design, use of parts). Given the importance of this industry in terms of production and exports (CSO, 2001, 2002), it also has the potential impact significantly on the Irish economy. How firms and nations react to this and other similar legislation may be a factor in their competitiveness.

The level of environmental regulation in an industry influences the extent of environmental activities undertaken by firms (e.g. chemical, utilities and pharmaceuticals) (Banerjee, 2001). It also affects the level of variation among firms in terms of environmental management – highly regulated industries tend to converge through industry associations and, where little or no regulation exists, there is also little variation among firms. However, where new environmental regulation is introduced firms' reactions differ considerably with leaders and resisters to change evident (Klassen, 2001).

Apart from regulations there are other pressures on firms, and public interest in corporate social responsibility is a driver for many improvements (Banerjee, 2001; Cabugueira, 2000; Houlder, 2001). Mere compliance with regulations may no longer be sufficient and firms must become proactive and pre-empt or anticipate changing regulatory and customer expectations (Handfield *et al*, 1997). In a study of quality award winning firms, among the numerous external drivers of environmental initiatives identified were customers,

regulators and activists (Angell, 2001). This is in comparison to the quality initiatives which were found to be primarily customer-driven in that study. Corporate image can be a strong external driver, however it may also be misleading and a 'green image' may in fact conflict with other firm activities (Newton and Harte, 1997). Lessons to be learned from industrial environmental crises, show that corporate social responsibility is not just a matter of ethics but a matter of long-term survival of the firm (Shrivastava, 1995a).

2.5.2 Environmental management in the firm

While Porter and van der Linde (1995a) propose regulations to trigger innovation they also suggest that firms can accelerate the progress towards a more competitive environmental approach by:

1. measuring direct & indirect environmental impacts (to overcome lack of innovation due to ignorance)
2. recognising opportunity cost of underutilised resources
3. creating a bias in favour of innovation-based, productivity-enhancing solutions

Organisational capabilities for environmental initiatives in manufacturing operations were found to be jointly developed by a strategic corporate environmental approach and strategic processes (Bowen *et al*, 2001), and, communication and accountability have also been found to influence a firm's environmental performance (Chinander, 2001). However, Angell (2001) found that in quality award winning firms, successful environmental initiatives did not seem to be driven by support, understanding or formal strategic approval of top-management, which were necessary elements for the successful implementation of the quality initiatives. Other internal drivers include employee health and safety, liability reduction and synergy with lean production (Corbett and Kleindorfer, 2001) as well as resource efficiency for energy and raw materials (Valenduc *et al*, 2000).

Choice of manufacturing strategy is linked to competitive strategy and priorities such as the emphasis on quality, price, customer service and flexibility (Lindberg *et al*, 1998; Ward and Duray, 2000). In the cumulative capability model proposed by Nakane (1986), capabilities of competitive firms are developed according to the sequence: quality, dependability, cost efficiency, flexibility. There has been considerable support for this model with some authors proposing modifications such as the Ferdows & De Meyer (1990) (sand-cone model: quality (most important capability), dependability, flexibility, cost efficiency) and Noble (1995) (quality, dependability, delivery, cost efficiency, flexibility and innovation). These capabilities should be prioritized for improved competitiveness and better performing firms have been found to compete on the basis of multiple capabilities. Capabilities of the firm, as well as both individual and organizational learning, are viewed as playing significant roles in how an environmental strategy is introduced and implemented (Avadykian *et al*, 1999; Delmas and Terlaak, 2001; Rennings, 1998). In this context the evolutionary theory of the firm, the resource-based view of the firm and the cumulative model of capabilities are being favored by many authors (Avadykian *et al*, 1999; Christmann, 2000; Darnall, 2003; Klassen and Whybark, 1999; Rennings, 1998; Russo and Fouts, 1997).

Hart (1995) advances the resource based theory to include the firm's relationship with the natural environment. He proposes that three interconnected strategies of pollution prevention, product stewardship and sustainable development confer sustained competitive advantage on a firm. Russo and Fouts (1997) draw on the social corporate responsibility and resource based view of the firm literatures to empirically examine

firm performance over two years. They conclude that environmental and economic performance are linked, particularly in high-growth industries, and that shrewd managers will assemble the resources to capitalize on opportunities arising from the rise in importance of environmental concerns.

Darnall (Darnall and Edwards Jr., 2006) further developed the combined institutional /RBV theories in looking at cost of EMS adoption. Firms with greater internal capabilities incurred lower costs in EMS adoption. In addition it was found that ownership played a role in the capabilities and costs of EMS adoption.

Christmann (2000) found that it is the firm's complementary assets which are significant in determining firm performance and that implementing environmental management best practices does not necessarily enable a firm to become green and competitive. The selection of environmental strategies to match existing resources and capabilities is an important factor in success. Likewise, in employing the Miles and Snow taxonomy, Aragón-Correa (1998) identified firms with the most proactive business strategies, 'prospectors', as those which were also more proactive in their approaches to the natural environment (both traditional corrective and modern preventative).

Firm size, a variable which correlates with many others in the management literature, is also significant regarding environmental performance (Aragón-Correa, 1998; Russo and Fouts, 1997; Sharma, 2000). However, Angell and Rands (2002) present contradictory evidence and suggest that the influence of stakeholders and events which are correlated with size could be used as better indicators of environmental change initiatives.

This is now being debated in the literature and, emergent research indicates varying results as to the drivers (e.g. regulation, organisational or market-place), sources, performance and relationships of environmentally motivated innovation and competitiveness.

2.5.2.1 Corporate Environmental Strategies and Management Systems

The array of drivers for corporate environmental responsibility is manifest in the numerous environmental strategies and management systems pursued by firms. Many of these comprise of voluntary compliance with certain standards and guidelines and require the firm to develop policies, objectives, audits and overall explicit environmental standards [e.g. EU Eco-Management and Audit Scheme (EMAS) and Eco-Label Scheme, ISO 14000, Environmental Management System (British Standards), Global Reporting Initiative (UN Environment Programme)]. However, the real merit of many of these voluntary approaches has been questioned where certification may be awarded for a system which merely complies with minimum regulations. Many are not outcome orientated and/or there may be no requirement to publish policy or evaluations (Newton and Harte, 1997) and it has been found that implementation of environmental policies and product development do not necessarily result in any environmental benefit (Chen, 2001). Although the debate concerning the overall merits of regulation compared to a free-market voluntary-type approach is ongoing (Cabugueira, 2000; Newton and Harte, 1997), many countries are adopting ISO 14001 as the standard in their regulatory processes (Delmas, 2001).

The ISO14001 EMS was launched in 1996 and is becoming the dominant system of standards worldwide (Corbett and Kirsch, 2001; Morrow and Rondinelli, 2002) with 66,070 certificates in 113 countries in 2003 (ISO, 2004). It is also a system adopted and promoted by many national authorities, including Ireland (NSAI, 2004). Darnall (2003) found that early adopters of ISO14001 were more likely to have well-developed

quality management systems and hence the internal capabilities to engage in continuous improvement. Environmental initiatives and management systems are often linked and compared to the processes of quality management systems (Kennedy, 1998; Weisse *et al*, 1998) such as ISO9000 and Total Quality Management which are also associated with performance improvement (Kaynak, 2003). ISO14001 follows the structures of ISO9000 quality system upon which competencies a firm can build (Darnall, 2002) and which has been identified as important in the diffusion of ISO14001 (Corbett and Kirsch, 2001; King and Lenox, 2001). Focussing on processes and management systems ISO14001 lacks specific environmental outcome and performance measures and is less rigorous than the European Eco-Management and Audit System (EMAS). EMAS, while also a voluntary system, takes a regulatory stance and focuses more on changing environmental performance as well as requiring an environmental statement (Morrow and Rondinelli, 2002; Starkey, 1998). In 2001 EMAS integrated ISO14001 as the required environmental management system in its criteria (EMAS, 2005). EMAS is an EU system whereas ISO14001 is globally recognised. Evidence shows that an accredited environmental management system does lead to improved environmental performance overall although results on which aspects of EMS are most effective remains tentative (REMAS, 2005). EMAS has a greater positive impact than ISO14001. In addition, moving towards certification tends to temper stakeholder pressures perceived by managers (Henriques and Sharma, 2004).

In manufacturing terms the supply chain has been used as framework for identifying and orchestrating environmental initiatives (Best, 2001; Bowen *et al*, 2001; Corbett and Kleindorfer, 2001; Lamming *et al*, 1996; Vachon *et al*, 2000; Welford, 1998). Other frameworks employed are Life Cycle Assessment, Total Cost Assessment and Design for Environment (Egan and Pferdehirt, 1998; Kennedy, 1998; Weitz and Sharma, 1998).

The interaction between environmental management systems, operations management and competitive advantage have only recently begun to be widely studied (Corbett and Kleindorfer, 2003) and there are conflicting conclusions in the literature on the relationship of manufacturing operations with environmental performance. Rothenberg *et al* (2001) found that while there was evidence that lean management practices contributed to resource efficiency (solvent inputs), they did not sufficiently reduce emissions to meet regulations. However, King and Lenox (2001) conclude that lean production, as measured by ISO 9000 adoption and low chemical inventories, is complementary to reduction of waste and pollution.

2.5.2.2 *Environmental management and sustainable development*

There exist many descriptions of stages of sustainable organisations in the literature. For example, Dunphy *et al* (2003 pp. 23-26) identify six phases in the development of corporate sustainability in both human and ecological terms:

1. Rejection: employees are exploited with minimum investment in training. The environment is available to be exploited and polluting waste and emissions discharged
2. Non-responsiveness: financial and technological factors dominate. Human resource management (HRM) is dominated by industrial relations and environmental is not considered.
3. Compliance: financial and technological factors dominate. HRM and environmental management are compliance oriented.
4. Efficiency: HRM developed but cost-benefit oriented and environmental management focus is on cost avoidance/reduction

5. Strategic proactivity: Workforce viewed as a strategic resource, HR programmes developed e.g. flexible work practices. Community stakeholders considered in strategies. Environmental management viewed as strategic to business and competitive advantage. Products and processes substituted with environmentally sustainable options. Seeks to be environmental leader.
6. The sustaining corporation: Strong ethical orientation. Workforce seen as valuable in own right. Active promoter of environmentally sustainable values and best practice. Nature valued for own sake.

The main difficulty with this description is that at each stage it links strategic development of human resources with environmental management whereas in reality the two may not progress hand-in-hand and Dunphy *et al* (2003 p. 228) acknowledge that this model is based on an idealised progression. And, while sustainable development requires social issues be addressed, strategic HRM does not necessitate the incorporation of environmental management. However given the importance of organisational, social and institutional innovation in sustainable development (Rennings, 1998) it is feasible to envisage firms in the later stages having both strong HRM and environmental management and those in the earlier phases more likely to be disjointed. Given the strategic importance of HRM in achieving any of an organisations goals (Cullen and Farrelly, 2005) it is probable that HRM is developed in firms ahead of environmental management.

2.5.3 Measures and Indices of Environmental Sustainability

Numerous measures and indicators for environmental sustainability exist which also influence behaviour. At national levels indices may influence firm location and at firm level indices may influence investor decisions or strategic partnerships of relationships with stakeholders. These are produced mainly by environmental or governmental organisations and usually include environmental, economic and social measures. For example, in addition to its indices and indicators of national competitiveness and innovation, the World Economic Forum launched an Environmental Sustainability Index (ESI, 2001; Samuel-Johnson *et al*, 2000). The ESI has been found to correlate with per capita income as well as with rankings on the WEF Competitiveness Index, however there is no correlation with growth in per capita income (ESI, 2001). The ESI provides no evidence of any trade-off between environmental and economic performance and suggests these are a matter of independent choices. In Ireland, the NCC's (NCC, 2000b) national competitiveness report includes indicators on 'Technological Innovation Performance' relating to investment in research and development, patents granted, information technology etc and indicators on the 'Environment' relating to waste recycling and CO₂ emissions. At the level of the firm, similar indices also exist, often aimed at the 'ethical' investor, for example, the Dow Jones Sustainability Group Index (DJSI, 2006).

2.5.5 Conclusions on Environmental Management in firms

A review of the literature has identified links between environmental management and organisational capabilities, competitive advantage and performance. Whether it is firms with these capabilities that are taking on environmental challenges or whether the new environmental capabilities are affecting firm performance is unclear. The various institutional and strategic perspectives enrich the knowledge and understanding. However, there remain many questions and the dynamics between numerous factors and levels is complex and examinations of limited variables or extremely focused linkages do not seem to provide conclusive answers to how firms can best move towards sustainable development.

2.6 Focus of Proposed Enquiry

This research seeks to learn from innovative entrepreneurial firms and their engagement in the realm of environmental management. The proposed enquiry is broadly two-fold. Firstly, what insights can we gain from current environmental management in innovative entrepreneurial firms? How does environmental management interact with innovation and other strategic processes? How does it function within the organisation as an open system? What are the resources and capabilities for successful environmental management?

Secondly, given their increased likelihood of business survival in the longer term, how can we orientate innovative entrepreneurial firms towards sustainable development and to better integrate innovation and environmental management? What are the drivers, activities and processes which motivate them to implement successful environmental initiatives?

Sustainable development is a complex and comprehensive subject matter and, in order to appropriately address the complexity of, and to gain greater understanding of, the subject matter a mixed-methods approach is adopted. The first phase of this research, which employs data from the international manufacturing strategy survey, takes a resource-based view. It examines the relationship of innovation and performance with environmental management and the strategic salience of the environment in manufacturing strategy. The opportunity to use international data enables the identification of innovative entrepreneurial firms in the global context. The analysis tests the hypothesis that these firms will also give more prominence to environmental management in the manufacturing priorities, goals, action programmes and performance improvement.

In this mixed-methods study the second phase of research comprises case study and triangulation. The case studies provide in-depth insights into the role of environmental management in organisations. Institutional and strategic perspectives complement each other to provide a comprehensive analysis of environmental management in the context of sustainable development.

The next two chapters relate to methodology: Chapter 3 describes research paradigms and philosophies; and Chapter 4 details the methods employed in the survey instrument, analysis and selection of case firms.

METHODOLOGY

PART 1 – Philosophy and Paradigms

3. METHODOLOGY

PART 1 – Philosophy and Paradigms

3.1 Introduction

This research seeks to learn from innovative entrepreneurial firms and their engagement in the realm of environmental management. It seeks to gain insights into firms which combine progressiveness and natural environmental management at both strategic and operations levels. It takes place in two distinct phases and combines different methodologies in order to address the complexity of environmental management. The first phase of this research examines the relationship of environmental management with innovation and other performance measures through participation in an international manufacturing survey. In the second phase of the research, six Irish based firms are selected for case study analysis. The purpose of the case studies is to provide more complete description of the role and implementation of environmental management in organisations.

These two phases of research represent distinct methodologies: survey and case study. Many viewpoints and research paradigms regard these as incompatible. Therefore in order to address this criticism the Methodology section of the thesis is divided into two chapters (Part 1 - Philosophy and Paradigms, and Part 2 - Methods). In this chapter, I discuss research philosophy and paradigms. I outline my position as a pragmatic critical realist and how I use mixed methods, triangulation and elements of adaptive theory in my research. I argue in the chapter that the mixed-methods approach provides comprehensive insights and learning opportunities. In the next chapter, Methodology Part 2 - Methods, I present and discuss the details of the research processes involved in undertaking this thesis: data collection, analysis and integration.

Here I discuss research philosophies and paradigms, firstly, from a personal perspective which led to the choice of subject matter and, secondly, from the research perspective. Given the importance of his work in the debate about paradigms in the social sciences I outline Kuhn's arguments. This is followed by a discussion on paradigms in the social sciences and how they are presented in the literature. Some anomalies and conflicts are critiqued. I discuss the debate of paradigms in the social sciences particularly in relation to the scientific approach and critical realism. This chapter concludes with a discussion on paradigms and methodology with a focus on mixed-methods and adaptive theory which are employed in this research and detailed in Chapter 4.

3.2 Research Philosophy

3.2.1 Personal Paradigm

In this study, I have an interest in environmentally sustainable manufacturing and I view this as an ethical responsibility which should encompass all activity of an enterprise. I recognise that it is not a prevailing view within manufacturing or business in general but it is a feasible strategic and operational goal. Views change over time, so what is not dominant nowadays may become best business practice and eventually standard practice in the future. I am trying to contribute in some small manner to the understanding of what firms are doing in order to help increase the rate of sustainable manufacturing with the hope that it may eventually become normal practice. This view has elements of advocacy and a purposefulness more typically associated

with non-(post)positivist research such as advocacy/constructivism/pragmatism (Creswell, 2003, p. 6). However, as I outline in this chapter below, I identify myself with the critical realist paradigm.

I view commercially successful firms that are progressive and innovative in natural environmental management as progressive and innovative. In adopting this view I assume that progressiveness and innovativeness are firm characteristics which may be observed through firm activities and adoption of new methods and technologies in general. I expect this type of firm will be more open to new ideas and will create opportunities to investigate and adopt or generate new methods etc. In this sense I am not neutral or objective in my assessment of firms.

Principally it is my hope, and in parts of my work my hypothesis, that generally progressive and innovative firms will strategically engage in natural environment management or at least be actively aiming towards environmental sustainability as a goal and that improvement in this area will be a strategic priority. For this reason, I identify these firms and examine the strategic salience of natural environment management and incorporation of environmental criteria and actions into their innovative strategies and operations. I hope that by conducting and presenting this work I will contribute to the understanding of natural environmental management in organisations and consequently may make a contribution, albeit small, to the wider debate of sustainable development in society as a whole.

It has been stated that there is no need to go into great depth in a discussion of paradigms and methodology (Karlsson, 2002) and, indeed, it has been pointed out by readers of this work that perhaps it is unnecessary. I feel obliged, therefore, to explain why I have presented such a lengthy discussion in this chapter. During the course of my research a member of faculty, not linked to my work, pressed upon me that my methodology would be unacceptable for a Ph.D. degree, that mixed-methods was not a suitable choice and I would encounter serious difficulties. Furthermore, this person was emphatic that this was evidence of an incoherent research paradigm and, considering that a Ph.D. is a degree in philosophy, I would need to be extremely conversant with paradigms and philosophy and be very clear about my own position. This is why I have written this chapter.

3.2.2 Different Research Approaches and Paradigms

A paradigm refers to the approach or perspective from which phenomena are explained and the world is conceptualised. The origin of the word paradigm refers to a pattern or exemplar (OED-Online, 1989). Research paradigms are the frameworks that guide research communities in the natural or social sciences and provide ways of looking at the world (Usher, 1997).

Firstly, different paradigms are discussed in order to place this piece of research in the context of my own approach. It is beyond the scope of this work to look exhaustively at the nature of paradigms and how they are applied in research of organisations. They are rightly the subject of many a thesis in themselves. However, a selection of works which deal with the issues of paradigms, ontology, epistemology and methodology are outlined starting with an overview of Kuhn's work on paradigms in the sciences. There follows a critique of some works from the social sciences on paradigms. The critique emphasises how these issues are far from resolved by the research community and shows how they are treated and presented in very different forms by various authors. I outline my own position on these issues and where they apply in this work.

3.3 Kuhn's Paradigms

Thomas Kuhn introduced the term paradigm in his essay *The Structure of Scientific Revolution* in 1962 and, given that so many authors refer to this work, it merits some attention. The term 'paradigm' was used by Kuhn (2nd ed., 1970, p. 10) when depicting the route to normal science. His 'normal science' refers to research based on previous achievements acknowledged by a particular scientific community *for a time* as providing the foundation for its further practice. He goes on to relate how, prior to textbooks, the famous classics (e.g. Aristotle's *Physica*, Ptolemy's *Almagest* and Franklin's *Electricity*) served 'for a time implicitly to define the legitimate problems and methods of a research field for succeeding generations of practitioners'. They were able to do so because they shared two essential characteristics:

'Their achievement was sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity. Simultaneously, it was sufficiently open-ended to leave all sorts of problems for the redefined group of practitioners to resolve.'

He relates the term 'paradigm' closely to 'normal science' meaning that

'some accepted examples of actual scientific practice – examples which include law, theory, application and instrumentation together – provide models from which spring particular coherent traditions of scientific research.....Men whose research is based on shared paradigms are committed to the same rules and standards for scientific practice. That commitment and the apparent consensus it produces are prerequisites for normal science, i.e., for the genesis and continuation of a particular research tradition.'

Kuhn places much emphasis on the state of crisis which often precedes revolutionary new discoveries and new paradigms, for example, where anomalies exist and current knowledge does not explain them or different explanations are incompatible. A given paradigm provides the tools for the solution of puzzles and problems and the science will progress rapidly until the tools no longer enable this and retooling is required (Kuhn, 1970, pp. 66-76). Versions of the paradigm will proliferate and rules of puzzle-solving relaxed so that a new paradigm will eventually emerge (Kuhn, 1970, p. 80). A shared paradigm is a sign of maturity in a field where previously differing groups and divergences disappear (Kuhn, 1970, p. 17). An accepted paradigm will free a field of research from constantly re-examining its first principles (Kuhn, 1970, p. 163).

A new paradigm is based on new knowledge which revolutionises and reconstructs the fundamentals, theoretical generalizations and many methods and applications in a given field (Kuhn, 1970, p. 85). Kuhn illustrates his thesis with the historical examples of light & electricity: prior to Newton's or Franklin's discoveries there were fundamental disagreements among different groups on the nature of light and electricity. Subsequently, each of these fields achieved a paradigm which was able to guide the whole group's research (Kuhn, 1970, pp. 10-22). These, he claims, are historically typical examples of mature situations. Fields such as mathematics and astronomy in which the first paradigms date from prehistory and biochemistry which arose by division and recombination of specialities are less typical. Kuhn reflects on how achieving a firm research consensus is 'extraordinarily arduous' but that it is an important aspect of science. In some specialities, the study of heredity for example, the first universally received paradigms are still recent; and he suggests that it is an open question whether parts of social science have acquired such paradigms at all. However, in the absence of a paradigm fact-gathering becomes more random and casual and all new evidence may appear equally relevant.

Kuhn's paradigm revolution is not based on ontology, epistemology or methodology. A paradigm is brought about by new knowledge which determines accepted practice for a time until some more new knowledge changes or revolutionises it.

Puzzle-solving was a term that Kuhn used for the activities of normal science. Although not all activity could entirely be classified as such since a solution may not be actually be available or, for example, if the available pieces of puzzle do not match (Kuhn, 1970, p. 36). However, he acknowledges that not all puzzles can be solved by any given theory at a given time and in fact it is 'just that incompleteness and imperfection of the existing data-theory fit that, at any time, define many of the puzzles that characterize normal science' (Kuhn, 1970, p. 146).

Paradigms provide criterion for the choice of problems to be addressed and guide research even in the absence of rules which determine scientific activity (Kuhn, 1970, pp. 42). Although rules derive from paradigms the emphasis is on shared paradigms not shared rules. Specializations lead individuals to different paradigms. Different fields will also be affected differently by new knowledge, it may revolutionise one field and have no impact on others. For example the discovery of x-rays revolutionised radiation theory while merely providing new information for astronomers whose paradigm was unaffected (Kuhn, 1970, p. 93).

Kuhn also discusses paradigm as a world view (which is its common usage in the social sciences) and gives his analysis on how 'paradigm changes [do] cause scientists to see the world of their research-engagement differently' (Kuhn, 1970, p. 111). We see things based on what our previous visual-conceptual experiences have taught us to see. Our perception is shaped by our paradigm. When a new experience exposes us to something outside of our paradigm we may experience initial confusion but then we can adapt and see things from a new perspective. Paradigm also influences the questions asked. However even after a paradigm change and new questions we are still looking at the same world (Kuhn, 1970, pp. 129). Paradigms presuppose interpretation of observations and data. Given new knowledge and a new paradigm we may interpret these differently (Kuhn, 1970, p. 122) but also the data themselves may change as we may measure them differently (Kuhn, 1970, pp. 134-135).

Kuhn draws some interesting comparisons between natural and social scientists. Natural scientists, who can produce work for an audience from their own community which shares the same values and beliefs, need not worry about broader acceptance of their work. This insulation means they can focus on the problems they know they are likely to solve and so appear to make greater progress. Others, such as social scientists, engineers, doctors and theologians, often need to focus on the most important or pressing problems regardless of the tools available to them and also for audiences outside of their own research community. In this way the issues of paradigms and commensurability are subject to more debate among the social sciences (Kuhn, 1970, pp. 160-170).

In his book's second edition (1970), Kuhn writes a postscript which addresses the difficulties over the concept of the paradigm which arose after the publication of the first edition in 1962.

He writes how in much of his book the term paradigm is used in two different ways. Firstly, in a sociological sense, as 'the entire constellation of beliefs, values and techniques shared by members of a given community' and, secondly, as denoting one element of that constellation, 'the concrete puzzle-solutions which ... can replace explicit rules as a basis for the solution of the remaining puzzle of normal science' (Kuhn, 1970, p.

175). As was famously observed by Masterman, paradigm is used in as many as 21 various ways throughout the book (Poole, 1995, p. 44).

As Kuhn acknowledges when conflict about choice of paradigm emerges, each group uses its own paradigm to argue in defence of that paradigm and each paradigm will be shown to satisfy more or less the criteria that it dictates for itself and to fall short of a few of those dictated by its opponent (Kuhn, 1970, p. 110).

With regard to incommensurate theories Kuhn posits that ultimately the choice of theory is personal and subjective (Kuhn, 1970, p. 199). Delving into individual personality in the study of the progress of science however is not fruitful as it is the decisions of the community which govern. Shared intuition and persuasion lead to community decisions.

Given the same stimuli any two people may perceive and experience them differently (Kuhn, 1970, pp. 192-196). The processes of sensations are different and may differ between groups or communities where each group has a shared education, language, experience and culture. In this sense they may occupy different worlds although the objects, the sources of the stimuli, remain the same. 'What makes the integrity of perception worth emphasizing is that so much past experience is embodied in the neural apparatus that transforms stimuli into sensations.' Different perceptions do not imply just any ones at all. In fact the following characteristics apply to the process of transforming stimuli to sensations to knowledge: it is transmitted through education; it has, by trial, been found to be more effective than historical competitors in a groups' current environment; and it is subject to change both through further education and through the discovery of misfits with the environment.

In conclusion, certain facets of Kuhn's paradigms stand out which are not generally acknowledged in the paradigmatic debates of social science. They are not about an overall view of reality but rather based on given accepted knowledge at a point in time. They are open to change and discovery. They express a view of science that is uncertain and constantly seeking new knowledge and possibilities in a search for truth and understanding. The understanding of paradigms in the social sciences usually differs in that they reflect an accepted understanding of reality and how we may know that reality and examine it (ontology, epistemology and methodology). They are not based on actual accepted knowledge and therefore when new knowledge emerges they are unlikely to change. The following discussion looks at how selected authors in the social sciences present paradigms.

3.4 Paradigms in the Social Sciences

The term paradigm is most commonly used in three ways (Grix, 2004 pp. 24-25). Firstly, paradigm may represent an institutionalisation of intellectual activity as coined by Thomas Kuhn (Kuhn, 1970). In the human sciences this has come to mean an established academic approach based on common assumptions, theories, terminology and practices and methods. Secondly, paradigm sometimes refers to broad descriptions or categories of research approaches to the study of specific topics. For example, a top-down or bottom-up approach to a specific social event. Thirdly, the term paradigm can refer to the broad approaches to research which may form the basis for many academic perspectives, for example a positivist or interpretivist paradigm. This is the manner in which Grix and many authors use the term. Each approach has underlying basic assumptions providing theoretical foundations for the researcher. Research approaches differ along various continua: *ontology* - the understanding of reality and being; *epistemology* - the view of knowledge

and the relationship between the researcher and the matter being researched; and *methodology* - how research should be conducted.

3.4.1 Four paradigms, two-dimensions

I use the seminal model of paradigms presented by Burrell and Morgan (Burrell and Morgan, 1979, p. 22) to illustrate some of the difficulties with the classification of paradigms. They present four paradigms for the social sciences: Radical Humanist, Radical Structuralist, Interpretive and Functionalist. However, they differentiate these along only two principal dimensions: the objective-subjective dimension and the radical change-regulation dimension (Figure 3.4.1).

Their objective-subjective dimension refers to four analytical strands: ontology, epistemology, human nature and methodology. These strands each have assumptions based on extremes of objective-subjective nature. The extremes of these four strands reflect two positions generally described as sociological positivism and German idealism (Burrell and Morgan, 1979, p. 7). Their second dimension which determines paradigm refers to the sociology of regulation and sociology of radical change. The former concerns itself with the status quo, the unity of society and what brings integration and cohesiveness while the latter is concerned with the changes, breakdowns and conflicts of society (Burrell and Morgan, 1979, p. 18).

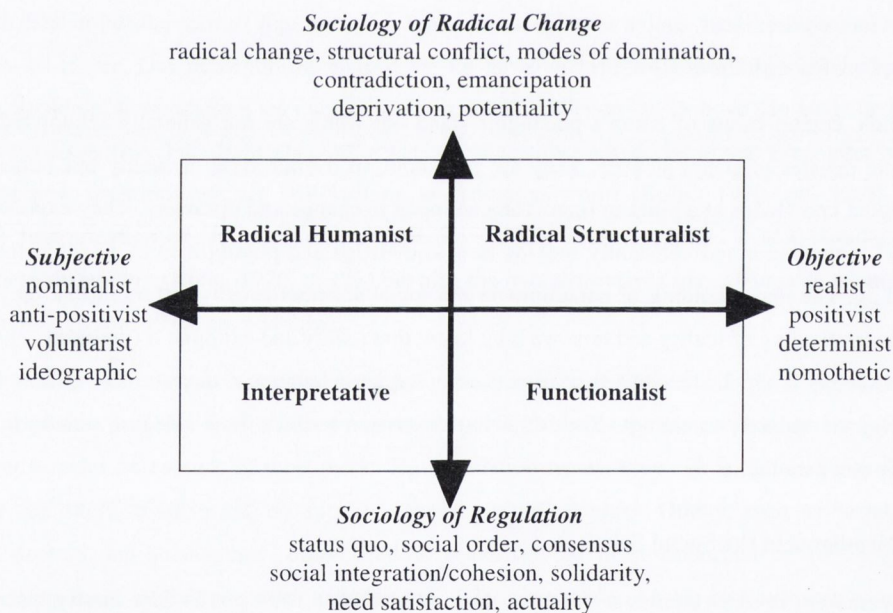


Figure 3.4.1: Two Dimensions: Four Paradigms (adapted from Burrell and Morgan, 1979)

In choosing these two dimensions I find their categorisation of paradigms restrictive. Firstly, the objective-subjective debate is not clear-cut and, secondly, the radical change-regulation debate, as they present it, to be more related to subject matter rather than to paradigm. Burrell and Morgan place themselves in the objective/regulation corner – the functionalist paradigm (Burrell and Morgan, 1979, p. 396). Perhaps this reflects both their need to explain and categorise and to see overall patterns despite their efforts to step outside their paradigm to understand the other paradigms. Burrell and Morgan’s (Burrell and Morgan, 1979, p. 5) explanations of each of the four strands of the objective-subjective debate (ontology, epistemology, human nature and methodology) are outlined in Table 3.4.1.

The main issues with the objective-subjective debate relate to the fact that, at one extreme, objectivity does not acknowledge individuals' interaction with the social world (or situation) as if the social world is totally independent of the actions and influences of individuals and as if individuals do not filter or interpret social events in their own minds. This does not explain the make up of the social world and how it may change over time nor does it explain how individuals behave or understand things differently in the same situation. At the other extreme the subjectivity does not fully acknowledge social structure and society. It does not believe that any universal truths may apply to the social world which may only be understood from the individuals directly engaged in the activity being studied. From the researchers' viewpoint subjectivity stresses the need for the researcher to understand from the inside, from the frame of reference of the subject being studied (Burrell and Morgan, 1979, p. 5). At the extreme, this view does not allow the researcher to be an external observer nor does it allow for any patterns of society or social world to be identified.

Table 3.4.1

Four Strands of Debate comprising the Burrell and Morgan's Objective-Subjective Paradigmatic Dimension (Burrell and Morgan, 1979, pp. 4-9)

Ontological debate - realist versus nominalist views of reality

Realism views the social world as made up of tangible, immutable structures such as the natural/physical world. Whether or not we are aware of or label these structures they exist as 'empirical entities' and are independent of an individual's appreciation.	Nominalism views the world beyond the individual as being made of names, concepts and labels. These are regarded as artificial convenient creations in order to make sense of the external world.
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Epistemological debate - positivism versus anti-positivism

Positivism seeks to explain and predict the social world through patterns and causal relationships. The approach may be through verification or falsification processes. The researcher is an objective observer.	Anti-positivism sees the search for patterns and causal relationships as futile. The social world is relativistic and can be understood only from the inside, from the frame of reference of those being studied. The researcher is subjective and cannot generate objective knowledge.
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Human Nature debate – voluntarism versus determinism

Determinism views individuals and their actions as being determined by the environment and situation.	Voluntarism views individuals as being autonomous and free-willed.
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Methodological debate – ideographic versus nomothetic theory

Nomothetic approach to social science stresses the methodological process and focuses on scientific rigour. Prescribed methods, hypothesis testing and quantitative analysis are prominent tools.	Ideographic approach stresses the importance of obtaining first-hand knowledge by getting close to the subject under investigation. Methods allow the subject matter to 'unfold its nature and characteristics' during the process.
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The researcher may achieve a middle ground regarding the level of objectivity and subjectivity attained. While society and the social world may be made up of individuals, the fact that 'society' (or societies) exists and has evolved exhibits the existence of some form of self-organisation over time. Such patterns of organisation may be observed and these are capable of both emerging slowly and changing radically depending on combined synergy of time, events and individuals. Although there is mutual influence and

interaction, these structures and systems of society are real and independent of the individual and may be studied as such.

One may seek some general truths and patterns, however, constant reference to individual cases and examples will emphasize the infinite diversity and complexity of the (social) world. The objective researcher may achieve a level of subjective understanding while empathising with the individuals involved. Apart from anything else no matter how objective a researcher claims to be, this in itself is a reflection of his or her own beliefs and will reflect in the choice of data, analysis and interpretation.

Burrell and Morgan's second dimension determining paradigm is the sociology of radical change-regulation debate. They propose this dimension to rearticulate 'in a more explicit and radical form' Dahrendorf's order-conflict debate on theories of society which was the subject of much criticism. The radical change end of their spectrum is influenced by philosophers who emphasised conflict, human consciousness and the alienation of individuals by dominant forces of society such as Marx and Habermas as well as the existentialist philosophers. The regulation end of their spectrum is influenced by philosophers such as Durkheim and Weber who emphasised the integrated structure of society and how it functions collectively. However, as Jaffe points out these philosophers cannot so easily be classified and for them many paradoxes and contradictions existed (Jaffe, 2001, pp. 10-13). For example, Marx saw how, while further fuelling resistance and opposition, capitalism and the exploitation of workers contributed to increasing wealth. Durkheim saw the increasing differentiation and division of labour brought about by economic development as a threat to social order and solidarity. And Weber viewed increasing bureaucracy and organisational efficiency as a source of alienation of individuals. While Durkheim did not consider individuals in examining social facts and emphasised the determinism of social structures, Weber based his theories on individuals and their motivations to explain social systems (Strati, 2000, p. 6).

It is particularly in the combination of these two dimensions (objective-subjective and radical change-regulation) where difficulty arises. On the one hand the interpretative and radical humanist paradigms 'are both founded upon the notion that the individual creates the world in which he lives' (Burrell and Morgan, 1979, p. 279) i.e. firmly in the subjective end of the spectrum. The extreme of subjectivity is reflected in the German idealism intellectual tradition which denies the utility of models and methods. Social reality exists merely through assumptions and shared meanings. On the other hand if there is no reality or society outside of individual creation and society is made up of multiple shared created realities, how does society influence the individual to the extent of dominance and alienation as in the case of radical humanism? And how do underlying patterns and order emerge as in the case of the interpretive paradigm (Burrell and Morgan, 1979, pp. 253-255; 306-307)?

The functionalist paradigm covers the following approaches: action frame of reference, theory of bureaucratic dysfunction, pluralism, social systems theory and objectivism (Burrell and Morgan, 1979, pp. 118-226). The latter two comprise the dominant perspective within organisation studies which is primarily concerned with 'understanding organisations and the behaviour of individuals within them from an essentially managerial point of view'. Social systems theory includes, for example, classical management theory, industrial psychology, open systems theory and contingency theory. Pluralism relates to the study of social control, interests, power and conflict in organisations within functionalists paradigm. Action frame of reference is the most subjective and voluntarist of the functionalist paradigm (Burrell and Morgan, 1979, pp.

189-201). They place it within this paradigm since its proponents view it as a method and a source of propositions for analysis of organisations and reality although the emphasis is on individual level analysis rather than the systems level more typical of functionalist paradigm. Adherents of the action frame of reference differ from social system theorists in that they do not assign needs or self-regulating attributes to organisations.

Burrell and Morgan's interpretative paradigm is like the functionalist in that it also assumes that there is an underlying pattern and order to the social world but differs in that it believes objectivity is unattainable (Morgan, 1980).

According to radical humanists, social processes control and alienate individuals from their true inherent potentialities by influencing their processes of reality creation (Morgan, 1980). If society dominates and alienates individuals and individuals are not part of any external society (they create their own social realities), this implies that it is not a natural part of humanness for individuals to commune or have influence on the world outside of themselves. Is it not possible that society may be a means to fulfil potentialities rather than merely constraining them? Radical humanist research focuses on the alienating factors in modern industrial society. For example, capitalism is viewed as totalitarian, moulding and controlling all aspects of life including the mystification of ideological concepts such as scarcity and leisure. However, capitalism, whether good or bad, is not something created independently of man and society. One may argue that it was created by people in power and not the ordinary citizen, as were other forms of governance, but even the revolutionary as an ordinary citizen can rise to attain power. This differentiates the voluntarist from the determinist view of human nature. Morgan states that the radical humanist is like the radical structuralist in that they believe that society is a dominating force (Morgan, 1980). This implies a level of determinism which does not fit with the placing of the radical humanist along their subjective-objective dimension.

Critical theory school of social philosophy is identified as the least subjective of the radical humanist paradigm (Burrell and Morgan, 1979, p. 283). Four core concepts concern critical theorists: *totality* – the social world must be understood as a whole before one can understand the parts; *consciousness* – which creates and sustains the social world; *alienation* – the cognitive wedge between consciousness and totality; and *critique* – analysis of the alienation which prevents individuals reaching their full potential. Organisations are intermediaries which contribute to the alienation of individuals. These organisations reflect the totality of the social world rather than being discreet parts in themselves. As it relates to the study of organisation, the radical humanism of Burrell and Morgan moves towards an anti-organisation theory and utopian notions of society influenced by nature and Eastern philosophies such as Zen (Burrell and Morgan, 1979, pp. 310-325). However, these notions tend to be naïve understandings of 'nature' and these philosophies. Even if we acknowledge critical theory to be the least subjective of the radical humanist paradigm, do these philosophies not also demand some form of structured society, interdependency and community? Is nature not highly organised and structured and also cruel?

According to Burrell & Morgan the interpretative and radical humanist paradigms differ in their approach to study. The interpretivist will seek patterns, albeit subjective through shared multiple realities, while the radical humanist seeks only to examine the individual consciousness. However, if we take paradigm to mean a view of reality, this difference is not related to paradigm but rather to field of study. It is the focus of research which distinguishes the radical humanist from the interpretivist. Within each field of study there

maybe a paradigm of shared community knowledge in the Kuhnian sense but it is not the fundamental distinguishing feature.

While it is useful and instructive to be able to differentiate between different approaches to reality and research, this two dimensional structure is imposing and forced, nor is it a true reflection of the range of schools or fields of research. Conversely, if we take each field of research to represent a different paradigm then the number of paradigms would be indefinite and unmanageable therefore this representation of approaches to social theory through four paradigms would be convenient and easy to manage should one wish to do so. Burrell and Morgan do position different philosophies and fields of research along the two dimensions. However, this structure is rather crude and lacking in subtlety. They themselves identify four strands of debate as presented above in Table 3.4.1 (page 53) which they then present along the one subjective-objective axis. Also, they present the regulation-radical change debate as a reworking of the order-conflict debate which they themselves say is problematic and subject to intense criticism (Burrell and Morgan, 1979, pp. 10-16). In the case of radical structuralism they even state that this broad categorisation does violence to the constituent schools of thought given the plurality of traditions they classify in this paradigm (Burrell and Morgan, 1979, p. 333). Some arguments are self-contradictory. For example, while the functionalist sees behaviour as always 'being contextually bound in a real world of concrete and tangible social relationships', the scientist as observer conducts objective and value-free research (Morgan, 1980). Behaviour, whether it be scientific or not, is either contextually bound or it is not.

Burrell & Morgan (Burrell and Morgan, 1979, p. 255) describe Kuhn's view of science as representing an interpretive paradigm in the sense that this perspective sees scientific knowledge as socially constructed and accepted within a given community, akin to the language, meanings and communication of Wittgenstein. For Kuhn's scientist, choice of theory is personal and subjective. However, investigating individuals in the study of the progress of science is pointless as it is the decisions of the community which govern. Shared intuition and persuasion lead to community decisions (Kuhn, 1970, p. 199).

Also, while Kuhn's view of scientific knowledge may fit somewhat with the interpretative paradigm, his view of paradigm is very different from that presented by Burrell & Morgan. Kuhn's view of paradigm is accepted and shared knowledge but it is subject to significant change if new knowledge or discoveries arise and are accepted by a given community. Kuhn's paradigm allows for new knowledge and discoveries which may lead to its own demise and a new paradigm to emerge. The paradigm of Burrell and Morgan would not necessarily change based on new knowledge. It frames research in such a way as to incorporate new knowledge rather than leading to its own replacement.

Burrell and Morgan note that inter-paradigmatic switching is rare and they claim that this is in keeping with Kuhn's notion of revolutionary science which rarely leads to such switching (Burrell and Morgan, 1979, p. 24). However, this is not in keeping with Kuhn's notion of paradigm change which is driven by the compelling nature of new knowledge and experience, hence his use of the term 'scientific revolution'.

It is also notable that Kuhn does not try to describe all paradigms of science, rather he gives examples. He does not indicate the attributes of various paradigms or along which dimensions they orientate because these are not what differentiates his paradigms from each other. He describes how different specialisations and fields of research each have their own paradigms. Although Burrell and Morgan acknowledge that they use

the term paradigm in a broader sense than Kuhn they direct the reader to Kuhn's work for a full discussion on the role of paradigms in science (Burrell and Morgan, 1979, pp. 35-36).

Burrell and Morgan argue 'that social theory can be conveniently understood in terms of the co-existence of four distinct and rival paradigms defined by basic meta-theoretical assumptions in relations to the nature of science and society' (Burrell and Morgan, 1979, pp. 35-36). However, besides the four-paradigm two-dimensional model of Burrell and Morgan other representations of paradigms exist. For example, the Alternative Paradigms of Lincoln and Guba: positivism, post-positivism, critical theory, constructivism and participatory (Lincoln and Guba, 2000); Creswell's Alternative Knowledge Claims: post-positivism, constructivism, advocacy/participatory and pragmatism (Creswell, 2003); and Grix's Key Research Paradigms: positivism, post-positivism/critical realism and interpretivism (Grix, 2004). I will discuss these below as examples which further illustrate the difficulty in finding a resolution to these issues but which enable me to elaborate my own paradigm.

3.4.2 Development of paradigms in the social sciences

Confusion and lack of clarity surrounding paradigms, research strategies and methods are obvious by the many conflicting views on the issues. Some authors believe that paradigm determines method and that some methods are inconsistent with some paradigms. This can give rise to dilemmas where, for example, a researcher may pursue a method typically associated with a paradigm not consistent with his/her own stated paradigm. This is very common and has led to further paradigmatic and methodological debates on pluralism, pragmatism, and mixed methods.

This section gives an outline of the development of paradigms in the social sciences and links to methodology. It is followed by a critique of several models or portrayals of paradigms and how the critical realism paradigm emerged as an alternative to the traditional of incompatible dichotomous approaches. It includes a reflection of my own experience and influences on the choice of paradigm in my research.

3.4.2.1 Different paradigms in the social sciences

This section gives an outline of the development of different paradigms in the social sciences. Positivism is said to represent the paradigm of the natural sciences which has been adopted by the social sciences. Positivism posits that there is only one reality independent of the observer. We obtain and learn objective truths about this reality through rigorous methodological scientific observation, experimentation and analysis. We can formulate rules of nature which do not depend on the observer. Easterby-Smith *et al* go as far as to say according to positivism human interests should be irrelevant (Easterby-Smith *et al*, 2002, p. 30).

Positivism is described variously as an epistemology (Burrell and Morgan, 1979, p. 5), a paradigm (Easterby-Smith *et al*, 1991, p.23; Grix, 2004, p. 78; Lincoln and Guba, 2000, p. 164) and a knowledge claim (Creswell, 2003, p.6). Gill and Johnson describe an approach to research as positivist (Gill and Johnson, 1991, p.7) but seem to avoid stating explicitly what positivism is, rather including in their analysis statements such as 'the hypothetico-deductive tradition is intimately bound up with what is often termed 'positivism'' before outlining its characteristics (*ibid.* p. 32).

The core tenets of positivism are objectivity and value-free research which tends to be deductive, deterministic, reductionist and quantitative in nature. It has been associated with the methodologies of the

natural sciences. It derives its name from Auguste Comte who, in the mid-nineteenth century, promoted the use of 'positive science' by social scientists in an attempt to emulate the natural sciences. In this 'positive state' science aims to discover the laws of nature through reasoning and observation rather than by means of theological or metaphysical study. Other prominent nineteenth century social theorists influencing this development in social sciences include John Stuart Mill and Émile Durkheim (Burrell and Morgan, 1979; Creswell, 2003). It is important to point out that the context of the rise of positivism in social science was to provide a defence for value-free and ontology-free scientific knowledge, in particular the theory of evolution, which was under attack from existing scientific theories, religious interests and popular opinion (Powell, 2003). This view of social science then dominated through most of the twentieth century. In modern times there has been a move away from pure positivism to post-positivism in acknowledgement of an inability to obtain absolute truths about human behaviour and society and where science aims to get as close as possible to these truths but where inquiry is value-laden to a certain extent through influence of the researchers (Creswell, 2003; Lincoln and Guba, 2000; Teddlie and Tashakkori, 2003). Opposing positivism, at the other extreme, interpretivism/constructivism posits that no reality exists independent of the human observer and that, depending on the observer, numerous realities may exist e.g. Kant's book which, unless one knows otherwise, appears for example just as a bound bundle of patterned paper (Andersen, 1995).

Popper exposed some weaknesses of positivism (Poole, 1995, p. 47). For example, the literal application of the need for verifiability while at the same time assuming that the world behaved uniformly when either observed or not observed. However, what is not observed cannot be verified and therefore does not even meet positivism's own criterion of verifiability. Popper used the famous example of black swans to illustrate his falsifiable notion of theory (Easterby-Smith *et al*, 2002, p. 51) [It could never be proven that all swans are white unless all swans in the world were observed. It would only take one black swan to disprove the theory. A suitable criterion for good theory would be the ability to falsify it]. Post-positivism places emphasis on falsification of theories but, given the complexities of the human social environment and the number of variables possibly involved, it may not always be feasible to develop a falsifiable (or verifiable) theory (McKenzie, 1997a). In this vein, interpretivists could design their research to allow for the finding of both confirmatory and contradictory evidence which would satisfy falsification criteria in that it would provide more certainty if no contradictory evidence is found. This design would be particularly useful for managers and other practitioners who tend to seek confirmatory evidence of their strategies etc (Easterby-Smith *et al*, 2002, p. 52). They should also be aware of their own views and experiences without allowing them to dominate their research – this has been termed critical sensitivity or critical subjectivity (*ibid.*, p. 52).

The traditional hegemony of the positivist (post-positivist) paradigms in the social sciences is being eroded and the newer interpretive and post-modern paradigms are now widely espoused and accepted (Lincoln and Guba, 2000, pp. 163-164). However, the issue remains far from resolved with a 'paradigm war' developing in the late twentieth century (Lincoln and Guba, 2000; Robson, 2002; Scherer, 1998). Rather than replacing positivism with one new paradigm this has led to a new acceptance of paradigmatic pluralism and fragmentation (Strati, 2000, p. 33). Also, the traditional demarcation of opposing incompatible dichotomous positions is being blurred and 'the various paradigms are beginning to interbreed' (Lincoln and Guba, 2000, p.164). Two previously irreconcilable positions can now inform one another in a new third position of confluence. Despite these changes, the debates on paradigms, ontology, epistemology and methodology are typically presented as opposing extremes or dichotomies (Table 3.4.2).

However, these dichotomies do not necessarily represent the position of researchers who in practice tend to find themselves somewhere in between and the practice of research does not usually entail making a decision between apparently incommensurable extremes (Gill and Johnson, 1991, p.127). Gill *et al* refer to a rapprochement of different approaches as methodological pluralism. (This differs from the pluralism of Burrell and Morgan which relates to the study of control, power and conflict in organisations within the functionalist paradigm (Burrell and Morgan, 1979, pp. 202-217)). For example, Hofstede’s large-scale study on cultural differences which is often cited as an example of positivist work did not in fact conform totally to positivist criteria (Easterby-Smith *et al*, 2002, p. 36). As he himself points out, the four key dimensions of national culture were identified only after significant amount of post hoc analysis and not as hypotheses to be tested. Also, the dimensions are clearly mental constructs rather than hard facts. The interpretation is not totally value free, different methods would provide different perspectives and triangulation or quantitative and qualitative methods would enrich the data. Therefore, while initially appearing as, and often given as an example of, a classical positivist study, Hofstede’s study actually mixes paradigms. Subsequent work on culture has identified innumerate variables, possible combinations and interpretation making a purely positivist approach extremely difficult.

Table 3.4.2 Typical Dichotomies presented in the literature	
Positivist	Phenomenological
Realism	Nominalism
Objectivist	Constructivist
Foundationalist	Anti- Foundationalist
Independent	Interpretative
Determinism	Voluntarism
Objective	Subjective
Empiricism	Rationalism
Deductive	Inductive
Nomothetic	Ideographic
Reductionist	Holistic
Explanation	Understanding
Quantitative	Qualitative
Closed	Open-ended

Sources: (Burrell and Morgan, 1979; Creswell, 2003; Easterby-Smith *et al*, 1991; Easterby-Smith *et al*, 1991; Gill and Johnson, 1991; Grix, 2004; Hussey and Hussey, 1997; Slife and Williams, 1995)

While acknowledging that pluralism or the multi-paradigm perspective has become more valued in organisation science, Scherer (Scherer, 1998) questions the justification for pluralism and calls for further debate since, if each paradigm has deficiencies, why should a combination necessarily be an improvement? For instance pluralism does not necessarily resolve issues such as what combinations of paradigms to apply and of incommensurability. However, Scherer does not address the issue of how a weakness in one paradigm may be balanced by a strength in another (e.g. level of objectivity or researcher involvement) and that this

would at least be an improvement on isolationism of perspectives. Gill and Johnson argue that methodological pluralism is tenable only when based on certain ontological assumptions, namely those of the realist as defined by Burrell and Morgan (Gill and Johnson, 1991, pp.127-131).

3.4.3 Portrayals of paradigms and critical realism

As discussed above many portrayals and models of paradigms in the social sciences exist in the literature. This section gives some examples of such portrayals with a critique to illustrate the conflicts and unresolved issues. It discusses the scientific approach and argues the case for critical realism, mixed-methods and adaptive theory which are employed in this research.

Lincoln and Guba (Lincoln and Guba, 2000) outline basic ontological, epistemological and methodological positions according to the main paradigms of Positivism, Post-positivism, Critical theory, Constructivism and Participatory (Table 3.4.3). The former two are realist paradigms and the latter three are classed as interpretivist or new paradigms.

Table 3.4.3
Basic Beliefs of Alternative Paradigms (adapted from Lincoln and Guba, 2000, p.168)

Issue	Realist Paradigms			Interpretivist Paradigms	
	Positivism	Post-positivism	Critical Theory	Constructivism	Participatory
Ontology	naïve realism reality real & understandable	critical realism reality real but imperfectly understandable	historical realism reality virtual and shaped by values over time	relativism constructed realities	participative reality subjective- objective & co-created reality
Epistemology	dualist/ objectivist findings true	modified dualist/objectivist findings probably true	transactional/ subjectivist value-mediated findings	transactional/ subjectivist created findings	critical subjectivity experiential practical knowing, co- created findings
Methodology	experimental/ manipulative verification, mainly quantitative methods	modified experimental/ manipulative falsification, may include qualitative methods	dialogic/ dialectic	hermeneutic/ dialectic	political participation collaborative inquiry

From my own standpoint I do not agree with the breakdown of paradigms given by Lincoln and Guba. For example, I believe that reality is real and imperfectly understandable which would suggest I have a critical realist ontology and a post-positivist paradigm. However, I also believe that some social dimensions of reality are influenced by culture and values and may change over time which fits with a historical realism ontology and a critical theory paradigm. Furthermore, I believe that in many cases findings will be value-mediated, that they are interpreted by researchers and influenced by their social relations and experience and that in some circumstances participation and collaborative inquiry may be the most appropriate methodology.

I believe that in many circumstances social theories are not falsifiable (or verifiable). Perhaps my background in the natural sciences has influenced my reading of this breakdown.

3.4.3.1 Scientific Approach

If reality is manifest in two forms – the physical or natural reality and the social reality - the same criteria for research do not always apply to these forms. It is hard to imagine that any scientist nowadays would believe that the world is flat but in the past, despite the fact that the earth was round, it was widely believed, imagined or assumed to be so. Or perhaps, maybe even more likely, the question never arose for most people and it was only when the subject was broached did people wonder about it or consider it. Reality was independent of our knowledge of it but this did not affect our lives. So while previously scientists (who were usually also theologians and philosophers) and non-scientists alike believed or assumed that the earth was flat, when new knowledge emerged they began to doubt this 'fact' and ultimately prove that this was not so and that earth was in fact round. Due to the nature of this knowledge it moved beyond the realm of science into common accepted knowledge.

My primary degree is in the natural sciences - a reflection of my own curiosity about the natural world and a wish to help construct a better world. The focus of my research was environmental and ecological soil science within the broad discipline of zoology. I soon realized that I found the social influences on sustainable development more intriguing and compatible with my interests. (I had spent almost two years looking down a microscope at mites and other micro-arthropods extracted from soil samples!) I accept that this background in the natural sciences may have been formative in my paradigm and choice of methods. However, I make clear distinctions in the type of research involved in each situation. I do not reject traditional scientific methods. In the natural and physical world these methods are valid and have been effective over the years. In the social world the traditional scientific forms of data collection undoubtedly contribute greatly to our knowledge. However, in the social world there are levels of understanding, interaction and interpretation which cannot be readily measured or controlled. In this instance other methods of data collection may provide complementary, richer or more meaningful data.

A key feature of the natural sciences, which commentators on paradigms in the social sciences often seem to oversee, is that science is essentially about gaining new knowledge in a systematic manner. Scientists are curious to know more about the world and how it works. Science is quintessentially about new learning and discoveries which means that in many ways the 'real' world is always changing. The truth or reality is based on the current state of knowledge and is open to change and new knowledge. The current state of knowledge represents an accumulation of all preceding knowledge. However, it will not just accept any theory or idea. The focus on explanation and causality is a practical function of science. On the other hand, there is no point in trying to 'understand' why one molecule may react with another because molecules do not make choices or individual decisions. They are not influenced by the attitudes of neighbouring molecules or their own beliefs. In certain circumstances they will behave in certain ways and scientists can learn this through systematic observation. We cannot know a final truth about the world given our current state of knowledge but the natural sciences are open to debate on the subject based on theoretical developments which in turn are based on our current state of knowledge. As Winston comments, 'science is about uncertainty' (Winston, 2004, p. xiii).

Following on from this pursuit of new knowledge is another often overlooked feature of the natural sciences - the practical emphasis. While purely theoretical work is important and valid in its own right, most scientific activity is focused on practice and what theory can be applied in the world for the betterment of society. How can our new knowledge be effectively used? Different scientists may be working on various stages (pure theoretical work will eventually contribute to very practical outcomes) and the cumulative shared knowledge enables us to improve our world or at least to try new innovations resulting from our curiosity and eagerness to improve.

There is an emphasis on hypothesis testing in the natural sciences which has been transferred into the positivism of the social sciences. However, this again is to overlook the practical nature of such an approach. An experiment or research must be based on something – some hunch, trigger, observation or previous knowledge - some reason why x or y should be studied, some driver for research action. Even in inductive social research there must be some driver for studying a particular phenomenon. This may be sheer curiosity or it may be a desire to bring about change and improvement.

Even in inductive research if no theory or hypothesis is proffered, such as in grounded theory, when a theory emerges what happens with it? Should no further work be done to develop this theory? Is that the end of it? Is it of no use beyond the single situation or event? Grounded theorists overcome this dilemma by distinguishing between substantive theory and formal theory (Layder, 1998, p. 20). Substantive theory is what applies to grounded theory research where the explanation and learning is limited to the research situation. Theory may then be developed into a formal testable theory. However, this still implies a shift from the grounded 'atheoretical' method.

Distinctions between explanation and understanding can also be spurious. Claims that positivism, in being a reflection of the natural sciences paradigm, is about explanation, cause and effect, and that interpretivism or social science is about understanding, meaning and significance (Behling, 1980) again misrepresent the natural sciences. Positivism emerged as a move away from theology and metaphysics to focus on observables. It is this belief that the world can be observed which is fundamental to scientific endeavour (Poole, 1995, p. 33). However, it is through observation and explanation that we may reach a greater understanding of the world around us. Ultimately we may find a reason for our existence and, as Hawking says, we may then 'know the mind of God' (Hawking, 1989, p. 175). This does not mean that there is no room for speculation and theorising in scientific endeavour. In fact, it is creativity and the ability to imagine possible outcomes and answers which drives many scientists.

Therefore, in striving for a 'scientific' approach this does not mean that I am advocating a positivist approach to social science. I find the delineation in comparing scientific and non-scientific methods to quantitative and qualitative, or to positivist and relativist designs, as spurious. While there is heavy use of experimentation and statistics in the natural and applied sciences, one also finds application of other qualitative and inductive methods for example medical cases, ecological studies and theoretical physics. The fundamental method in science is *observation*. And experimentation, for example, is merely a method to facilitate observation by reducing the number of variables involved. In fact, many scientific discoveries are unplanned outcomes of studies/experiments investigating some other matter. Many experiments originate in hunches and intuition. What makes a study 'scientific' is whether the approach is systematic with explicit and well documented methods. Science can be exploratory or confirmatory as it is about increasing our understanding of the world.

Comparisons between scientific and positivist approaches in the natural and social sciences are also spurious because they are not comparing like with like. While natural scientists and positivists advocate objectivity and avoidance of observer influence this occurs under different circumstances to the social sciences. Natural scientists are very conscious of the importance of context which is the reason why the controlling of context in experiments is such an important factor. To reach the effective core of a phenomenon as much of context should be removed as possible and reduced to as few variables as can be controlled. In this way basic rules of nature, independent of context and our observing situation may be formulated. This is a fundamental assumption in science. This does not mean to say that context should always be eliminated but that, once the core is understood, this may then be examined in different contexts. Many experiments are designed to examine phenomena in different situations. However, scientists acknowledge that there are situations where aspects of context cannot be controlled. This is most obvious in applied sciences, for example, pharmaceutical science, where the process of bringing a drug from laboratory to patient is extremely rigorous and laborious and even then mistakes are being made. Therefore, once the context is acknowledged, transparent and accounted for we may learn both from it and about it. In the case of social research involving organisations the context and environment cannot be totally methodically controlled no matter how positivist the approach is claimed to be in a study. But this does not mean that study of organizations is unscientific but rather that the context should be acknowledged.

On the other hand a study may exist where the actual context may not appear to be important where, for example, the research question revolves around how much or how many rather than how or why. Such a study is not necessarily scientific; in fact it may be argued that it is not at all so because the context is ignored thereby missing an essential observable element. It is easy for a positivist study which apparently looks at facts and figures to be unscientific if, rather than acknowledging a possible role of context, it ignores it. As mentioned above natural science is about observation and therefore not to observe context is unscientific. Controlling experiments in the natural sciences are about trying to control aspects of the context where this is possible. If an aspect of the context cannot be controlled this does not mean it should be ignored.

Essentially, the natural and social sciences are both pursuing knowledge and understanding of the world. As Robson argues, any research design may be scientific provided it is carried out in a systematic, principled fashion (Robson, 2002 p. 5). However, their worlds are different in the sense that the natural sciences look at the physical world which, although extremely complex, can be studied and manipulated in a manner unavailable to the social sciences whose world has been, and is, shaped by the endless labyrinth of the human mind.

3.4.3.2 Critical realism

Lincoln and Guba (Lincoln and Guba, 2000, p.174) argue that positivism and post-positivism paradigms are compatible and few people would disagree with this. Likewise, they see commensurability among the interpretivist paradigms of critical theory, constructivism and participative inquiry. However, they argue that positivist and interpretivist paradigms are incommensurate or incompatible due to their opposing axioms which are 'contradictory and mutually exclusive' and, for researchers, picking and choosing from these paradigms would be problematic. They go on to give the example of how action distinguishes the adherents of positivism and post-positivism from adherents of the new interpretivist paradigms. This results in their interpretive paradigms having more in common with the natural sciences than they would appear to

appreciate. While natural scientists look for objectivity in their work through the independence of the activity from their own influence this does not mean that they do not aspire to bring about change in the world. Action based social research, while it may engage the researcher directly, is also mainly driven by this desire to bring about change. The difference is the field of operation where the social world and the physical world have different characteristics. A natural scientist would be fascinated to see they could change a chemical, physical or biological experiment merely by being present or not at a critical point in the reaction and that this would legitimately serve as a premise for further research, theory and hypothesis development. Critical realism allows for both the existence of an objective world and for the creativity of man's mind. It recognises that social reality is composed of actors' meanings and subjective understandings as well as systemic structural factors which exert influence on individuals and that social activity and subjective lived experiences are never free from social context or system (Layder, 1998, pp. 86-87).

While Grix argues that one cannot combine both positivist and interpretivist paradigms as they are 'logically incompatible', he argues that the demarcations are not clear-cut and that the best research is often undertaken on the margins of these paradigms (Grix, 2004, pp.82-83). Placing post-positivism/critical realism between the two paradigms of positivism and interpretivism (having said they are incompatible), he then goes on to explain that critical realist scholars have since the 1970s tried to combine the understanding of interpretivism (how?) with the explanation of positivism (why?) (Grix, 2004, pp. 84-85). Despite reservations over his arguments I find that I am in agreement with Grix's characterization of critical realism as outlined below (Grix, 2004, pp.84-87):

1. Critical realism straddles both positivist and interpretivist paradigms sharing a foundationalist ontology with positivism (that the world exists independently of our knowledge of it) while allowing for interpretation in research.
2. A critical realist approach believes while social science can use the same methods as natural science regarding causal explanation, it also needs to move away from them by adopting an interpretative understanding.
3. Critical realists, unlike interpretivists, generally seek not only to understand but also to explain the social world.
4. Critical realists conceive of social change and conflict in society as not always apparent or observable, believing that the perceived characteristics rarely reveal everything – i.e. we need to look beyond the surface.
5. Critical realists believe in a structured or stratified reality which requires a depth ontology and the interpretation of causal links not always observable in order to attain a fuller explanation of an event etc.
6. Critical realists believe that pre-existing structures affect and are affected by actors.
7. Whilst acknowledging that interpretive understanding is an important feature of social science, the objects and structures in society are understood to have causal powers, so critical realists are able to make causal statements and identify causal mechanisms unlike interpretivists. But the realist's idea of causation differs from the positivist's – causes do not simply determine action – what causes something to happen has nothing to do with the number of times we may observe it happening.

Explanation depends on identifying the causal mechanisms and how they work and under what conditions. Efficient causes (actors) initiate action and material causes (social structures) facilitate or constrain such action.

8. Structure and agency are looked upon as mutually constitutive but they can be treated separately for analytical purposes thereby facilitating research.
9. Critical realism is compatible with a wide range of research methods and suggests that the choice of which method to employ should depend on the nature of the object of study and what we want to learn about it.
10. Finally, many critical realists, unlike positivists, recognise the 'double hermeneutic': a means of understanding society and social actors and *their* perceptions of *their* roles in society.

Easterby-Smith *et al* (2002) offer a different view of critical realism to Lincoln *et al* (2000) and Grix (2004). They also place critical realism between positivism and constructivism but give it a distinct ontology of relativism as opposed to the nominalism of constructivists and the realism of positivism. (They also divide positivism into traditional and internal realism where internal realism represents post-positivism of other authors) (Easterby-Smith *et al*, 2002, p. 33). This critical realism is more relativist than presented by Grix and Lincoln *et al*. Consensus between viewpoints on what is truth is a requirement and facts depend on the viewpoint of the observer. Critical realists consciously position themselves between the extreme positions of positivism and constructivism. They accept as real the influence of social conditions whether or not they are observed or labelled but also accept that concepts are human constructions (Easterby-Smith *et al*, 2002, p. 33). Realism is thus often presented as a middle ground struggling for position in the debate 'between the strictures of positivism and the tolerance of phenomenology' (Symons, 1996). However, it is a mistake to view critical realism in this light – as a compromise or something that is floating between other paradigms. As Poole acknowledges, critical realism, is a 'defensible position' for the natural sciences (Poole, 1995, p. 42).

Schumpeter defined science as 'any kind of knowledge that has been the object of conscious efforts to improve it' (Schumpeter, 1954, p. 7 cited in McKenzie 1997b). As McKenzie points out this definition does not privilege one type of research practice or methodology over another and enables an open, inclusive and multidisciplinary approach to achieving progress (McKenzie, 1997b). Robson discusses the scientific attitude which can prevail regardless of the type of study. The key features of scientific research are: 1. *systematic* – good planning, explicit about how observations are made and their nature and role of researcher; 2. *sceptical* – subjecting research to scrutiny and disconfirmation; and 3. *ethical* - following a code of conduct ensuring the safeguarding of all participants concerns and interests (Robson, 2002, p. 18).

It is my view that critical realism is not so much a compromise between the extremes but rather a challenge to both approaches. Therefore rather than placing it in the middle of a continuum between positivism and interpretivism, I prefer to place it independently. I am not trying to find a compromise or consensus, or to combine attributes of the two paradigms such as understanding and explanation (Grix, 2004) or overcome tensions between extremes of empiricism and rationalism (Layder, 1998, p. 22). Rather critical realism reflects the way I think about and view the world. Realism challenges both the objective/positivist and the subjective/interpretive approaches to social science. This is similar to the critical realism proposed by Bhaskar (Bhaskar, 1989, p. 2). In criticising the new paradigms which emerged in opposition to the

traditional hegemony of positivism, Bhaskar advocates a 'critical realism which conceives the world as structured, differentiated and changing. It is opposed to empiricism, pragmatism and idealism'. Bhaskar initially distinguished between a general philosophy of science (transcendental realism) and a particular philosophy of social science (critical naturalism). These terms evolved into the amalgam term critical realism (Bhaskar, 1989, p. 190). (The term transcendental derives from the critical philosophy of Kant (criticism), which is a critical examination of the faculty of knowledge (OED-Online, 1989).) Transcendental realism

'regards the objects of knowledge as the structures and mechanisms that generate phenomena; and the knowledge as produced in the social activity as science. These objects are neither phenomena (empiricism) nor human constructs imposed on the phenomena (idealism) but real structures which endure and operate independently of our knowledge, our experience and the conditions which allow us access to them. Against empiricism, the objects of knowledge are structures, not events; against idealism, they are intransitive...both knowledge and the world are structured, both are differentiated and changing; the latter exists independently of the former...' (Bhaskar, 1998, p. 19).

Perhaps Robson's description of realism is clearer (Robson, 2002, pp. 33-34)

'Realists can acknowledge values in a way not open to positivists ... And because there is a reality to which reference can be made, there is a basis for choice among different theories. Similarly, realists do not aspire to the universalist claims of positivism, but see knowledge as a social and historical product that can be specific to a particular time, culture or situation. It is the task of science to invent theories that aim to represent the world.'

Realism recognises fundamental differences between natural and social phenomena. However, the natural and social sciences still share many common principles which become more evident in practice than in debate, for example, realists will study social objects scientifically with carefully chosen suitable methods (Robson, 2002, p. 35). Thus critical realism can enable a practical approach to conducting research which is scientifically rigorous but also sensitive to social context and interpretation. This can lead to a more pragmatic approach to research and the use of whichever philosophical approach and methodology suit a particular research matter as well as the use of mixed-methods (Robson, 2002, p. 43). There exists a philosophical closeness of critical realism and pragmatism.

3.4.4 Pragmatism

Creswell is one of few authors who present pragmatism as a main paradigm along the same lines of positivism and interpretivism/constructivism (Creswell, 2003). Interestingly, he does not align his choice of paradigms (knowledge claims) in linear extreme to extreme fashion nor along defined dimensions or axes Table 3.4.4. His four alternative paradigms are: post-positivism, advocacy/participatory, constructivism and pragmatism (Creswell, 2003 pp. 3-26). In the framework he presents, a paradigm constitutes one of three elements of inquiry. The other two elements are strategies of inquiry and methods. These three elements of inquiry combine to form one's approach to research (Creswell, 2003 pp. 3-26). According to this framework three approaches to research exist: quantitative, qualitative and mixed-methods. The approach is then translated into practice and design of the research process.

While Creswell's book has been useful to my own work with regard to mixed-methods research, I find the directional framework he presents for research design flawed and tautological. Three elements of inquiry

define one's research approach: paradigm, strategies of inquiry and methods. Research approach in turn translates into the design of research processes. This presentation is problematic. Firstly, the research approach is both defined by methods and determines methods (processes). Secondly, the strategies of inquiry

Table 3.4.4

Creswell's Alternative Knowledge Claims (Paradigms) (Creswell, 2003, p. 6)

Postpositivism	Constructivism
Determinism	Understanding
Reductionism	Multiple participant meanings
Empirical observation and measurement	Social and historical construction
Theory verification	Theory generation
Advocacy/participatory	Pragmatism
Political	Consequences of actions
Empowerment issue-oriented	Problem-centred
Collaborative	Pluralistic
Change-oriented	Real-world practice oriented

which define research approach are qualitative, quantitative and mixed methods. Then the research approach itself is either qualitative, quantitative or mixed methods. Thirdly, after presenting the framework, he outlines other criteria for selecting an approach: the research problem, the researcher's personal experience and the target audience. Although the three elements of inquiry determine the approach, the approach can be chosen based on other criteria. This is an example of how the interrelations between paradigm and practice are extremely complex.

Creswell's categorisation of research approaches is problematic. He divides research approaches into qualitative, quantitative and mixed methods. The strategies of inquiry associated with quantitative research include experiments and surveys, structured interviews and generalisation from sample to population. Qualitative research uses ethnography, grounded theory, case studies, narrative and phenomenological research. These strategies of inquiry are very distinct whereas the strategies of inquiry Creswell associates with mixed-methods research relate to timeframe and use of theory: sequential, concurrent and transformative. The former two refer to whether quantitative and qualitative data are gathered simultaneously or in sequence whereas the latter refers to the use of a theoretical lens or perspective which may govern the research process. This is presented as action or value based research with the use of diverse methods and a focus on action based solutions along the lines of advocacy/participatory/empowerment approach (Creswell, 2003, p. 136).

Creswell characterises pragmatism as follows (Creswell, 2003, p. 12):

1. Pragmatism is not committed to one system of philosophy and reality. Pragmatic researchers draw liberally from both quantitative and qualitative assumptions.
2. Individual researchers are free to choose methods, techniques and procedures which best meet their needs and purpose.

3. Pragmatists do not see the world as an absolute unity and so use of different and various methods are appropriate.
4. Truth is what works at the time. It is not based on a strict dualism between the mind and an independent reality. Mixed-methods are used because they help provide the best understanding of the problem.
5. Pragmatist researchers are purposeful in their choice of what and how to research - they focus on the intended consequences of their research.
6. Pragmatism acknowledges the social, historical political and other contexts. Mixed-methods research may be reflexive of social justice and political aims.
7. Pragmatists would like to stop asking questions about reality and laws of nature.

One problem with the above description is in the first point which states that pragmatism is not clearly associated with any particular philosophy or reality. However, this in itself is a philosophy or knowledge claim as he himself outlines previously and many of the other points reflect this. For example numbers three, four and six which all refer to reality and an understanding of reality and the research context. Although several points refer to reality, the final point Creswell makes is that pragmatist would not like to dwell on this issue! Another problem is that Creswell clearly identifies mixed-methods with the pragmatic paradigm. In doing so Creswell reinforces his paradigmatic divide between qualitative and quantitative research. If one does not agree with this divide then mixing methods does not necessarily indicate a pragmatic paradigm and mixed-methods may be used within other paradigms. Of course mixed-methods would be a likely research strategy for pragmatists who do not restrict themselves to either qualitative or quantitative methods.

Pragmatic researchers believe that the research question is more important than the methods employed or the prevailing paradigm. (Tashakkori and Teddlie, 2003; Teddlie and Tashakkori, 2003). They are 'consequence-oriented, problem-centred and pluralistic' (Creswell, 2003, p. 18). Pragmatism rejects the notion of incompatibility between paradigms or methods such as qualitative and quantitative. Pragmatism offers a practical and applied approach to research in which the values of the researcher play an important role in choice of topic. Tashakkori & Teddlie refer to their earlier work which suggested: 'Study what interests you and is of value to you, study it in the different ways that you deem appropriate, and utilize the results in ways that can bring about positive consequences within your value system'.

Three modes of pragmatism have been identified: epistemological, meta-methodological and methodological (Maxcy, 2003). Epistemological pragmatism refers to the philosophy of knowledge and the argument that no scientific rules should be imposed on inquiry. Meta-methodological pragmatism refers to the study of research methods. Methodological pragmatism refers to the use of the most appropriate, best or valuable method(s) to study a particular question. A pragmatic approach to organization studies ("pragmatic experimentation") is built around the pragmatist criterion of usefulness (Wicks and Freeman, 1998). It is in this methodological sense and in the criterion of usefulness that I identify with pragmatism. I see a purposefulness in my work which is consequence-oriented and I am a methodological pluralist. I acknowledge the social, historical, political and other contexts of the subject matter.

While pragmatism offers the researcher a suitable methodological approach which is pluralist, open to different methods and focuses on the purpose of the research, it also rejects the notion of paradigm to the

extent that it accepts whatever is going (or not). It is not rooted in any paradigm or concerned with these issues.

On the other hand critical realism provides an alternative paradigm at the level of ontology. It challenges the positivist and interpretivist approaches and enables mixed-methods to take place within the same study without necessarily mixing paradigms. While I identify with many aspects of pragmatism I also identify with the critical realist paradigm and in this sense I may be a pragmatic critical realist. In my research I use mixed-methods and elements of adaptive theory which I outline below.

3.5 Mixed-methods

The roots of mixed-methods research may be traced to authors such as Campbell and Fiske (1959) who used a multi-method matrix in a study of psychological traits, Sieber (1973) who combined traditional surveys with interviews, as well as Denzin (1978) and Jick (1979) who used triangulation to combine data sources to study the same social phenomenon and for the convergence of qualitative and quantitative data (Creswell, 2003; Teddlie and Tashakkori, 2003).

As noted above pragmatism was the philosophical basis of the emergence of mixed-methods research; however this does not necessarily confine mixed-methods researchers to the pragmatic paradigm. This conflicts with Creswell’s classification which places mixed-methods firmly in the pragmatic paradigm (Creswell, 2003, p. 18). Firstly, he identifies three research approaches qualitative, quantitative and mixed methods. This, as noted above, is not really a paradigmatic, but rather a methodological approach, where qualitative and quantitative refer to methods of data collection and analysis. Mixing of these can take place within or across paradigms. Pragmatism allows for mixed paradigms to take place in the same study and mixing of methods is typical in pragmatic research. However, this does not mean that the pragmatism and mixed-methods are inextricably linked. Mixed-methods research fits well within the realm of critical realism.

Despite the rise in critical realism, pluralism and mixing of methods, most authors still identify specific methodologies with particular paradigms Table 3.5.1 (Burrell and Morgan, 1979; Creswell, 2003; Easterby-Smith *et al*, 2002; Grix, 2004; Hussey and Hussey, 1997; Lincoln, 1985; Robson, 2002). Hussey & Hussey acknowledge that a positivistic paradigm may produce qualitative data, and that an interpretive paradigm may produce quantitative data, but they state that it is usual to associate a positivistic paradigm with measurement and they clearly classify different methodologies by the paradigm with which they are associated (Hussey and Hussey, 1997 pp. 55-77).

Table 3.5.1
Methodologies typically associated with opposing paradigms (adapted from Hussey and Hussey, 1997 pp. 55-77).

Positivism	Approaches to Social Science	Interpretivism
Associated methodologies		Associated methodologies
Cross-sectional studies		Action research
Experimental Studies		Case studies
Longitudinal studies		Ethnography
Surveys		Feminist perspective
		Grounded Theory
		Hermeneutics
		Participative enquiry

Robson distinguishes between fixed and flexible research designs (Robson, 2002, p. 4), stating that surveys and experiments are examples of the former requiring significant amounts of pre-specification and are generally quantitative in nature. Flexible design on the other hand is the term he adopts for qualitative designs – preferring the term flexible to allow for the use of quantitative data in real-world research. While *flexible* and *fixed* are useful terms to apply to a methodology, it is not true that qualitative or real-world type research is inherently flexible. Many qualitative studies have very fixed designs and in fact many authors advocate such fixed designs in attempting to make qualitative studies more methodologically rigorous (Alvesson, 2003; Yin, 2003 p. 20). Grounded theory is another example of how the terms fixed and flexible are not truly comparable to quantitative and qualitative. This is a research strategy developed by Glaser and Strauss (Glaser and Strauss, 1967) as a process for generating theory rather than an actual theory (Grix, 2004, p. 112). Typically, it involves a strict methodology of categorization, coding, sampling and testing of qualitative data in a constant and rigorous manner while allowing the codes and theory to emerge from the process. Theory is grounded through constant reference to the data (Hussey and Hussey, 1997 p. 70). Research designs are not flexible because they are qualitative, they may be flexible in methodology if they are open to new empirical opportunities and methods or, in theory development, if they are inductive. Differences between qualitative and quantitative research are more apparent than real and there are advantages in using mixed-methods (Robson, 2002, p. 6)

Case studies are also typically associated with interpretive paradigms (Hussey and Hussey, 1997). However, as Yin shows, they can also be undertaken in very positivist approach (Yin, 2003). While Yin does not actually state the paradigm or approach he adopts to case study methodology, he advocates a research design and rigor which aims to counter criticism of the case study as an unscientific research strategy. He does not place case study research within any particular paradigm nor does he discuss the issue but the foreword to his book is more explicit. In it Campbell states that Yin's approach is quantitative and quasi-experimental. It is, he affirms:

'more similar to the experimental isolation paradigm [which comes from the physical science laboratories] than to the randomized-assignment treatment model [from the agricultural experimentation stations] in that each rival hypothesis must be specified and specifically controlled for. The degree of certainty or consensus that the scientific community is able to achieve will usually be less in out-of-doors social science, due to the lesser degree of plausibility-reduction of rival hypotheses that is likely to be achieved. The inability to replicate at will (and with variations designed to rule out specific rivals) is part of the problem. We should use those singular event case studies (which can never be replicated) to their fullest, but we should also be alert for opportunities to do intentionally replicated case studies.' (Campbell, 2003)

This approach does not sit comfortably with constructivism or 'qualitative' approach where case studies are normally placed (Creswell, 2003; Hussey and Hussey, 1997) but may be classified as positivist/post(neo)positivist (Alvesson, 2003; Bailey, 1992; Dobson, 2001; Orosz, 1997).

Hussey & Hussey do not comprehensively address the issue of mixed-methods apart from stating that it is difficult to argue that opposing paradigms may apply in a study and that both quantitative and qualitative methods may be possible or even advantageous to use in a single study. Triangulation, which is dealt with as

a separate issue, is described as 'the use of different research approaches, methods and techniques in the same study' (Hussey and Hussey, 1997 pp. 72-74).

Quantitative procedures use pre-determined methods, instrument based, closed questions, quantitative data and statistical analysis. Qualitative procedures tend to use emerging methods, open-ended questions, qualitative data and text or image analysis. The procedures associated with mixed-methods research can be both predetermined and emerging, use of open and closed questions, all types of data and both statistical and text analysis (Creswell, 2003, p. 17).

In the context of case studies Yin addresses multi-methods studies only briefly (Yin, 2003 pp. 150-151). While case study may encompass other methods 'a totally different situation occurs when the case study has been deliberately designed to be part of a larger multimethod study'. The larger study will report separately the data gathered using other methods. He identifies three rationales for using case studies within larger multi-method studies;

- 1: *Triangulation* - to test whether data converges using the same research questions for case and other methods;
- 2: *Illustration* - use of case study to illustrate in greater depth results from a survey or quantitative analysis of archival data where the case study research questions emerge after the quantitative analysis;
- 3: *Complementarity* – use of case study to enlighten some underlying process and use of another method to assess its prevalence. The complementary methods may be employed simultaneously or sequentially and the case study research questions are closely aligned with those of the other methods.

It is in this latter sense of complementarity that this research employs case study within the mixed-methods approach.

Despite asserting the incompatibility of the 'pure' paradigms, Easterby-Smith et al. discuss how in practice researchers increasingly tend not to stick to one paradigm and the distinctions between approaches blur when it comes to choice of specific methods and research design (Easterby-Smith *et al*, 2002, pp. 41-42). However, they warn against mixing methods carelessly as this may lead to conflicting results and confusion. They also warn that the reality being investigated may be more complex than the data collection methods are capable of demonstrating. This second point seems to me to be illogical since, if a reality is particularly complex, mixing of methods is more likely to reach the reality than by use of one method alone. Although Scherer does not agree that this is necessarily the case as discussed above.

Triangulation is the use of multiple, but independent measures (Easterby-Smith *et al*, 1991 p.133). It often consists of a blend of quantitative and qualitative approaches e.g. (Beach *et al*, 2000). Such use of multiple sources of evidence for triangulation is advocated by many qualitative researchers (Barnes, 2001). Triangulation may be in the form of theoretical, data, investigator or methodological (Easterby-Smith *et al*, 2002, p. 146). In the end they advise that a researcher aiming to use different methods (e.g. qualitative and quantitative) do so from within the same paradigm whenever possible due to incompatibility of positivist and constructivist ontologies (Easterby-Smith *et al*, 2002, p. 146). They do not refer to critical realism in this context.

Qualitative and quantitative research may be distinguished in various ways. For example, at the level of paradigm where quantitative research is associated with positivism and qualitative with interpretivism (Hussey and Hussey, 1997, p. 47). With regard to the use of theory, deduction and hypothesis testing are often associated with quantitative research and induction with qualitative research (Grix, 2004, p. 113). Maxwell and Loomis (Maxwell and Loomis, 2003) distinguish between qualitative and quantitative studies in the approach to explanation with the variance theory and process theory of Mohr (1982). Variance theory looks at the relationships between variables (correlations, differences, hypothesis testing) and therefore has a close affinity with statistics. Process theory looks at events and the processes that connect and influence them. Because it looks at specific events process theory is more amenable to in-depth qualitative research. Qualitative and quantitative research may also be distinguished by the methods employed. For example, case study, ethnography and grounded theory are associated with the former and experimentation and surveys with the latter with a combination of qualitative and quantitative methods being referred to as mixed-methods (Creswell, 2003, p. 13). I use both qualitative and quantitative methods of data collection and analysis as well as in use of theory.

For researchers who believe that quantitative and qualitative methods are of different incommensurate paradigms and therefore cannot be used in the same study Sale et al attempt to offer a solution (Sale *et al*, 2002): the methods can be complementary by studying distinct phenomena. They give the example of a nursing study on both the lived experience of burn-out (qualitative study) and a measure of burn-out (quantitative). The authors themselves suggest that the phenomenon of burn-out may appear the same in both methods but the distinction lies in the 'lived experience' versus the 'measure'. However, this does not resolve the issue of using both quantitative and qualitative methods to study the same phenomenon in that it still assumes incommensurability. Both methods are used in this research not merely as complementary (in this sense of Sale et al) but to study the same phenomenon from different aspects – survey and case analysis.

Deduction and induction of theory are often used to distinguish paradigms and methodologies. Deductive research starts with existing theories and concepts and formulates hypotheses that are subsequently tested; its vantage point is received theory (Gummesson, 2000, p. 63). Inductive research starts with real-world data, and categories, concepts, models, and eventually, theories emerge from this input. Deduction is usually associated with positivism and quantitative methods and induction with interpretivism and qualitative methods.

Popper criticised induction as not contributing to significant advances in knowledge since it is based on data that is perceived but does not allow for imaginative leaps to explain the data which he termed conjectures (Susman and Evered, 1978). On the other hand deduction may offer no new knowledge about the world as this is based on what is already accepted (Pierce 1955 cited in Susman and Evered, 1978).

Many authors also have difficulty with the issues of induction and deduction. For example, while grounded theory claims to be both inductive and deductive through constant reference to the data (Hussey and Hussey, 1997 p. 70), this is really a misconstrual of deduction in that it only occurs from the data at hand within the current research which is primarily inductive (Layder, 1998, p. 135). Also, pattern theory in qualitative analysis according to Neuman (Neuman, 1991 cited in Creswell 2003) does not emphasise logical deductive reasoning. It looks for relationships but not for causal statements. It seeks relationships that 'make sense' to form a system of mutually reinforcing ideas and concepts (Creswell, 2003 p. 133). This seems slightly self-

contradictory to me. Although they may not be based on deduction, relationships that make sense can surely be based on logical reasoning even if inductive. Another problem with an emphasis on making sense, as with interpretivism, is that to rely on our ability to make sense of our world depends on our own perceptions, understandings and inevitably our limitations. This may cause us oversee some new knowledge and possible counterintuitive explanations (Poole, 1995, p. 47).

The action research approach also accommodates multiple paradigms and methodologies, each of which has its own distinctive emphasis (Coghlan and Brannick, 2003). Action research advocates that problems critical to society should be studied and Lewin was 'explicit about his concern for developing a better world' (Coghlan and Brannick, 2003). However, this concern is not unique to action researchers and is, for example, a driver in this research in trying to contribute to the understanding, implementation and attainment of sustainable development. On the other hand it is feasible that one may follow the methodological cycle of action research without necessarily studying a problem that is critical to society. One may study a real world albeit non-critical issue. Nonetheless, an accepted measure of the quality of action research is its usefulness (Andersen, 1995). Primarily, action research differs from most other research models in that it aims to bring about change during the course of the research engagement rather than as a result of a finished research product. Pragmatic critical-realism is also a suitable paradigm for action research (Coghlan and Brannick, 2003).

The survey and case study methodologies employed in this research, described in the following chapter, provide the means to address the research questions and contribute to the body of research. In this research, action research, apart from shifting the research focus, would not have been feasible due to time constraints and most importantly lack of accessibility to firms.

Mixed-methods as employed in this research allows for both deduction and induction; confirmatory and exploratory research; quantitative and qualitative data collection and analysis; and triangulation. This is done in the context of adaptive theory which is described in the next section.

3.6 Adaptive Theory

In proposing adaptive theory, Layder advocates a broadly realist approach in social science which should 'attempt to trace the modes in which both subjective and objective factors influence each other' (Layder, 1998, p. 87). Theorizing in the adaptive theory approach is organic, unfolding and continuous. It is inclusive and open as opposed to the rigid exclusive approach advocated under some paradigms such as positivism and some methodologies such as grounded theory (Layder, 1998, p. 37). The key features of Adaptive Theory are outlined below in Table 3.6.1.

Layder introduces 'orientating concepts' as a way of guiding the research (Layder, 1998, pp. 107-112). They suggest lines of inquiry and theoretical thinking. They may be derived from existing theory, analysis and works to give direction to the initial stages of new research and also provide a 'provisional means to ordering data'. However, he distinguishes orienting concepts from the sensitizing concepts of Blumer which were developed in contrast to the definitive testable concepts associated with positivist research. Layder's orientating concepts are not inherently linked to interpretative social analysis and are consequently even more flexible than sensitizing concepts.

Orientating concepts can be deliberately identified through the active reading of relevant literature. This requires the reader to be open to be intuitive, perceptive, sensitive and ready which gives the researcher a predisposition and openness to ideas and concepts. Orientating concepts facilitate inspirational and creative thinking which enable the researcher to move between the general (abstract) and the particular (concrete) necessary for theorizing.

Table 3.6.1
Key Features of Adaptive Theory (adapted from Layder, 1998)

The Nature and Scale of Adaptive Theory	
1.	Adaptive theory is a synthetic approach which both borrows from other approaches and provides an alternative to them.
2.	Adaptive theory is 'middle range' in terms of immediate focus on empirical research but has an 'open-ended' relation with larger-scale or more inclusive theories or types of research.
3.	Adaptive theory both shapes and is shaped by the empirical data from research. It allows for the dual influence of existing theory and emerging theory. Adaptive theorizing is an ever present feature of the research process.
The Philosophical, Methodological and Theoretical Context	
4.	Adaptive theory uses both inductive and deductive procedures for developing and elaborating theory.
5.	Adaptive theory is based on a realist paradigm embracing elements of subjectivism and objectivism.
6.	Adaptive theory is open to and inclusive of all methodological approaches.
7.	Adaptive theory assumes that the social world is complex, multi-faceted, layered and dense.
8.	Adaptive theory focuses on the multifarious interconnections between human agency, social activities and social organisation (structures and systems).

The use of orienting concepts also enables a researcher to be aware of and reflexive of one's own preconceptions and biases rather than pretending that they do not exist (as in positivist approaches) or that a theoretically neutral position may be adopted (as in grounded theory). In this sense they are also particularly suited to a critical realist approach. Layder stresses the provisional nature of orientating concepts. They can provide an initial guide to the research but as data are collected and analysed these concepts may recede and be replaced or rejected. On the other hand, they may change or perhaps strengthen and develop. Essentially they are flexible, adaptable and dispensable.

I see orienting concepts as akin to hypotheses which inform the research direction but which are flexible and subject to change during the course of the research process. They are somewhat similar to the conjectures of Popper. Susman & Evered refer to Popper's conjectures when describing how new knowledge about social systems is created in action research (Susman and Evered, 1978). The consequences of such conjectures are to test them by taking action which will further strengthen or weaken our belief in them. I believe that orienting concepts explicitly provide a means of theorizing based on deduction and induction that does not absolutely and exclusively rely on data (for the testing or development of theory) but also allows for the

dynamic amalgamation of previous and emergent theory as well as the adaptation of one's ideas and theories over the course of a research project through constant reference to both the data and readings.

3.6.1 Adaptive theory: structure-agency and grounded theory

A dilemma in social research has been the interaction between structure and agency (Grix, 2004, pp. 48-50). The extent to which individuals shape their social context versus the extent to which the social context determines, constrains or facilitates an individuals' actions. Giddens proposed a structuration theory which integrates structure (non-active social phenomena such as social systems, structures, cultural knowledge) and agency (active, intentional and reflexive human agents) into an interdependent duality (Grix, 2004; Layder, 1998). While structure and agency may be inextricably bound they have varying degrees of influence on social activities and practice depending on the social life, point in time and context (Layder, 1998, p. 84). Problems arise when a distinction between the two is desired or needed to facilitate empirical research and, in this case, they have been likened to forged metal alloys which in practice are interwoven but can be analytically separated for the purposes of research (Grix, 2004, p. 49). Emphasis given to either or both may vary in a piece of research. The separation of the different but connected properties and effects of agency and structure is crucial to the realist position distinguishing it from both the (post)positivist and interpretivist approaches (Layder, 1998, p. 110). Adaptive theory research stresses the interconnections and complexity of structure and agency (Layder, 1998, p. 146).

Grounded theory rejects general theory and in focusing solely on the research subjects does not adequately appreciate the structural and systemic factors in society and consequently cannot deal with these issues in their research (Layder, 1998, p. 19; 37). Also, grounded theory, in rejecting the role of existing theory, is extremely empiricist. The theory generated is based on the data and observations gathered within the confines of the particular research being undertaken whereas adaptive theory acknowledges and elevates the role of prior theory (Layder, 1998, p. 47).

3.6.2 Elements of adaptive theory employed in this research

Some key elements of adaptive theory are employed in this research. Adaptive theory is suitable because:

1. It is based on a realist paradigm whereas pragmatism and mixed-methods are not rooted in any particular paradigm.
2. Adaptive theory embraces theory as a core element of research. Mixed-methods do not necessarily imply any role for theory and focus tends to be on methods and procedures used such as quantitative and qualitative.
3. This research employs existing theory and use a certain amount of hypothetico-deductive methods. It also uses induction and particularly throughout the research constant reference was made to the literature. It allow theories to emerge from empirical data analysis.
4. Adaptive theory acknowledges the complexity of the structure and agency while allowing for different emphasis in research.
5. Adaptive theory is open to all methodological approaches and mixed methods.

I use orientating concepts throughout my work. Initially I used them to guide my reading of the literature and in the formulation of my ideas and hypotheses relating to the links between innovation and environmental management. In my earlier work these were developed into deduced hypotheses and tested employing statistical techniques while I continuously referred to the literature. In my further analysis, both the results from my deductive analysis and my readings enabled me to develop guiding concepts for semi-structured interviews and inductive analysis. Throughout my analysis and integration I employed and constantly revised orientating concepts as I developed ideas and theory about my subject matter.

Not all elements of adaptive theory apply to this research. For example, although I refer to them and they have a bearing on my research, I do not focus on the interconnections between structure and agency nor do I trace their mutual influences. Layder stresses the research orientation of adaptive theory as focussing on the agency-system linkages. However, I do not agree that this focus always necessary. The agency-structure relationships may be acknowledged, accounted for or even included in the work but in order for the main principles of adaptive theory to be applied they do not need to be the main focus of the research.

For the purposes of this work I find adaptive theory to be an appropriate amalgam of critical realism and mixed methods.

3.7 Relevance to Proposed Research

This research seeks to learn and gain insights into entrepreneurial firms which combine progressiveness and environmental management at both strategic and operations levels in organisations which are viewed as open systems. I argue that a mixed-methods approach enables the enquiry to appropriately address the complexity of, and to gain greater understanding of, the subject matter. Sustainable development is a complex and comprehensive subject matter and the mixed-methods approach provides comprehensive insights and learning opportunities. In addition a mixed-methods approach is compatible with my critical realist viewpoint.

Mixed-methods, comprising survey and case studies, also enables both deduction and induction to take place. The first phase of this research quantitatively examines the relationship of environmental management with innovation and other performance measures through participation in an international manufacturing strategy survey. The second phase of the research selects firms for case study analysis. The purpose of the case studies is to provide a broader and more qualitative description of the role and implementation of environmental management in organisations. These two phases of research represent distinct but complementary methodologies: survey and case study. Many viewpoints regard these as incompatible however, as discussed earlier, the mixed-methods approach provides comprehensive insights and learning opportunities. Furthermore, mixed-methods provides the opportunity for triangulation which is discussed more fully in section 4.1.2 of the next chapter.

That the empirical data collection was done over several years enabled the development of learning and research cycles. The constant referral to the literature throughout also meant that ideas and orientating concepts matured and changed over time. This is consistent with the organic and continuous theorising of adaptive theory. In addition to enabling the selection of the cases, the learning from the analysis of the international manufacturing survey influenced the development of questions for the case studies. Similarly,

learning from the case studies influenced further subsequent analyses of the survey data. The use of adaptive theory is described in following chapter: section 4.1.3.

3.8 Conclusion

In many ways the, so-called 'paradigm war' (Lincoln and Guba, 2000; Robson, 2002; Scherer, 1998) is akin to the dispute over how many angels fit on the head of a pin. While labels are convenient and may aid readers in their selection of reading, if a researcher is clear and explicit in presenting his or her work then the reader can accept or reject it according to his or her own criteria regardless of what label is put on it. Thus for the convention of using labels I may be described as a pragmatic critical realist who uses mixed methods, triangulation and elements of adaptive theory in my research.

METHODOLOGY

PART 2 - Methods

4. METHODOLOGY

PART 2 - Methods

4.1 Introduction

As discussed in the Methodology Part 1, this research employed mixed methods, adaptive theory and triangulation. Both quantitative and qualitative data were analysed. Primary data were collected through the use of an international survey instrument as well as through interviews with six Irish firms. The survey provided significant international data and enabled extensive quantitative multivariate analysis including the development of a measurement of the prominence of environmental management in manufacturing strategy. A limited amount of quantitative analysis was also conducted on the data subset from Ireland. As well as the survey instrument, triangulation and case analyses were conducted. The survey analysis as well as interviews with experts identified six Irish based firms for further analysis using a qualitative case approach. Interviews were conducted in each of these firms and secondary data was also employed. In using survey and case analyses both deductive and inductive approaches were used. Elements of the analysis were confirmatory and based on hypotheses testing while other elements were exploratory and involved interpretation.

This second chapter of the Methodology presents the actual methods and processes used in the research. After presenting a general introduction and outline I discuss triangulation, validity and reliability in the research. I then discuss the use of adaptive theory in the research process. Next follows the details of the empirical data collection and analysis: survey development, administration and analysis; development of measures and scores using both all the international data as well as the Irish data on its own; the identification and selection process of Irish based firms for case analysis; and finally, the processes involved in interviewing and analysing the cases.

4.1.1 Outline

The main empirical work was conducted through two main sources of primary data collection. Firstly, a survey instrument was employed and secondly interviews were conducted. The survey instrument was the Irish contribution to the third International Manufacturing Strategy Survey (IMSS III) which examines strategy, competitive priorities, capabilities, operations and performance. Seventeen countries contributed to a shared database. This enabled the comparison of Irish based manufacturing with other countries at both the aggregate and firm levels. The Irish questionnaire also included some additional questions relating to environmental management and practices. Analysis of the IMSS data as well as interviews with experts in the field of environmental management led to the selection of six firms for case analysis in the second phase of data collection. Managers in these selected firms were then interviewed and the case analysis was supported by literature, documentation and secondary data. The selected firms also provided further survey data through a second iteration of the IMSS (IMSS IV). Therefore the case analyses of the selected firms included data from two IMSS surveys (IMSS III & IV), interviews with two key persons within the firm, interviews with experts in the field of environmental management in business as well as available documentation and literature. The research process took place in the following stages:

- Literature review (which continued on an on-going basis)
- Secondary Data Collection and Analysis (International productivity)

- Primary data collection - International Manufacturing Strategy Survey (IMSS III)
- Initial analysis of Irish IMSS data subset
- Analysis of preliminary (incomplete) IMSS III database release
- Availability and Analysis of final International IMSS III database
- Selection of Irish based firms for further analysis
- Interviews with experts
- Secondary data collection and literature review
- Primary data collection - Interviews with selected firms
- Primary data collection - second survey - IMSS IV – with selected firms
- Analysis of both interview and survey data
- Integration & writing

4.1.2 Triangulation, validity and reliability

Triangulation in which a combination of research strategies, methodologies or sources are employed to collect data is a common practice in social sciences and management research (Scandura & Williams, 2000). As explained in the previous chapter triangulation is employed in this mixed methods study. Of the four types of triangulation (theoretical, data, investigator or methodological) (Easterby-Smith, Thorpe, & Lowe, 2002) triangulation of the data and methodology are used. Data was collected over time from the main survey, interviews, secondary sources and follow-up survey. The interviews also involved different people in the firms to the survey respondents. Triangulation of methodology refers to the use of both quantitative and qualitative data collection. While this includes the use of surveys and interviews it also includes the use of secondary data and documentation as well as the use of expert interviewees in the research.

The advantages of this triangulation are the improved reliability and validity (Hussey & Hussey, 1997): the survey data increases generalizability and reliability of the data while the case analyses increase the validity and assessment of the causality between variables. Construct validity in the survey data was ensured through use of the IMSS questionnaire in two previous rounds and extensive piloting by the international working group prior to the current research. The validity of the additional environmental questions in the first Irish questionnaire (IMSS III) was ensured through extensive literature and internet research as well as through consultation with experts in the field. The questionnaire was then further validated through the interview process in the course of the case analyses. The second questionnaire (IMSS IV) was similarly validated through piloting and consultations. New environmental questions included in the Irish circulation of this questionnaire were based on an eight country OECD-validated survey. Statistical internal reliability was tested through inter-item correlations using Cronbach's alpha.

Triangulation is a feature of mixed methods research which also combines well with an adaptive theory approach to the research process. I discuss the implications of adaptive theory for this research in the next section.

4.1.3 Adaptive theory and orienting concepts

As mentioned previously this research followed a process advocated in Layder’s adaptive theory (Layder, 1998). Orienting concepts is a term Layder employs to describe the means of guiding research questions and hypotheses throughout the research process. In this work the development of research hypotheses were conducted at an early stage through readings of the literature. These hypotheses were then tested. As the results from the first stage of analysis emerged further hypotheses were developed for the next stage of analysis. Throughout the study the hypotheses were revisited and reviewed. As the work was conducted in several stages over a few years the process was on-going. Reference to the literature was constant throughout the process influencing the analysis until conclusions were developed and reached. Conversely, as results emerged from the analysis they influenced the choice of and reading of the literature.

The writing, review and rewriting of conference and journal papers as well as interaction with leading academics and peers at conferences and seminars also influenced and guided the research. While these are normal activities in academia, they are not generally acknowledged in theses when describing research design and methods. However, these activities should be explicitly acknowledged as they contribute to the development and elaboration of ideas, hypotheses, methods and analysis. New knowledge and learning was systematically integrated into the research questions and analysis at each stage as the work progressed and matured. This process also facilitated both deductive and inductive cycles of the research to take place. It reflects the way we learn in everyday experience as illustrated by Kolb’s learning cycle (Figure 4.1.1). Likewise, objective positivistic hypothesis development and analysis could be complemented by more intuitive inductive questioning in keeping with the critical realism paradigm and use of pragmatic mixed methods.

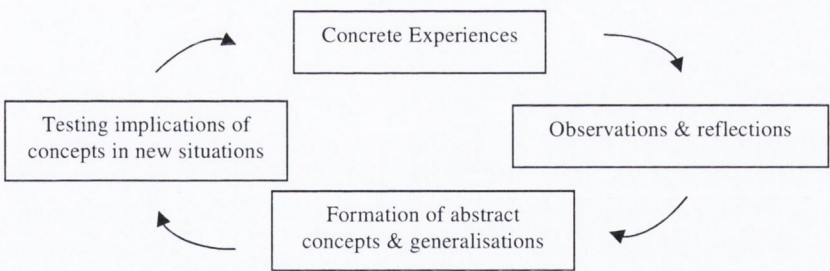


Figure 4.1.1: Kolb’s Experiential Learning Cycle (from Gill & Johnson, 1991)

Each step in the process whether large or small was not just an opportunity for gaining new knowledge and learning but also an opportunity to assimilate new ideas gained from earlier steps in the process or from new readings or feedback from writings and peers. Thus each step provided an opportunity to review and assess the hypotheses and orienting concepts. The sequential nature of the data collection (survey followed by interviews) and analysis allowed each step to build upon the previous ones. Had the survey and interviews been conducted simultaneously this would not have been possible. The sequential nature of research is presented below. Each stage in the process is influenced by all the previous stages. Hypothesis development through readings of the literature is also influenced by interaction with other people such as supervisors, academics and peers. Data collection is likewise influenced by the above and in turn data collection and

analysis influences the hypotheses by rejecting, accepting or modifying them. Results from analyses will influence subsequent readings of the literature guiding the researcher to new material or providing new insight into previously read material. Over time the cumulative work results in layers of influence where each layer is influenced by all the previous layers and in turn influences the subsequent layers.

Literature, data and others (supervisor, other academics, peers and practitioners as well as feedback from conferences and journals) are key elements in a research process. They all influence each other and provide the orientating concepts, hypotheses and theory which the researcher elaborates leading to final conclusions and writing. I have sought an analogy for this work - a winding stairs may suffice. The illustration below (Figure 4.1.2) aims to convey the mutual influences and the progressive, layering and cumulative nature of the research process. This differs from research models presented by other authors (e.g. Eisenhardt, 1989; Yin, 2003) in that it recognises the more organic and fluid nature of influence and progression rather than a strict linear format. It reflects the iterative cycle of action research where learning is carried through to the next stage or cycle (Coughlan & Coghlan, 2002) except in this case there is no action taking place during the research process.

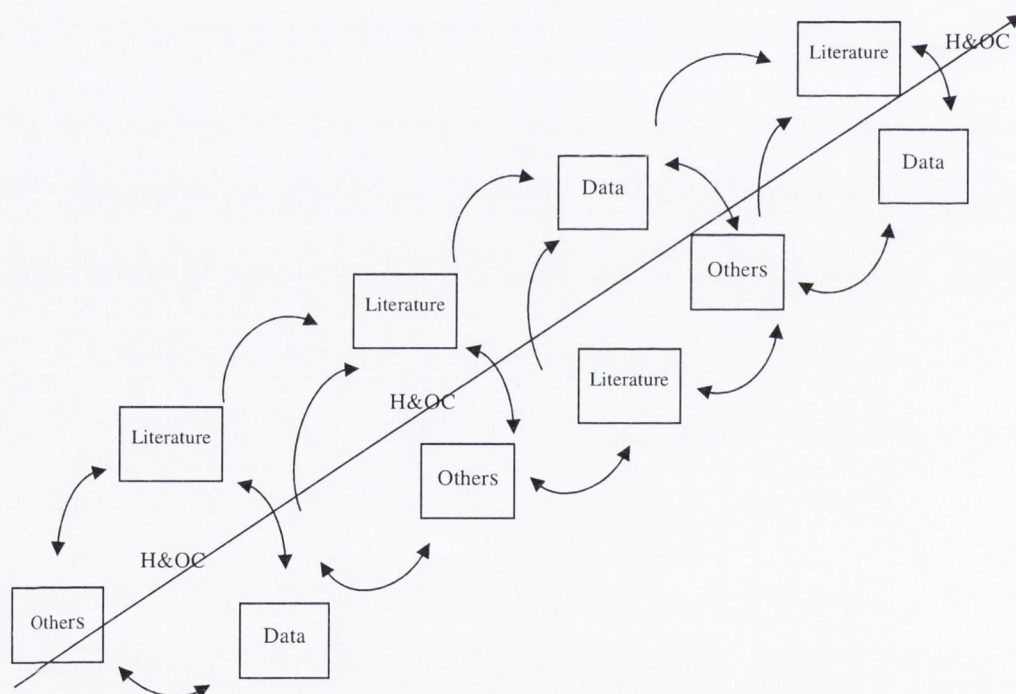


Figure 4.1.2: Progressive Layering and Cumulative Nature of the Research Process - A Winding Stairs.

The mutual influence of literature, data and others (people, supervisors, academics, interaction and feedback from conferences, journals, practitioners) which give rise to and stimulate theorising, hypotheses and orienting concepts (H&OC) for the researcher to elaborate.

I use orientating concepts throughout my work. Initially they guided the reading of literature and in the formulation of ideas and hypotheses relating to the links between innovation and environmental management. In my early work these were developed into deduced hypotheses and tested on the survey data employing statistical techniques while I continuously referred to the literature. In further analysis, both the results from the deductive analysis as well as readings enabled me to develop guiding concepts for semi-structured

interviews and inductive analysis. Throughout the analysis and integration I employed and systematically revised orientating concepts as I developed ideas and theory about my subject matter.

The next sections describe the details of the survey (development, administration, population and sample, tool for analysis). This is followed by a description of the environmental variables, development of two measures and analysis in the IMSS as well as a measure of innovation. These were used to aid selection of cases in conjunction with expert interviewees. The processes of case selection and case analyses are described.

4.2 IMSS Survey

4.2.1 Background

The IMSS survey was first employed in 1992 and was developed by leading academics in the field of manufacturing in consultation with industry. The IMSS addresses issues of firm strategy, competitive priorities, capabilities, operations and performance and aims to include best practice firms. To date four surveys have been administered (1992, 1996, 2001 and 2005). Other research from these surveys has examined manufacturing strategy, firm level performance and competitiveness (Acur, Gertsen, & Boer, 2003; Arkader, 2000; Da Silveira, 2005; Da Silveira & Fogliatto, 2000; Demeter, 2000; Frohlich & Westbrook, 2001; Lindberg, Voss, & Blackmon, 1998; Mellor & Gupta, 2000; Milling & Hasenpusch, 2000; Zotteri, Spina, & Verfanti, 2000). These and other publications also validate the use of the IMSS as an internationally accepted instrument.

The survey instrument employed in this research was the third round of the International Manufacturing Strategy Survey (IMSS). The survey instrument was administered to firms classified by the ISIC (rev.2) Division 38 – Manufacture of Fabricated Metal Products, Machinery and Equipment and the survey was completed by the director/head of operations/manufacturing. The unit of analysis is the plant/business unit. This research employs the final release of the international dataset from 17 countries comprising 558 respondents.

Participation in the IMSS III (2001) provided a rich empirical opportunity enabling a significant part of this research. This was also the first time Ireland was represented in the survey. The benefit of using the IMSS III data for this research is that it facilitated international benchmarking and the identification of progressive and innovative firms on the international level from the perspectives of both manufacturing and environmental considerations in strategy. The identification process included Irish based firms which could be treated as an aggregate and also individually identified. A second major benefit for the purposes of this research was the ability to incorporate some additional environment related questions in the Irish circulation of the survey. Manufacturing strategy in the IMSS survey was examined through questions on priorities, goals, practices and performance (Figure 4.2.1) which were divided in four sections:

- | | |
|-----------|---|
| SECTION A | Strategies, objectives, priorities and costs |
| SECTION B | Current manufacturing and integration practices |
| SECTION C | Past and planned manufacturing activities |
| SECTION D | Manufacturing Performance |

The Irish Survey included an additional fifth section:

- | | |
|-----------|---|
| SECTION E | Strategies and practices relating to environmental management |
|-----------|---|

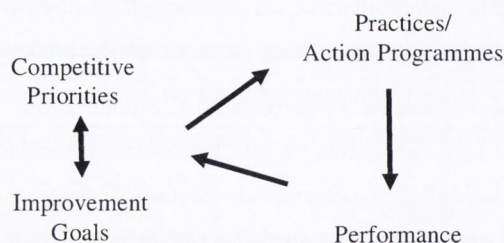


Figure 4.2.1: Manufacturing Strategy in the IMSS Questionnaire

4.2.2 Environment Questions in the Irish IMSS III

The Irish copy of the IMSS III questionnaire included additional questions in the final section (E) relating to environmental management and practices. These questions were developed based on current issues and general practices. The aim of these questions was threefold:

1. to assess environmental management, certification and awareness of current issues by firms in the sector;
2. to relate the above to manufacturing priorities, practices, performance and innovation; and
3. to identify firms for further analysis.

A copy of the IMSS III questionnaire employed for the Irish circulation of the IMSS survey is available in the Appendix.

4.2.3 Complementary Follow-Up Survey

A fourth IMSS survey was conducted in 2005. It covered the same manufacturing sector using the updated international classification system ISIC (rev.3) and more countries were also involved. Essentially, the questionnaire was the same as for the previous surveys with some improvements. These improvements included greater clarity and specificity in questions and scales as well as the removal of little used items. While the international survey actually decreased the environment related questions, this opportunity to gather more data on environmental management in Irish based firms could not be overlooked. As before additional questions were appended to the main IMSS survey. These environment related questions were refined and enhanced by the experience of the previous IMSS III (2001) survey, interviews with experts and firms as well as drawing from an OECD survey conducted in 2003 in seven countries (United States, Canada, Germany, Hungary, France, Norway and Japan) (Rennings, Frondel, Horbach, & Till, 2004). For this purposes of thesis only data employed from this survey were those provided by the six Irish based firms selected for further analysis. A copy of the IMSS IV questionnaire employed for the Irish survey is available in the Appendix.

4.2.4 Survey Administration

Each participating institution was responsible for the administration of the IMSS in its own country using an agreed approach. The international data for IMSS III were collected between Autumn 2001 and Summer 2002 and pooled by the international co-ordinators into a common database. The common database was then circulated to each participating institution.

4.2.5 Population and Sample

The survey population was manufacturing firms in the International Standard Industrial Code (ISIC) Division 38 – Manufacture of Fabricated Metal Products, Machinery and Equipment (this is the second revision of ISIC 1968). The sample was biased towards best practice firms. In Ireland, given the small size of the population and that it was the first time to participate in the IMSS, the survey targeted all firms employing more than 100. The rationale was that firms of this size would provide a manageable population while covering established firms which have built up successfully to this size or larger. Irish based firms were selected from various available sources such as the Kompass Ireland Directory (1999), Dun and Bradstreet (2000) and the IDA (2001) as well as through contacts in the industry. Although these lists are not definitive it is accepted that they are as complete as is practicable for the purposes of the research. A list of 108 firms in ISIC Division 38 with 100 or more employees was compiled (although it transpired that they did not all employ this many at the time of the survey).

The survey was conducted in Autumn 2001. All 108 firms were contacted and I spoke by telephone directly with the operations/manufacturing manager/director in 72 firms. It was impossible to make contact with the others and after five phone calls with no success no further attempts were made. Each potential respondent was promised a copy of a report to be published on the Irish results, an individual customised benchmarking report as well as an invitation to participate in a workshop to be hosted by the Irish Management Institute (IMI, Dublin). The thrust of the invitation was to invite the firms to participate in a network providing a considerable amount of feedback and discussion rather than simply a request to complete a questionnaire. Agreement to participate in the research was received from 53 firms and, of these, 32 returned completed questionnaires (60%). This response is deemed satisfactory given the cumbersome and time-consuming nature of the questionnaire and relative to response rates in other participating countries. Also it took considerable effort to obtain even these 32. The whole process took several months (September-December) and included numerous follow-up phone calls as well as two written reminders. Of the thirty-two Irish based respondents the majority (25) are subsidiaries of MNCs 18 of which are of United States origin.

The survey was conducted in Autumn 2001. Data was inputted directly into the international template and submitted to the international co-ordinators excluding the additional environmental questions. Some analysis was conducted on the Irish data (comprising 32 respondents). A preliminary release of the International data including 474 respondents from 14 countries was made available in early 2002. The targeted final release was to include approximately 700 plants from 24 countries and this was awaited before conducting a fuller analysis. I was anxious to make full use of all available data and as well as data from the United States since this country was so strongly represented in the Irish data. In the end, the final database was only made available in September 2003 comprising 558 respondents from 17 countries (Table 4.2.1, page 88). It is this data which is used to conduct the survey analysis and to aid the selection of firms for further investigation.

4.2.6 Unit of Analysis

The unit of analysis is the business unit which may be a stand-alone firm or manufacturing plant. A firm may have several plants in any country. In this case the manufacturing plant is the unit of analysis since plants may operate differently from one another according to the product(s) being manufactured, the number of production lines, the age of the plant, position in supply chain, strategic position etc. The Irish data cover only one plant from any given firm.

Table 4.2.1
Country by Number of Respondents and Mean Number of Employees

Country	No. Respondents	Mean Size
Argentina	14	281
Australia	40	279
Belgium	19	428
Brazil	35	625
China	30	2603
Croatia	35	355
Denmark	38	445
Germany	32	678
Hungary	58	546
Ireland	32	415
Italy	60	1991
Netherlands	14	223
Norway	51	56
Spain	20	667
Sweden	19	846
UK	47	1886
USA	14	7954
Total	558	1031

4.3 Survey Data Analysis

This section briefly describes the tools employed for the survey analysis followed by a description of three measures developed using survey variables:

an IMSS environment score (all IMSS respondents)

an IMSS innovation score (all IMSS respondents)

and an Irish environment score (based on additional questions answered by the Irish respondents).

4.3.1 Tools

Data was compiled in Microsoft Excel which was the standard format for the international dataset. It was imported into SPSS (Statistical Package for the Social Sciences) where most of the analysis was conducted although Excel was also employed. Standard statistical techniques were employed: descriptive analysis, comparative (parametric: t-tests, ANOVA and non-parametric: chi-square, Kruskal-Wallis, Mann-Whitney), some data reduction and/or predictive (correlation, regression and factor analysis) as well index development – measurement scores.

4.3.2 Environment: variables and measures and analysis in the IMSS

Five questions in the main IMSS questionnaire address environmental strategy. These are ISO14001 certification and four other questions concerning manufacturing strategy. The ISO14001 question was located in the quality part of the questionnaire along with ISO9000 certification. The remaining four questions in the main IMSS questionnaire in which environmental management was included as an item within lists of items addressing strategy are:

List A: Competitive Priorities - the importance of order winners;

A6 (b) Compared to your competitors, you *win orders* from your customers by aiming to:

List of ten competitive priorities to win orders from customers (Table 4.3.1).

List B: Action Programmes - the use of action programmes in past three years;

C5. This question explores the action programmes (*major projects aimed at producing considerable changes in the company's management practices and organisation*) to which your company is now devoting high resource and innovation effort and on which is concentrated the management focus and commitment.

List of 14 Action Programmes (Table 4.3.1). Three columns in this question looked at: the degree of use in last 3 years, relative payoff and expected use in next three years. The first of these, use in last 3 years was used in this research.

List C: Performance Improvement in past three years;

D2. Please indicate the amount of change of the following performance dimensions over the *last 3 years*: (Table 4.3.1). List of 17 performance dimensions (Table 4.3.1).

List D: Improvement Goals for next three years.

C1. Please indicate the importance of the following *improvement* goals for your manufacturing function for the next 3 years. List of 17 improvement goals is the same as the list of performance dimensions (Table 4.3.1).

Each list has been developed over the years based on the literature and based on the analysis of previous IMSS surveys. Each list is operationalized through a 5-point numerical scale with anchor headings at each end point and, in the question on performance, with an anchor at the middle (Table 4.3.1)

Table 4.3.2 shows the mean results for each environmental item. Only as a competitive priority (the importance of environment as an order winner) is the mean less than 3, where only 32% of respondents answer 4 or 5 compared to 42% and 47% for the other three items.

Taking the four environmental items together, reliability analysis gives a high internal consistency (Cronbach's Alpha = .6592). Bearing in mind that these four items were included in separate lists we accept this level as we would for newly developed scales (minimum alpha=0.60) (Flynn *et al*, 1995). A correlation matrix for these four environmental items is presented in Table 4.3.3. All correlations are significant with the correlation between importance of environmentally sound products and environmental improvement goals being the strongest ($r=0.400$).

Table 4.3.1

Environmental Management in Manufacturing Strategy – Four IMSS Strategy Questions	
Competitive Priorities	Action Programmes
1 (not important) -5 (very important)	1 (no use) - 5 (high use)
Product design and quality	Updating process equipment
Conformance quality	Expanding manufacturing capacity
Dependable deliveries	Process automation
Faster deliveries	Information/communication technologies/ERP
Superior customer service	Reorganizing for e-commerce
Lower selling prices	Restructuring supply strategy
Wider product range	Outsourcing non-core activities
Greater order size flexibility	Process focus & streamlining
Newer products more frequently	Implementing pull-production
<i>Environmentally sound products</i>	Quality improvement
	Equipment productivity improvement
	Delegation & knowledge of workforce
	New product development improvement
	<i>Environmental compatibility / health & safety</i>
Changes in Performance	Improvement Goals
1 (strongly deteriorated) – 3 (no change)	1 (not important) - 5 (very important)
– 5 (strongly improved)	
Manufacturing conformance	Manufacturing conformance
Product quality and reliability	Product quality and reliability
Product customisation ability	Product customisation ability
Volume flexibility	Volume flexibility
Mix flexibility	Mix flexibility
Time to market	Time to market
Customer service & support	Customer service & support
Delivery speed	Delivery speed
Delivery reliability	Delivery reliability
Manufacturing lead time	Manufacturing lead time
Procurement lead time	Procurement lead time
Procurement costs	Procurement costs
Labour productivity	Labour productivity
Inventory turnover	Inventory turnover
Capacity utilisation	Capacity utilisation
Overhead costs	Overhead costs
<i>Environmental performance</i>	<i>Environmental performance</i>

Table 4.3.2

Environment in Strategy - Mean Score of Respondents (N=558)

	n	Mean	std. dev.	% response 4 or 5
A. Importance of environmentally sound products as competitive priority (1=not important - 5=very important)	502	2.93	1.17	32
B. Use of environmental / health & safety Action Programmes in past 3 years (1=no use - 5=high use)	505	3.25	1.07	42
C. Improvement in Environmental Performance in past 3 years (1=strongly deteriorated - 5=strongly improved)	518	3.48	0.75	47
D. Importance of Environmental Improvement Goal for next 3 years (1=not important - 5=very important)	542	3.42	1.09	47

Table 4.3.3.
Correlations (Pearson) between Environment Strategy Variables (N=558)

	A	B	C	D
A. Importance of environmentally sound products as order winner	-	-	-	-
B. Use of environmental / health & safety Action Programmes in past 3 years	.204**	-	-	-
C. Improvement in Environmental Performance in past 3 years	.243**	.384**	-	-
D. Importance of Environmental Improvement Goal for next 3 years	.400**	.238**	.391**	-

** p < 0.01; Cronbach's Alpha 0.6592

An example of how the environmental item fits into each list is the question on competitive priorities (List A). In general, the ten competitive priorities of respondents most closely reflect the Noble (1995) model sequences - emphasising quality, dependability and delivery, with lower prices taking precedence over flexibility and innovation (Table 4.3.4). Overall, environmentally sound products are the least important order winner. This table helps to illustrate an important point for this analysis.

An individual respondents' list of priorities may have quite a different pattern to the overall pattern as observed in Table 4.3.4 and the ability to capture relative individual positions is lost by looking at the environmental item separately and by employing absolute answers. A respondent may assign a higher or lower score than the overall mean for the environmental item but this does not indicate the relative importance of the item for that particular respondent. For example, a respondent's answer of 3 is about the average for the environmental item but the same respondent may have given the nine other items in the list an answer of 5. This negative positioning of the environmental item would not be recorded as negative if merely compared to the overall mean. Therefore, rather than using the actual answers, the *relative* position of the environmental items in each list for each respondent is examined and an index is created to look at the combined positioning of environment in strategy.

Table 4.3.4
Ten Competitive Priorities (List A) N=558

Priority 1=not important, 5=very important	n	Mean	Median	Std. Dev.
product design and quality	528	4.3	4	0.87
conformance quality	529	4.2	4	0.86
dependable deliveries	535	4.1	4	0.86
faster deliveries	530	4.0	4	0.89
customer service	518	3.9	4	1.01
lower selling prices	537	3.7	4	1.08
wider product range	513	3.3	3	1.10
greater order size flexibility	519	3.3	3	1.22
newer products more frequently	518	3.2	3	1.15
environmentally sound products	502	2.9	3	1.17

4.3.3 Environmental Scores

Two environment measures or scores were developed using the survey data. The first environment in strategy (ES) score applies to all IMSS respondents (N=558) and is developed using the four environment items in the strategy questions. The second environment score, the Irish Environment (IE) score is developed using some of the additional questions answered by Irish respondents (n=32). They are described below.

4.3.3.1 IMSS Environment in Strategy (ES) Score

A scoring system was created to classify respondents by their composite responses to the four environmental strategy items in the main IMSS questionnaire. ISO14001 certification was not included in the score as it is deemed to be an indicator or predictor of environmental strategy implementation and salience. Also, since it is the only certification specified in the survey its inclusion in the index would prejudice those implementing other formal EMS's.

The score was elaborated in two stages. First, the relative position of the environmental item within each list was established for *each respondent*. This was achieved through calculating the number of standard deviations above or below the mean for the items in each list. For example, the mean score for the ten competitive priorities was computed for *each respondent* and then the difference from the mean for the environmental item was computed. Rather than taking the absolute answers, this approach enabled me to establish whether the environmental item was of greater, lesser or equal importance to the respondent compared to the other items in the respective lists. Also, since each list was independent, the relative position rather than the absolute score enabled the items to be compared directly and used together in a composite variable. In the second stage, the general prominence and strategic coherence of environmental management by each respondent is measured by summing the four results from the first stage (i.e. the number of standard deviations from the mean for each item) to give an environmental score. (This is effectively a standardisation process as in the use of z-scores).

Based on the score three groups were identified: firms with a relatively negative positioning of environmental management score less than -1, neutral positioning scores range from -1 to +1, and positive positioning scores are higher than +1⁴.

The purpose of this environmental score is not to create a definitive index or measure to assess environmental management of firms but rather to identify environmentally oriented firms in the context of the IMSS. The IMSS is primarily a manufacturing strategy survey and the environmental questions were posed in this context. The aim of the environmental score therefore is to examine whether the firms placing lesser or greater emphasis on environmental management within their manufacturing strategy in this context can be distinguished in other areas of innovation and performance. The score enables firms to be analysed based on the relative importance assigned to the environmental items compared to other items in the strategy questions. The applicability of the actual score beyond the IMSS is not intended. However, the rationale in creating it may possibly be applied to other questionnaires and topics. That is the use of relative positioning of an item to determine position for each respondent rather than the use of absolute answers and the comparison of individual responses to the sample means.

⁴ Comparisons of actual responses with the relative positioning of each item and with the final environment (ES) score are given in the Appendix Tables A4.1 and A4.2

In testing the hypotheses, standard multiple regression analyses were conducted to predict the emphasis or salience of environmental management strategy. The four environmental items and the environmental score were the dependent variables in separate models. The main dependent measure, the environmental score, represents overall emphasis or salience of natural environment management. The selection of the independent innovation and performance variables based on the literature is shown in Table 4.4.1 (page 96).

4.3.3.3 Irish Environmental (IE) Score

The additional environmental questions were developed based on current issues and general practices with the aim of getting a general indication of environmental management, certification and awareness of current issues from firms in the sector and then relating these to manufacturing priorities, practices, performance and innovation. Finally, these questions would aid the selection of firms for further case analyses. The analysis is confined to the Irish respondents ($n=32$). In order to classify respondents by their composite responses and to create a measure for selection purposes an Irish Environmental (IE) score was elaborated.

The scoring system is outlined in Table 4.3.5. The four environmental variables from the main IMSS questionnaire were not included but as noted in the table ISO14000 certification was (1 point).

Reliability analysis gives Cronbach's alpha of 0.665 for these items⁵ which is acceptable for a new or exploratory scale (Flynn *et al*, 1995). When these are combined with the four positioning variables used for the main IMSS environment in strategy (ES) index the alpha is 0.646. This shows the inter-item consistency and correlation of the environmental questions. There is also a correlation between the two environmental scores ($r= 0.431$, $p<0.05$).

The research question asks if environmental management is more prominent in innovative/progressive firms and therefore the relationships of these environmental scores to innovation and performance indicators in the IMSS is examined. In addition, the environmental and innovation scores assisted in the selection of firms for further case analysis.

⁵ Cronbach's Alpha of 0.665 for IE scale items excluding Repak/Green Dot, EMAS/Eco-label and the additional reported initiatives (due to mostly missing values)

Table 4.3.5 Irish Environmental Index Scoring System			
Item	Score		
an action plan/strategy for recovery of waste from end-users of your <i>products</i>	1		
a system in operation to recover waste <i>product</i> from end-users	1		
recovery of waste <i>packaging</i> from end-users	1		
operation of a waste management system(s)			
manufacturing by-products	1		
packaging	1		
paper	1		
other (specified)	1		
ever conducted an environmental audit, eco-audit or similar	1		
member of or certified by:			
Repak/Green Dot	1		
ISO 14000	1		
environmental impacts are considered sometimes / regularly (1 point) or always (2 points) in planning for the following eight operations:	sometimes /regularly	always	<i>special initiative</i>
Product design			
Manufacturing process	1	2	3
Energy use	1	2	3
Emissions	1	2	3
Packaging	1	2	3
Distribution	1	2	3
Transport	1	2	3
Recovery	1	2	3
<i>A further 3 points was given for any innovative or proactive environmental initiative specified in each of the above areas</i>	1	2	3
Maximum possible		26	24

4.4 Innovation: variables, measures and analysis in IMSS

To explore the relationships of the prominence of environmental management with innovativeness and performance in firms, variables and proxy variables in the IMSS were identified and selected. Eight indicators of innovation are identified in the IMSS as well as indicators of performance which are employed later in the analysis. The selection of variables available within the IMSS is linked to supporting literature on innovation, performance and the entrepreneurial firm in Table 4.4.1. The innovation indicators are: use of technology for operations, use of enterprise resource planning systems (ERP), R&D investment (% unit's revenues), process equipment (% unit's revenues), training (% unit's revenues) and manufacturing overheads (% manufacturing costs). These selected indicators of performance may be categorised into three groups: formalization of strategies and strategic fit; external integration and collaboration; and size (employees and sales), industry sector and internationalisation (foreign origin and external trade).

The figures for R&D investment (% unit's revenues), process equipment (% unit's revenues), training (% unit's revenues) and manufacturing overheads⁶ (% manufacturing costs) were employed directly. Use of the technology and ERP were both measured using composite variables. Use of the technologies for operational activities was evaluated using a multi-item question comprising of 13 items⁷. The extent of use (1-5) for each

⁶ Manufacturing overheads include salaries within design, planning and maintenance, and of indirect personnel in production, but exclude costs such as administration and sales.

⁷ e.g. Stand-alone/NC machines, Machining centres, CNC-DNC, Automated tool change, Robots, AGVs, Automated storage-retrieval systems, Flexible manufacturing/assembly systems/cells, Computer-aided inspection/ testing/ tracking, CAD, LAN-WAN/ Intranet / Shared databases/Internet

technology was summed to give a composite variable for technology use (maximum=65). The inter-item consistency was high (Cronbach's Alpha=0.7781). The extent of the use (1-5) of Enterprise Resource Planning (ERP) to support various management areas⁸ also had a high inter-item consistency (Cronbach's Alpha=0.8769). These items were summed to create a composite ERP variable (maximum=35).

Co-ordination of Design and Manufacturing was assessed using three variables based on 5-point scales (use of rules and standards; use of cross-functional teams; and use of job rotation between design and manufacturing). To reduce the amount of items, factor analysis was conducted on the variables relating to product development. These three variables loaded onto one factor. Likewise, management of the Product Development Cycle was assessed using three 5-point scale variables which loaded onto one factor (early involvement of the manufacturing function; use of concurrent engineering; and use of tests and prototypes). The two factor scores were saved as variables and used as indicators of innovation.

4.4.1 Innovation score

A measure of innovation in the form of a score was generated based on the eight indicators of innovation identified in Table 4.4.1 and described above. The actual figures for R&D, process equipment, training and manufacturing overheads were used as well as the composite variables for technology and ERP, and the two factor scores for product development. If a response was in the top quartile for any indicator a score of 1.0 was awarded and a score of 0.5 for a position in the second quartile. A response below the median was awarded no score. A maximum score of eight is possible.

As with the environmental score, the purpose of this score is not to create a definitive or transferable measure of innovation. The purpose is to assess the innovative and progressive firms within the context of IMSS. The international database on manufacturing presented the opportunity to select firms based on the specific measures available which are supported by the literature.

Other variables and measurements: To assess co-design activity, a value of one was assigned to each co-design activity⁹ with suppliers, customers or other organisations (Cronbach's Alpha=0.6987). These were summed to obtain an overall figure for range of co-design activity with a maximum of 21.

Supply chain integration was assessed through a seven-item scale for both suppliers and customers¹⁰. Given the high consistency among these items (Cronbach's Alpha for supplier co-ordination =0.7289 and for customer co-ordination =0.8137), the sum of the items was used to measure the extent of, and to give new variables for, supplier co-ordination and customer co-ordination. Using these variables a further classification of respondents' supply chain co-ordination and integration was adapted from Frohlich and Westbrook (2001) who used IMSS-II data to develop the arc of integration¹¹.

⁸ Material management, Production planning & control, Sales & distribution, Accounting & finance, Human Resource Management, Project management.

⁹ Product's concept, functional specifications, design, & manufacturing process design as well as component functional specifications, design and process design.

¹⁰ *How do you co-ordinate planning decisions and flow of goods?* Level of use (1-5) e.g. Share information about the inventory levels; Share information about production planning decisions and demand forecast; Co-location of plants; Standard packages and containers; Agreements on delivery frequency; Kanban systems to deliver your products, Vendor Managed Inventory.

¹¹ Respondents were classified as follows: Inward-facing - In lower quartile for both suppliers & customers; Periphery-facing - Above lower quartile for either suppliers or customers but below upper quartile for suppliers and customers; Supplier-facing - In upper quartile for suppliers and below upper quartile for customers; Customer-facing - In upper quartile for customers and below upper quartile for suppliers; Outward-facing - In upper quartile for both suppliers & customers.

Table 4.4.1
Indicators of Innovation & Performance in the IMSS survey data and in supporting literature

IMSS Variables	Supporting Literature
Indicators of Innovation	
• Use of technology for operational activities • Use of ERP • R&D investment (% unit revenues past 3 years) • Process equipment investment (% unit revenues past 3 years) • Training & education (% unit revenues past 3 years) • Manufacturing Overheads • Co-ordination of design and manufacturing (e.g. Cross-functional teams) • Management of Product Development Cycle (e.g. Concurrent Engineering)	IT, Engineering equipment (Kostopoulos, <i>et al.</i>, 2002) Technological competencies (Best, 2001, Danneels, 2002) Adopting external technology, ERP (Cassiman and Veugelers, 2002, Best, 2001, Waarts, <i>et al.</i>, 2002) R & D investment (Tsai, 2001) Internal/External Funds (Kostopoulos, <i>et al.</i>, 2002) Knowledge/Human (Kostopoulos, <i>et al.</i>, 2002) Proportion of specialists & professionals employed (Damanpour, 1991) Manufacturing and human resource practices (Florida and Davison, 2001)
Indicators of Performance	
<i>Formalisation, Quality and Efficiency</i>	
• Extent of formal/written strategy • Translation of business/marketing goals to manufacturing • Influence of manufacturing on business/marketing strategies • ISO9000 • ISO14000	Formalization (standardisation of work processes in manufacturing) (Damanpour, 1991) Formal reporting & explicit management system (Barney, 1995) Formalised strategies (Demeter, 2000) Fit between manufacturing and business/marketing strategies (Milling and Hasenpusch, 2000) Complementarity between innovation strategies (Cassiman and Veugelers, 2002) Quality management systems (Kaynak, 2003) Throughput Efficiency (Best, 2001)
<i>External Integration & Collaboration</i>	
• Co-Design activities • Co-ordination with customers • Co-ordination with suppliers	Collaboration & networking (Kiston and Michie, 1998, Roper, 2000) Acquiring external know-how (Cassiman and Veugelers, 2002) Co-design activities (Zotteri, <i>et al.</i>, 2000, Best, 2001) Arc of Integration (Frohlich and Westbrook, 2001) Supplier/customer relationships (Oliver, <i>et al.</i>, 2002) Internal & external Communication (Best, 2001, Damanpour, 1991)
<i>Size, Sector & Internationalization</i>	
• Size (no. employees in plant and worldwide) • Sales. Return on Investment (ROI), Return on Sales (ROS) • Industry sub-sector (ISIC 381-385) • Foreign origin • Imports (purchases from own economic region excluding own country & from outside own economic region - e.g. EU, NAFTA) • Exports (sales to own economic region excluding own country & to outside own economic region - e.g. EU, NAFTA)	Size (Aragón-Correa, 1998, Damanpour, 1991, Russo and Fouts, 1997, Sharma, 2000, Swamidass, 2003, Tsai, 2001) Industry (Angell and Rands, 2002, Banerjee, 2001, Damall, 2003, Russo and Fouts, 1997) Country (Best, 2001, Bradley, 2001, Brennan, <i>et al.</i>, 2002, 2003, Chandler, 1992a, b)

The innovation and environmental scores assisted in the selection of firms for further case analysis.

4.5 Selection of Firms for Case Analysis

Firms were selected for further analysis based on the results of the survey analysis, namely the environment and innovation scores as well as based on interviews with experts in the field of environmental management in manufacturing organisations. A range of firms were selected enabling both literal (predicting similar results) and theoretical (predicting contrasting results for different reasons) replication through case analysis (Eisenhardt, 1989; Yin, 2003). The type of study involves a holistic multiple-case design where each case a single unit of analysis (Yin, 2003). In using multiple cases rather than single cases the external validity is augmented and this also helps guard against observer biases (Leonard-Barton, 1990).

To examine innovation and environmental management there are four selection criteria from the survey data: the two environmental scores, the innovation score and ISO14000 certification. A fifth criterion is recommendation from experts. Due to the dynamic business environment not all firms were available for further analysis. Of the twelve firms with a high Irish environmental score 3 had closed (due to rising costs in Ireland) after the survey had taken place. The following number of firms met each criterion:

- 9 firms with a high innovation score
- 7 firms with high IMSS environmental score
- 12 firms with high Irish environmental score
- 13 firms with ISO14000 certification
- 10 firms were recommended by experts (described in next section)

Nine firms from the survey were identified as suitable for further analysis and four of these agreed to interviews (Table 4.5.1). Two other firms not included in the survey (X and Y) were each recommended by two experts and these also agreed to interviews (Table 4.5.1).

Table 4.5.1 Firms Identified as Suitable for Further Analysis						
Selection Criteria						
Firms from Survey	High Innovation Score	High Irish (IE) Score	High IMSS (ES) Score	ISO 14000	Experts	Accept Interview
1	✓		✓			✓
2	✓	✓		✓	✓	✓
3	✓	✓		✓		
4	✓	✓				
5	✓	✓				
6	✓	✓	✓	✓	✓	
7	✓	✓	✓	✓		
8		✓		✓		✓
9		✓				✓
Total	9	7	3	5	2	4
Others						
X	-	-	-	-	✓✓	✓
Y	-	-	-	-	✓✓	✓

Two firms had a high Irish environmental score but did not meet any of the other criteria. It was decided to include these in the interview process in order to further assess the scoring processes. One of these firms had closed, the remaining one was included and accepted to be interviewed (I) (Table 4.5.1).

In total, the four experts recommended ten firms which included two survey respondents (unknown to the experts). Two of these firms were each recommended by two experts and both agreed to be interviewed. One of the recommended firms had just closed.

One firm (6) met all five criteria (four survey and expert recommendation) but was unavailable for interview. A second firm (7) met all the survey based criteria but was also unavailable for interview. Three other firms (five in total) refused requests for interviews and further analysis. The reasons given for refusal were time constraints, lack of interest and confidentiality. In the end, six firms agreed to interviews four of which had been included in the IMSS survey plus two recommended by experts. Both these firms, not included in the original IMSS survey but recommended by two experts and interviewed, also responded to the second survey. Of the six firms interviewed five responded to the second IMSS survey. Six cases enables both literal and theoretical replication (Yin, 2003).

The four firms identified in the survey analysis are from this point on called A, B, C and D. The two firms identified through experts are X and Y (Table 4.5.2).

Table 4.5.2
Firms Agreeing to Further Analysis

Firm	Selection Criteria					Accept Interview	2 nd Survey
	High Innovation Score	High Irish (IE) Score	High IMSS (ES) Score	ISO 14000	Experts		
1 (A)	✓		✓			✓	✓
2 (B)	✓	✓		✓	✓	✓	x
8 (C)		✓		✓		✓	✓
9 (D)		✓				✓	✓
X	-	-	-	✓	✓✓	✓	✓
Y	-	-	-	✓	✓✓	✓	✓
Total	2	3	1	4	3	6	5

4.5.1 Interviews

As mentioned above primary data were also collected through interviews with selected firms which were chosen on the basis of their responses to the IMSS III survey as well as through consultative interviews with experts and available secondary data. The interviews served several purposes. Firstly, the interviews with experts enabled the additional identification of progressive and innovative manufacturing firms in the arena of environmental management. Secondly, interviews with experts and firms assisted in understanding the current situation in Ireland regarding the take-up of environmental management practices and strategies such as certification, legislation, institutional support mechanisms as well as general barriers and motivators. Lastly, the interviews with firms provided rich empirical data unavailable from the survey and they provided clearer insights into the practices and strategic approach to environmental management within each firm.

4.5.1.1 Interviews with Experts

Contact was made with a range of leading organisations dealing with manufacturing firms in the realm of environmental management in Ireland. Sustainable Energy Ireland (SEI) is a division of Enterprise Ireland the state agency supporting indigenous business development. SEI promotes sustainable manufacturing through a range of programmes, awareness raising, training and financial supports. Business in the Community Ireland (BITCI) is a membership based organisation which was established in Ireland in 2000 and specialises in providing consultancy support for social responsibility and community involvement. BITCI currently has 40 members which are leading organisations in Ireland and large employers. The Irish Business and Employers Confederation (IBEC) is the leading business and employers organisation in Ireland with 7,500 members from all sectors. IBEC hosts many industry groups and networks and provides expert training and consultancy in all areas of business including environmental management. Certification Europe is a Dublin based international consultancy specialising in training, auditing and certification in the areas of quality, health and safety, energy management, electronic signatures and environmental management including ISO14001 and EMAS.

Interviews were conducted with the following experts:

Dorothy Maxwell – Sustainable Energy Ireland (Enterprise Ireland)

Darina Eades – Business in the Community Ireland

David Manning - IBEC Environment Unit (and formerly of Repak)

John Ryan – Certification Europe (ISO14001)

Also, a short telephone conversation was held with Noel Duffy – Clean Technology Centre (CTC), Cork Institute of Technology. The CTC works closely with the Environmental Protection Agency in researching and promoting the use of improved manufacturing technologies for organisations.

4.5.1.2 Interviews with Firms

Regarding the selected firms, contact was made with the survey respondent and interviews were arranged directly with them and/or with another nominated firm representative. In most firms other relevant personnel were also interviewed so that at least two people were interviewed. In some cases people were interviewed separately and in others together depending on what most suited the interviewees.

All interviews were conducted on-site and lasted between 1.5 and 2 hours. A semi-structured format was followed. A list of themes and topics to be covered was consulted and considerable scope was also given for discussion to develop with interviewees. The intention was to give direction in terms of topic and relevance to study while allowing the interviewee to elaborate as freely as possible. Interviews in four of the six firms were recorded and written up and categorise thematically within two days of taking place. I did not work from transcripts but was able to consult and re-listen to the recordings as the need arose. Interviews in the remaining two firms were not recorded for reasons of impracticality but extensive notes were taken during the interviews and these were written up and categorise thematically immediately afterwards.

4.5.2 Case analysis

Three levels of analysis of case studies are suggested by Skrtic (Skrtic, 1985). The first level occurs with data collection in the field, the second during the utilizing/categorising process. The third level comprises

analysis, interpretation, synthesis and translation - presenting data for reader with interpretation, tacit knowledge and values of researcher (Skrtic, 1985).

The term case analysis is used to describe the analysis of the firms. Although full case studies of the selected firms were not conducted, the process of data collection (interviews, documentation and survey) and analysis follows the processes typical of case study (Yin, 2003). Full case study was unfeasible due to issues of access to firms and confidentiality.

The strategy of analysis involved relying on theoretical propositions – the most preferred strategy according to Yin - where theoretical orientation and propositions guide the study and aid the researcher to focus on required data and to organise (Yin, 2003).

The technique employed for the analysis involves a combination of pattern-matching, explanation and thematic cross-case analysis – (Yin, 2003). Pattern-matching compares an empirically based pattern with a predicted one such as the relationships between innovation and environmental management. Explanation is a form of pattern-matching using a presumed set of causal links to explain the phenomena such as the links between environment, innovation and performance. Cross-case analysis compares the individual firms with each other and tests for similar and/or different patterns and themes.

4.5.2.1 Presentation of Case Analyses and template

The results of the case analyses are presented in a narrative format according to the prominent themes. Results for each firm are presented separately followed by the cross-case analysis. The template for the presentation of case analyses is shown overleaf with a brief description of each topic. The headings differ slightly between firms depending on the emphasis each firm places on the topic and on the information available to the researcher. The information includes data from the IMSS surveys, interviews as well as other documentation from the firms and their websites and in some cases secondary data from third parties.

Template for Case Analyses - Headings

Selection for Further Analysis: This outlines the criteria by which the firm in questions was selected for further analysis.

Description: This describes the manufacturing activity of the firm and of the plant/site studied

Location: This gives the general location of the plant

Corporate Headquarters: Country of headquarters

Sales: Where possible this gives the sales

Employees: The number of employees at the plant and in the firm

Interviews: Interviewees, date and location of interview(s)

General Profile: General description of firm, its products and focus of relevant activities

Manufacturing: Description of manufacturing

Innovation & Technology This describes the emphasis the firm places on innovation and technology and highlights any particular points of interest such as investment in R&D.

Innovation, Technology & Environment This describes the inclusion of the environment in the firm's innovation and technology processes, R&D, budgets etc

Training This describes the training employees receive in general and in relation to the environment.

Incentives Where relevant this describes incentive schemes within the firm

Waste Management This describes the waste management operations of the firm

Packaging This describes the design and management of packaging

WEEE & RoHS This describes the effect of WEEE and RoHS regulations on the firm and its operations and how the firm is dealing with these.

Energy Use This describes the type of monitoring the firm uses and how energy savings are made. Whether the firm is engaged in Emissions Trading Scheme or if it requires a Greenhouse Gas Emission Permit.

Environmental Strategy This section details corporate policy, use of environmental management systems, integration with other activities and business requirements.

Environmental Management Systems (EMS) The use of a formal EMS is outlined and whether it is certified or not. Integration of EMS with other systems.

Training Outline any special training in environment

Drivers Describes major influences on environment policy and practices

Networking Outlines environment of corporate social responsibility related networking

RESULTS

PART 1 - Survey Analyses

5. RESULTS
PART 1 - Survey Analyses

5.1 Introduction

The results are presented in two chapters. This first chapter presents the results from the International Manufacturing Strategy Survey (IMSS). General results are first presented of variables relating to the position of the environment in manufacturing strategy as well as the general results of variables relating to innovation and performance. These results are presented for both all IMSS respondents and for the Irish based respondents. There then follow results pertaining to the development of the IMSS environmental index and subsequent analyses. The final section of this chapter presents some results specific to the Irish respondents relating to environmental management and used in conjunction with the IMSS environment index and innovation variables to assist in the selection of cases for further analysis.

The second results chapter, Chapter 6, presents the six cases selected for further analysis. These are all Irish based firms four of which were selected on the basis of the IMSS survey results and the remaining two were selected based on the recommendation of experts. The findings are discussed and analysed in Chapter 7.

5.2 IMSS Survey - General Results

The IMSS survey includes 558 respondents from 17 countries with 32 respondents from Ireland (Table 5.2.1). The mean size of the respondents is 1,031. However, as the table shows, size varies considerably and the median is 245. There is good representation across all size groups (Table 5.2.2).

Table 5.2.1
IMSS Respondents by Country and Mean Size

Country	Number	Percent	Mean No. Employees
Argentina	14	2.5	281
Australia	40	7.2	279
Belgium	19	3.4	428
Brazil	35	6.3	625
China	30	5.4	2,603
Croatia	35	6.3	355
Denmark	38	6.8	445
Germany	32	5.7	678
Hungary	58	10.4	547
Ireland	32	5.7	415
Italy	60	10.8	1,991
Netherlands	14	2.5	223
Norway	51	9.1	56
Spain	20	3.6	667
Sweden	19	3.4	846
UK	47	8.4	1,886
USA	14	2.5	7,954
Total	558	100	1,031
			std. dev = 4,515
			median = 245

Table 5.2.2 also shows the breakdown of respondents according to the International Standard Industrial Classification (ISIC) (revision 2). The majority of respondents are in the categories of metal products, machinery and electrical equipment. The ISIC pattern of Irish based respondents differs considerably from the overall with the majority of Irish firms (66%) in the category of electrical equipment, apparatus, appliances and supplies (383) and no representation from transportation equipment (384). This reflects the composition of the sector in Ireland.

Table 5.2.2
Size Group and Industrial Classification ^a of All IMSS Respondents (N=558)
and Irish Respondents (n=32)

Size Group		% All IMSS Firms	% Irish Based Firms
1-100		21	28
101-250		32	25
251-500		19	25
501-1500		18	16
1501-max		10	6

ISIC Code ^a	Mean Size	% All IMSS Firms	% Irish Based Firms
381	746	33	19
382	770	26	3
383	966	24	66
384	2,663	9	0
385	1,435	8	12
Total	1,033	100	100

^a ISIC (rev 2):
381 - Metal products, except machinery & equipment;
382 - Machinery, except electrical;
383 - Electrical equipment, apparatus, appliances & supplies;
384 - Transportation equipment;
385 - Professional & scientific, measuring & controlling equipment (not elsewhere classified) & photographic & optical goods.

5.2.1 Environment in Strategy

The IMSS survey includes four key manufacturing strategy questions relating to: competitive priorities, use of action programmes, performance improvement and improvement goals. Each of these questions comprises of a list of items each including one environmental item. These four environmental items are later used in the compilation of the environment in strategy (ES) index.

Competitive priorities (Table 5.2.3) show how the respondents view the importance of each item to win orders from their customers compared to their competitors on a scale of 1 to 5 (1= Not important and 5 = very important). Overall, the competitive priorities of respondents most closely reflect the Noble (1995) model sequences - emphasising quality, dependability and delivery, with lower prices taking precedence over flexibility and innovation. The only difference Irish firms show compared to the other IMSS respondents is in

the lesser importance they give to faster deliveries. Overall, environmentally sound products are the lowest ranked competitive priority and the only one with a mean of less than 3.

Action programmes are defined in the IMSS questionnaire as major projects aimed at producing considerable changes in management practices and organisation and to which management is committed, focussed and devotes high resource and innovation efforts. They are divided into 14 areas of activity (Table 5.2.3). Overall, most efforts in the previous three years were aimed at expanding manufacturing capacity, updating process equipment, information & communication technologies/ERP software, quality improvement and environmental compatibility / health & safety. Greater use of action programmes is reported by Irish based firms in all areas except in outsourcing non-core activities which is slightly, but not significantly, lower than other respondents. Significantly higher use by Irish firms is noted in seven areas including environmental compatibility and health & safety. Overall, action programmes for environmental compatibility / health & safety rank in the top five.

Table 5.2.3
Competitive Priorities and Use of Action Programmes over previous 3 years
for All IMSS Respondents (N=558) and Irish based Respondents (n=32)

Competitive Priorities	Mean Importance (1-5)	
	All IMSS	Irish Firms
Product design and quality	4.3	4.3
Conformance quality	4.2	4.2
Dependable deliveries	4.1	4.0
Faster deliveries	4.0	3.6*
Superior customer service	3.9	3.9
Lower selling prices	3.7	3.7
Wider product range	3.3	3.6
Greater order size flexibility	3.3	3.1
Newer products more frequently	3.2	3.3
<i>Environmentally sound products</i>	2.9	2.9

Action Programmes	Mean Use (1-5)	
	All IMSS	Irish Firms
Expanding manufacturing capacity	3.3	3.8*
Updating process equipment	3.2	3.5
Information & communication technologies/ERP	3.2	3.4
Quality improvement	3.2	3.6*
<i>Environmental compatibility / health & safety</i>	3.2	3.6*
Process focus & streamlining	3.1	3.6*
Workforce delegation & knowledge	3.0	3.1
Restructuring supply strategy	2.8	3.2†
Implementing pull-production	2.8	3.3*
New product development improvement	2.8	2.9
Equipment productivity improvement	2.7	2.8
Outsourcing non-core activities	2.6	2.3
Process automation	2.5	2.6
Reorganizing for e-commerce	1.9	2.5*

† p=0.053, * p<0.05

The remaining two IMSS strategy questions look at performance improvement over the previous three years and the improvement goals for the next three years in 17 areas of activity including environmental performance (Table 5.2.4). On average, improvement was reported in all areas of activity (mean >3). Greatest improvement is reported in product quality and reliability and volume flexibility. Product quality and reliability remains the most important improvement goal for firms followed by labour productivity, delivery reliability and procurement costs. Irish based firms on average report greater improvement in the performance of volume flexibility, labour productivity, capacity utilisation, inventory turnover and environmental performance. The improvement goals for Irish based firms differ slightly from other IMSS firms with significantly greater importance given to overhead costs and time to market.

Overall, despite having been ranked highly in the use of action programmes, reported improvement in environmental performance is among the lowest and it remains the lowest ranked improvement goal. This reflects its lowest rank in the competitive priorities. Among Irish respondents environmental performance is in the mid range of performance improvement and the second lowest improvement goal.

Table 5.2.4

Performance Improvement over previous 3 years and Importance of Improvement Goals for next 3 years for All IMSS (N=558) and for Irish based Respondents (n=32)

	Performance Improvement Mean Improvement (1-5)		Improvement Goals Mean Importance (1-5)	
	All IMSS	Irish Firms	All IMSS	Irish Firms
Manufacturing conformance	3.7	3.7	3.9	3.9
Product quality and reliability	3.8	3.8	4.3	4.2
Product customisation ability	3.6	3.4	3.4	3.3
Volume flexibility	3.8	4.1*	3.7	3.9
Mix flexibility	3.6	3.7	3.6	3.7
Time to market	3.5	3.6	3.8	4.1 †
Customer service & support	3.7	3.9	4.0	4.3
Delivery speed	3.7	3.6	3.9	3.9
Delivery reliability	3.7	3.8	4.1	4.1
Manufacturing lead time	3.7	3.8	4.0	4.2
Procurement lead time	3.4	3.4	3.9	4.1
Procurement costs	3.3	3.3	4.1	4.3
Labour productivity	3.6	3.9*	4.2	4.4
Inventory turnover	3.5	3.7*	3.9	4.0
Capacity utilisation	3.5	3.8*	3.8	4.1
Overhead costs	3.2	3.3	4.0	4.4**
<i>Environmental performance</i>	3.5	3.7*	3.4	3.6

** p<0.01, * p<0.05, † p<=0.05

5.2.2 Innovation and Performance Related Variables

As discussed in the methods chapter, the IMSS survey does not include direct measures of innovation and performance. However, variables relating to innovation and performance, and those reflecting innovative capacity and progressive use of new technologies and processes, are identified in the methods chapter (Table 4.4.1 page 96). The results of these variables are presented in following order: technology and management systems; innovation and innovation score; formalisation; external integration; quality, efficiency and

employee compensation; and internationalisation. These variables are later used in the analysis of the environment index and in the selection of firms for further case analysis.

5.2.2.1 Innovation and Performance – Technology, Management Systems and Product Development

Technology related variables include use of technology for operational activities and use of enterprise resource planning (ERP) systems software to support management of different functional areas (Table 5.2.5). In both cases a composite variable is created to give overall use of technology and ERP. These are created by summing the responses (1-5) in the list of items to give a possible maximum of 65 and 35 respectively. The use of these composite variables makes it easier to manage the assessment comparison of firm innovation.

Overall, use of technologies for operational activities remains low with only one technology, computer aided design/engineering, scoring a mean of more than 3. In the case of Irish based firms, use of stand-alone/numerical control machines is lower than average. Irish firms report significantly greater use of flexible manufacturing/assembly systems – cells, computer-aided inspection/ testing/ tracking, engineering databases, product data management systems and LAN-WAN /intranet/ shared databases/Internet. However, Irish firms do not differ from the IMSS sample in their overall use of technology.

Table 5.2.5

Use of Technology for Operational Activities, Use of ERP with ‘Overall’ Composite variables used for Innovation Score (sum) for All IMSS (N=558) and Irish based Respondents (n=32)

Use of Technology for Operational Activities	Mean (1-5)	
	All IMSS	Irish Firms
Stand-alone/Numerical Control machines	2.7	2.1*
Machining centres	2.2	1.8
Computer Numerical Control / Distributed Numerical Control	2.4	1.8
Automated tool change - parts loading/unloading	2.0	1.9
Robots	1.6	1.6
Automated guided vehicles	1.1	1.1
Automated storage-retrieval systems	1.4	1.4
Flexible manufacturing/assembly systems - cells	2.0	2.9*
Computer-aided inspection/ testing/ tracking	2.4	2.9*
Computer aided design/engineering	3.6	3.3
Integrated design-processing systems	2.3	2.1
Engineering databases, Product Data Management systems	2.9	3.8***
LAN-WAN/ Intranet / Shared databases/Internet	3.0	3.8**
<i>Overall Use of Technology for Operational Activities (max. 65)</i>	24	24
Use of ERP for Management		
Material management	3.7	4.4**
Production planning and control	3.5	4.1*
Purchasing and supply management	3.6	4.4***
Sales and distribution management	3.1	3.5
Accounting and finance	3.9	4.3*
Human Resources management	2.5	2.3
Project Management	2.5	2.5
<i>Overall Use of ERP (max. 35)</i>	23	26*

*** p<0.001, ** p<0.01, * p<0.05

In general, use of ERP is higher than use of technologies for operational activities (Table 5.2.5) and is highest in the areas of accounting / finance and material management. Irish based firms report significantly higher use of ERP in these areas as well as for production planning /control and purchasing / supply management. Overall mean use of ERP by Irish firms is higher than for other IMSS firms.

As well as the composite variables for use of technologies for operational activities and ERP, two composite variables are created for the management of product development. These two variables are Co-ordination of Design & Manufacturing and Management of the Product Development Cycle. They are based on the factor loadings for two groups of three related variables (use of rules & standards/cross-functional teams/job rotation and use of manufacturing in design/concurrent engineering/prototypes & tests) as outlined in Table 5.2.6. Irish firms differ from other respondents in their greater use of cross-functional teams.

Table 5.2.6
Product Development Variables – ‘Overall’ Composite variables used for Innovation Score (factor scores) for All IMSS (N=558) and Irish based Respondents (n=32)

Product Development	All IMSS	Irish Firms
Use of rules and standards	3.7	3.9
Use of cross-functional teams	3.4	3.8*
Use of job rotation	1.7	1.7
Overall Co-ordination of Design & Manufacturing (factor score)	0	0.19255
Early involvement of the manufacturing function	3.5	3.6
Use of concurrent engineering	3.4	3.6
Use of tests and prototypes	3.7	3.7
Overall Management of Product Development Cycle (factor score)	0	0.15273

*** p<0.001, ** p<0.01, * p<0.05

5.2.2.2 Innovation and Performance - Innovation and Innovation Score

Eight variables are employed to create an innovation score for each firm. These include the four composite variables described above: technology, ERP, co-ordination of design & manufacturing and product development. The four other variables used in the innovation score are: investment¹² in R&D, training/education and process equipment as well as costs of manufacturing overheads¹³. The development of the innovation score is described in the methods chapter (page 94)¹⁴. The results for these variables and of the innovation score are presented in Table 5.2.7. Irish based firms are distinguished in their higher use of ERP and greater investment in training and education. However, Irish firms do not differ from other IMSS respondents in the mean innovation score. Firms are categorised into three groups according to their

¹² Investment is % unit’s revenues.

¹³ Manufacturing overheads as a percentage of total manufacturing costs. Manufacturing overheads include salaries within design, planning and maintenance, and of indirect personnel in production, but exclude costs such as administration and sales. (Other manufacturing costs are direct salaries/wages, outsourced/contract work and direct material).

¹⁴ The innovation score is calculated by giving a respondent a score of 1 if it is in the top quartile (25%) for each of the eight variables and a score of 0.5 if it is in the second quartile (top 50-25%). These are summed to give a maximum possible innovation score of 8.

innovation score: low (0-1.5), medium (2-3) and high (3.5-8). The majority of firms are in the low scoring group (41%) while just over one quarter are have a high score.

Table 5.2.7

Innovation Variables and Innovation Score for All IMSS (N=558) and Irish based Respondents (n=32)

Innovation Variables	Mean	
	All IMSS	Irish Firms
Use of technology for operational activities (composite max. 65)	24	24
Use of ERP (composite max. 35)	23	26*
R&D investment (% revenues)	4.2	4.6
Process equipment (% revenues)	6.0	4.4
Training & education (% revenues)	1.8	2.6**
Manufacturing Overheads (% manufacturing costs)	18.4	18.6
Co-ordination of Design & Manufacturing (factor score)	0	0.19255
Management of Product Development Cycle (factor score)	0	0.15273
<i>Innovation Score (max. 8)</i>	2.3	2.5
	% All IMSS	% Irish
<i>Low Innovation Score (0-1.5)</i>	41	38
<i>Medium Innovation Score (2-3)</i>	32	31
<i>High Innovation Score (3.5-8)</i>	27	31

* p<0.05, ** p<0.01

5.2.2.3 Innovation and Performance - Formalisation

The following tables give the general results for the innovation and performance related variables identified in the IMSS survey in the following order: formalisation; external integration; quality, efficiency and employee compensation; and internationalisation (Tables 5.2.8 - 5.2.10). Formalisation of manufacturing strategy includes the extent (1-5) to which the firm uses a formal written strategy and the mutual influence between manufacturing strategy and business/marketing strategies and goals. In general manufacturing has less influence on business/marketing strategies (3.1) than vice versa (3.4). This pattern is stronger in Irish firms (2.9 and 3.7 respectively) although they do not differ significantly from other IMSS firms (Table 5.2.8).

Almost three quarters of all firms have ISO9000 quality management certification including all Irish respondents (Table 5.2.8). Less than one fifth of all firms have ISO14001 environmental management certification. However, 41% of Irish respondents are certified.

Table 5.2.8
Extent of Formalisation of Manufacturing Strategy and the Mutual Influence of Business/Marketing Strategies and Goals. Percent Firms with ISO Certification for All IMSS (N=558) and Irish based Respondents (n=32)

Formalisation	Mean (1-5)	
	All IMSS	Irish Firms
Extent of a Formal Written Manufacturing Strategy	3.4	3.5
Business/marketing goals translate into manufacturing strategy	3.4	3.7
Manufacturing influence on business/marketing strategies/goals	3.1	2.9
Certification	% All IMSS	% Irish
ISO9000 (Quality Management)	73	100
ISO14001 (Environmental Management)	18	41**

** p<0.01

5.2.2.4 Innovation and Performance - External integration

External integration includes the collaboration of firms with suppliers, customers and other organisations in the product development process and in planning decisions and management of flow of goods (Tables 5.2.9 and 5.2.10). Regarding the collaboration of firms in the product development process, suppliers in general have very little involvement in product development concept, functional specifications or design. However, they are more involved in component development and engage in this with approximately one third of firms. Around half of firms engage in product development with customers but not in component development. The role of customers in component design is significantly lower in Irish firms than for other IMSS firms. Overall collaboration with suppliers, customers and other organisations in the product development process is measured in a composite variable of co-design activities. This measures the total number of areas in which a firm collaborates with external organisations with a maximum possible score of 21 (Table 5.2.10). On average firms collaborate in three areas.

External integration can also be measured by the extent of co-ordination with suppliers and customers for planning decisions and flow of goods (Table 5.2.9). This is seen to a greater extent with suppliers in agreements on frequency of deliveries followed by sharing of information about production decisions and demand forecasts. In general there is less co-ordination with customers than with suppliers (Table 5.2.9). Agreement on frequency of delivery is also the most used form of co-ordination with customers. Irish based firms are generally more involved in the sharing of information, use of Kanban systems and supplier managed inventories compared to other firms. This is consistent with previous results on the use of technologies and management ERP systems.

Table 5.2.9
External Integration for All IMSS (N=558) and Irish based Respondents (n=32)

Co-Design Activities	with Suppliers		with Customers	
	%All IMSS	% Irish	%All IMSS	% Irish
Product concept	3	0	51	50
Product functional specifications	5	7	58	63
Product design	7	3	29	37
Manufacturing process design	10	10	4	0
Component functional specifications	21	30	27	17
Component design	33	30	16	3*
Component process design	33	33	7	3
Co-ordination Mean Use (1-5)	with Suppliers		with Customers	
	All IMSS	Irish Firms	All IMSS	Irish Firms
Share information about inventory levels	2.7	3.2*	2.3	3.1*
Share information about production planning / demand forecast	3.1	3.3	2.7	3.0
Co-location of plants	1.2	1.6	1.1	1.4
Use of standard packages / containers	2.5	2.5	2.3	2.7
Agreements on delivery frequency	3.6	3.9	3.2	3.7
Use of Kanban systems to acquire materials	1.8	2.4*	-	-
Use of Kanban systems to deliver product	-	-	1.3	1.6
Supplier managed/held inventories at firm	1.8	2.8**	-	-
Manage customer inventories / supply consignment stock	-	-	1.6	2.1

* p<0.05, ** p<0.01

Table 5.2.10
External Integration (Composite Variables) and Arc of Integration Groups for All IMSS (N=558) and Irish based Respondents (n=32)

External Integration	Mean	
	All IMSS	Irish Firms
Co-Design activities (max. 21)	3	3
Co-ordination with suppliers (max. 35)	17	20**
Co-ordination with customers (max. 35)	15	18*
Arc of Integration	% All IMSS	% Irish
Inward	12	6
Periphery	52	41
Supplier Facing	12	16
Customer Facing	12	6
Outward Facing	12	31
	difference	*

* p<0.05, ** p<0.01

Coordination with suppliers and customers for planning decisions and flow of goods are measured in two composite variables: co-ordination with suppliers and co-ordination with customers (Table 5.2.10). These

two variables can then be used to provide an overall measure of supply chain co-ordination and integration in the form of the Arc of Integration adapted from earlier IMSS analysis by Frohlich and Westbrook (2001). They classify Arc of Integration positions as follows:

Group	Position
Inward-facing	In lower quartile for BOTH suppliers & customers
Periphery-facing	Above lower quartile for either suppliers OR customers BUT below upper quartile for suppliers AND customers
Supplier-facing	In upper quartile for suppliers AND below upper quartile for customers
Customer-facing	In upper quartile for customers AND below upper quartile for suppliers
Outward-facing	In upper quartile for BOTH suppliers & customers

Over half of all firms are periphery-facing with 12% in each of the other three groups (Table 5.2.10). The pattern of Irish firms differs significantly from other IMSS respondents with almost one third in the outward-facing group.

5.2.2.5 Innovation and Performance – Quality, Efficiency and Employee Compensation

As seen in the manufacturing strategy results at the beginning of this chapter, quality was the most important competitive priority and improvement goal and among the most used action programmes (Table 5.2.3 & 5.2.4). The breakdown of quality expenditure and costs are presented here. On average more quality expenditure goes towards corrective maintenance than to preventive maintenance (Table 5.2.11). One third of quality costs are for inspection/control costs. While on average 19% of quality costs are for external quality the mean is only 10% for Irish firms. This may reflect the higher use of action programmes by Irish firms for quality improvement and ISO9000 certification for quality management of all Irish firms compared to three quarters of all IMSS firms.

Efficiency is measured as the amount of time spent working on products as a percent of total manufacturing lead time (from the start of the first operation to the finish of the last operation) – the mean throughput time efficiency is 43% (Table 5.2.11).

Over one quarter of firms use group incentives to compensate employees (Table 5.2.11). More firms use individual (31%) and companywide (38%) incentives. These figures are lower for Irish firms but the differences are not significant.

5.2.2.6 Innovation and Performance – Size, Sales and Internationalisation

As shown previously in Table 5.2.2, the number of employees is spread across all size groups. The mean is 1,031. Irish firms do not differ significantly although their mean size is 414. The global size of the Irish based firms is significantly greater reflecting the foreign origin of over three quarters of Irish firms compared to less than one third of all IMSS firms (Table 5.2.12). This internationalisation is also evident in the extent to which the Irish based firms import and export goods compared to IMSS firms in general (Table 5.2.12).

Table 5.2.11

External Integration, Quality, Efficiency and Employee Compensation for All IMSS (N=558) and Irish based Respondents (n=32)

	Mean	
	All IMSS	Irish Firms
Quality Expenditure (%)		
preventive maintenance	43	51
corrective maintenance	57	49
Quality Costs (%)		
inspection/control costs	33	38
internal quality costs	24	23
preventive costs	24	30
external quality costs	19	10**
Throughput Time Efficiency		
Time spent working on products as % total manufacturing lead time	43	42
Employee Compensation		
	% All IMSS	% Irish
Group incentives	27	19
Individual incentives	31	25
Companywide incentives	38	37

** p<0.01, * p<0.05

Table 5.2.12

for All IMSS (N=558) and Irish based Respondents (n=32)

	Mean	
	All IMSS	Irish Firms
Size		
Size (no. employees – Plant)	1,031	414
Size (no. employees – Worldwide)	20,859	24,975*
Sales (millions US \$ year 2000)	27	36
ROI (2000)	19	66*
ROS (2000)	10	12
Internationalisation		
	% All Firms	% Irish Firms
Foreign Origin (% Firms with Foreign Headquarters)	30	78***
Mean		
	All IMSS	Irish Firms
% Purchases from own country	59	21***
% Purchases from economic region (excl. own country)	28	41**
% Purchases from outside economic region	13	38***
% Sales to own country	52	10***
% Sales to economic region (excl. own country)	33	59***
% Sales to outside economic region	15	31***

*** p < 0.001; ** p<0.01, * p<0.05

The results presented thus far in this chapter give a general overview of the position of the environment in manufacturing strategy as well as those variables in the IMSS survey identified as relating to innovation and performance. The results of Irish based firms have been highlighted as these firms will be the source of cases for further analysis.

The next section of the results presents the findings in relation to the position of environmental management in manufacturing strategy and the development of a measure of its salience – the environment in strategy (ES) index. The relationships of the ES index with the innovation and performance related variables are then examined.

5.3 Environment in Strategy

Four key manufacturing strategy questions in the IMSS survey each include environmental management items. Table 5.3.1 shows the mean results for these questions. As noted in the previous section the environmental item is on average the lowest ranking competitive priority and improvement goal, and, despite being in the higher range of use of action programmes, its reported improvement is also in the lower range.

Table 5.3.1

Environmental Management in Manufacturing Strategy – Four IMSS Questions and Mean (N=558)

Competitive Priorities Mean Importance (1-5)		Action Programmes Mean Use (1-5)	
Product design and quality	4.3	Expanding manufacturing capacity	3.3
Conformance quality	4.2	Updating process equipment	3.2
Dependable deliveries	4.1	Information/communication technologies/ERP	3.2
Faster deliveries	4.0	Quality improvement	3.2
Superior customer service	3.9	<i>Environmental compatibility / health & safety</i>	3.2
Lower selling prices	3.7	Process focus & streamlining	3.1
Wider product range	3.3	Delegation & knowledge of workforce	3.0
Greater order size flexibility	3.3	Restructuring supply strategy	2.8
Newer products more frequently	3.2	Implementing pull-production	2.8
<i>Environmentally sound products</i>	2.9	New product development improvement	2.8
		Equipment productivity improvement	2.7
		Outsourcing non-core activities	2.6
		Process automation	2.5
		Reorganizing for e-commerce	1.9
		Changes in Performance Mean Improvement (1-5)	Improvement Goals Mean Importance (1-5)
Manufacturing conformance		3.7	3.9
Product quality and reliability		3.8	4.3
Product customisation ability		3.6	3.4
Volume flexibility		3.8	3.7
Mix flexibility		3.6	3.6
Time to market		3.5	3.8
Customer service & support		3.7	4.0
Delivery speed		3.7	3.9
Delivery reliability		3.7	4.1
Manufacturing lead time		3.7	4.0
Procurement lead time		3.4	3.9
Procurement costs		3.3	4.1
Labour productivity		3.6	4.2
Inventory turnover		3.5	3.9
Capacity utilisation		3.5	3.8
Overhead costs		3.2	4.0
<i>Environmental performance</i>		3.5	3.4

5.3.1 Environment in Strategy Index

As discussed in the methods chapter (pages 91-93), examining the mean results for all respondents is unsatisfactory for assessing the relative importance of environmental management in manufacturing strategy. As we see in Table 5.3.2, between 32% and 48% of respondents give responses of 4 or 5 for the environmental items. However, it cannot be assumed that these respondents assign greater importance to the environmental items over other items. Although these respondents give a response above the mean, they may actually assign less importance to the environmental item compared other items in the same question. For instance a response of four for the competitive priority item is above the mean (2.9). However, if the same respondent gives all the other priorities a response of 5 then the environmental item would, in fact, be of least importance to that respondent despite being above the mean and appearing to be more important. The converse is also possible and respondents who give a response below the mean for the environmental item may not necessarily rank the item below other items in the same question.

Table 5.3.2 IMSS Environment in Strategy Responses (N=558)				
% Firms Responding 1-5 for Environmental Items				
Response	Competitive Priority	Action Programme	Change in Performance	Improvement Goal
1	13	6	1	4
2	23	18	5	16
3	32	35	47	33
4	22	29	40	29
5	10	13	8	19
Mean Response	2.9	3.2	3.5	3.4

What is important in determining the salience of environmental management in manufacturing strategy is not the absolute value or actual response for the environmental item in comparison to the mean for all respondents but rather the relative response in comparison to the other items in the same question for the same respondent. Therefore the positioning of the environmental item in relation to the other items is calculated by determining:

1. each respondent's mean response and standard deviation for the list of items in the same question and
2. the number of standard deviations the environmental item is above or below each respondent's list mean

The results of the relative positioning of the environmental item within each strategy list are presented in Table 5.3.3. The environmental item is on average less than one standard deviation from the list means. On average, the environmental item is negatively positioned for competitive priorities, performance improvement and improvement goals and it is positively positioned for action programmes.

However, looking separately at the mean position of the environmental item within each list does not give a measure of the salience of environmental management in manufacturing strategy as a whole. Therefore these items are compiled into one index variable by adding the four positioning results. This index gives the general prominence and strategic coherence of environmental management in manufacturing strategy as a whole for each respondent. The index scores are presented in Table 5.3.4 and three groups are identified.

Firms with an overall negative positioning of natural environment management score less than -1, neutral positioning scores range from -1 to +1, and positive positioning scores are higher than +1. Scores range from -6.9 to 5.6. The mean index score is -1.03 and the median is -1.3.

Twenty-two percent of respondents fall into the positive index group. This group may be said to exhibit strategic coherence in that the four strategy areas *combined* give a positive result. That means, overall, they place more emphasis on environmental management than on other areas in terms of competitive priorities, action programmes, performance improvement and improvement goals. In other words, environmental management is salient in their manufacturing strategy. Over half of respondents (53%) fall into the negative group, these may also be said to show coherence in their overall negative positioning of environmental management in the four strategy areas. The neutral group (26% respondents) may reflect a generally neutral position in the four strategy areas or they may reflect a strategic incoherence in that some positive and negative results may combine to give a neutral result. The next step is to examine the relationship of the index with innovation and performance variables.

Table 5.3.3
Relative Positioning of Environmental Items in the Four IMSS Strategy Questions ^a (N=558)

Strategy List	Mean Relative Positioning of Environmental Item ^a	n
Competitive Priorities	-.7313	544
Action Programmes	.3360	533
Performance Changes	-.1130	531
Improvement Goals	-.4863	551

^a Mean number of standard deviation above or below respondent's list mean

Table 5.3.4
IMSS Environment in Strategy (ES) Index Results (N=497)

ES Index Score		
Lowest	-6.9	
Highest	5.6	
Median	-1.3	
Mean	-1.03	
(std dev)	(2.41)	

ES Index Groups	% Firms	Cumulative %
Negative (< -1)	52.9	52.9
Neutral (-1 to 1)	25.6	78.5
Positive (> 1)	21.5	100

5.3.2 Environment in Strategy Index, Innovation and Performance

The environment in strategy (ES) index provides a tool for examining the relationship of environmental management in firms with a range of variables associated with innovation and performance in the IMSS survey. The extent to which these variables can be used to predict the salience of environmental management in manufacturing strategy is later explored through the development of regression models.

5.3.2.1 Environment in Strategy Index – Comparative Analysis

Firstly, comparative results for the three index groups - positive, neutral and negative environmental positioning – show some relationships with innovation and performance related variables (Table 5.3.5). However, only one specific innovation variable was significantly associated with the ES index groups. Surprisingly, the ES index is inversely related to investment in R&D. The positive group spent less on average on R&D (3.2% revenues) compared to 3.9% for the neutral group and 4.8% for the negative index group.

Although the relationship of the ES index to the composite innovation score is non-significant it is interesting to note that only 7% of all firms have both a positive ES score and a high innovation score (Table 5.3.6). Nine percent of all firms have a positive ES score and a negative innovation score while 16% have a negative ES score and a high innovation score. Nineteen percent are both negative and low in ES and innovation scores respectively. It appears that there is no discernable pattern between the innovation and environment in strategy variables (Correlations are weak).

As a cluster, variables relating to formalisation and structure have the most association with the ES index groups (Table 5.3.5). Unsurprisingly, ISO14001 is the most significant variable when comparing the three index groups. Thirty percent of the positive group have certification compared to 21% of the neutral group and only 13% of the negative group. It is interesting to note that, of those with certification, more are in the negative group (37%) than either the neutral (29%) or positive groups (34%). Even so, this differs significantly from the pattern of those who are not certified with over half (57%) in the negative index group and only 19% in the positive group. (ISO14001 is also found to have a positive relationship with three of the innovation variables: technology for operational activities; Enterprise Resource Planning (ERP); and cross-functional teams in the co-ordination of design and manufacturing. Respondents with ISO14001 certification use significantly more of these technologies and work processes than those without. They also have a significantly higher level of co-ordination with both suppliers and customers. ISO14001 differs from the ES index in the pattern of association with the innovation variables).

The positive index group is also more likely to have a written formalised manufacturing strategy and the influence of manufacturing on business/marketing strategies is greater than for the other index groups (Table 5.3.5).

The three variables for external integration (co-design, coordination with suppliers and co-ordination with customers) do not differ between ES index groups (Table 5.3.5). However, interestingly, the Arc of Integration classification to look at overall supply chain integration shows 36% of customer-facing firms in the positive ES group compared to 22% of all firms (Table 5.3.7).

Table 5.3.5
Summary of Environmental Index Groups – Mean or Percent ^a (N=497)

Innovation	Environmental Index				difference
	Negative	Neutral	Positive	Total	
Operations Technology (max 65)	24.6	25.3	25.3	25.0	
ERP (max 35)	23.5	24.1	23.0	23.5	
R & D (% revenues)	4.8	3.9	3.2	4.2	**
Process Equipment (% revenues)	6.3	6.2	5.5	6.1	
Training (% revenues)	1.8	1.8	1.6	1.8	
Manufacturing Overheads (%)	18.6	16.9	20.1	18.5	
Co-ordination of Design & Manufacturing	-.07711	.03634	.12018	-.00686	
Product Development Cycle	.04497	.99367	-.11487	.02426	
<i>Innovation Score (8max)</i>	2.5	2.3	2.4	2.4	
Formalisation					
Formal Strategy (1-5)	3.4	3.6	3.7	3.5	*
Business/marketing goals translate to manufacturing (1-5)	3.4	3.5	3.6	3.5	
Manufacturing influence on business/marketing strategies(1-5)	3.0	3.1	3.3	3.1	*
ISO9000 (% index group)	74%	78%	77%	76%	
ISO14001 (% index group)	13%	21%	30%	19%	**
ISO14001 (% of certified)	37%	29%	34%	100%	
ISO14001 (% of non-certified)	57%	25%	19%	100%	**
Quality & Efficiency					
Inspection costs	32.2	34.9	32.8	33.0	
Internal quality costs	24.2	24.1	23.6	24.0	
Preventive costs	23.9	23.7	26.0	24.3	
External quality costs	19.7	17.3	17.6	18.6	
Throughput Time Efficiency	43.7	41.6	44.7	43.4	
External Integration					
Co-design (max 21)	3.2	3.4	3.2	3.2	
Customer Co-ordination (max 35)	14.1	15.0	15.6	14.6	
Supplier Co-ordination (max 35)	16.7	17.0	17.2	16.9	
Employee Compensation					
Workgroup incentives (% index group)	34%	23%	28%	30%	
Individual incentives (% index group)	37%	34%	25%	34%	
Companywide incentives (% index group)	40%	38%	46%	41%	
Size, International, Sector					
No. employees– Plant (n=495 ^b)	757	680	2,000	1,007	*
No. employees - World-wide (n=301 ^b)	16,259	25,915	22,632	20,001	
Foreign headquarters (% group)	31	31	29	31	
Sales (millions US\$, 2000)	43	53	44	45	
% Purchases from own region ^b	29	28	28	29	
% Sales to own region ^b	14	14	15	14	
% Purchases from other regions ^b	34	34	32	32	
% Sales to other regions ^b	15	17	17	17	
ISIC_381 (% sector) ^c	54	25	21	100	
ISIC_382 (% sector)	59	22	19	100	
ISIC_383 (% sector)	54	26	20	100	
ISIC_384 (% sector)	36	36	28	100	
ISIC_385 (% sector)	44	28	28	100	

^a Figures rounded so some additions not exactly to 100%

^b Means include outliers which are removed for the regression analysis

^c ISIC (rev.2) Division 38: 381 metal products except machinery & equipment; 382 machinery except electrical; 383 electrical equipment, apparatus, appliances & supplies; 384 transportation equipment; 385 professional, scientific & measuring, photographic & optical equipment.

* p<0.05; ** p<0.01; *** p<0.001 (ANOVA, Kruskal-Wallis or χ^2)

Table 5.3.6
Environment in Strategy (ES) Index Groups by Innovation Score (N=497)

Innovation Score	ES Index (% All Firms)			
	Negative	Neutral	Positive	Total
Low Innovation Score (0-1.5)	19	10	9	38
Medium Innovation Score (2-3)	18	9	5	32
High Innovation Score (3.5-8)	16	6	7	30
Total	53	26	21	100%

Innovation	ES Index (% Innovation Group)			
	Negative	Neutral	Positive	Total
Low Innovation Score (0-1.5)	49	27	24	100
Medium Innovation Score (2-3)	56	28	16	100
High Innovation Score (3.5-8)	55	22	24	100
Total	53	26	22	100

differences are non-significant

Table 5.3.7
Supply Chain Integration – Environment in Strategy Groups by Arc of Integration

Level of Integration	Group (% All Firms) (n=522)	Mean ES Index Score (n=484)	% Firms with High ES Score (n=484)
Extensive Integration with both Customer & Supplier ↑	Outward Facing (12%)	-0.7275	20%
	Customer Facing (12%)	-0.3491	36%
	Supplier Facing (12%)	-1.1929	24%
	Periphery Facing (52%)	-1.2895	18%
No Integration	Inward Facing (12%)	-0.7394	26%
	Total (100)	-1.363	22%
	difference	†	*

† p=0.050, * p<0.05

Size is also related to ES index groups with the firms in the positive group on average almost three times the size of firms in the neutral or negative groups (Table 5.3.5).

Size is strongly associated with most of the innovation and performance variables. For example, ISO certification is higher among larger firms - 38% of firms employing more than 1,500 have ISO14001 compared to only 9% of firms employing 250 or less (Table 5.3.8). However, controlling for size and ISO14001 certification does not influence the ES index as the number of firms with ISO14001 certification is small within each size group (n=10-32). Therefore while size is strongly associated with most innovation and performance variables it does not determine the association of ISO14001 and formalisation or other variables with the ES index i.e. the pattern of ES relationships to these variables is independent of size group. For example, size is not associated with investment in R&D.

Table 5.3.8
ISO9000 & ISO14000 Certification and Environment in Strategy (ES) Index by Size Group,
Origin and Industrial Classification^a (N=558)

ISO Certification			ES Index Score		
	ISO 9000	ISO 14000	Negative	Neutral	Positive
Total (%)	72	18	53	26	22
% of Size Group (no. employees in plant)					
Size Group	ISO 9000	ISO 14000	Negative	Neutral	Positive
1-100	44	9	54	28	18
101-250	74	9	54	30	16
251-500	82	21	55	18	27
501-1500	88	34	47	26	28
1501-max	91	38	53	20	27
difference	***	***	-	-	-
% of Foreign / Indigenous Firms					
Origin	ISO9000	ISO14000	Negative	Neutral	Positive
Foreign	86	34	52	26	20
Indigenous	76	13	53	26	22
difference	*	***	-	-	-
% ISIC Group					
ISIC	ISO9000	ISO14000	Negative	Neutral	Positive
381	67	14	54	25	21
382	72	11	59	22	19
383	83	31	54	26	20
384	80	18	36	36	28
385	76	23	44	28	28
difference	*	***	-	-	-

^a ISIC (rev.2) Division 38: 381 metal products except machinery & equipment; 382 machinery except electrical; 383 electrical equipment, apparatus, appliances & supplies; 384 transportation equipment; 385 professional, scientific & measuring, photographic & optical equipment.

*** p < 0.001, *p<0.05, - = non-significant

Despite the index having no relationship with ISIC industrial sub-sectors, sectors 384-transportation and 385-professional equipment each have 28% in the positive group (Table 5.3.8). The pattern of ISO14001 adoption also differs from the normal 18% across sub-sectors. More firms from sub-sector 383-electrical equipment are certified (31% with ISO14001) while fewer firms from 381-metal products and 382-machinery are certified (13% and 11% respectively). Similarly, sub-sector 383 differs by origin of plant with 36% of foreign origin compared to 25% for the other sub-sectors.

In summary, the positive ES index group, where environmental management is salient in strategy, is more formalised and has stronger links between manufacturing and business/marketing strategies. These firms are more likely to have ISO14001 certification and to be customer-facing. The average plant size and sales are larger than for other ES groups but they spend proportionally less of their unit's revenues on R&D.

5.3.2.2 Environment in Strategy Index – Predictive Model

The hypothesis that innovation and performance variables may be employed to predict the emphasis or salience of environmental management strategy is tested through regression analyses models. The four environmental items and the ES index were the dependent variables in five separate models. The main

dependent measure, the ES index, represents overall emphasis or salience of natural environment management. The results of regression analyses are presented in Table 5.3.9. Models are separated into groups of independent variables: innovation, formalisation, quality & efficiency, external integration, employee compensation and size/internationalization/sector. Finally, an adjusted model is presented containing only the significant variables (Angell and Rands, 2002).

The results show that some models are significant, including the ES index, and offer some support for the hypothesis. Controlling for variables such as size, ISO14001 and sub-sector does not significantly improve the model coefficients or R^2 s.

In the first instance, innovation related indicators account for 5% of variation in the main dependent measure, the ES index. R&D investment is the only significant variable and is negatively linked to strategic environmental management salience with a standardized coefficient of -.192.

Formalization accounts for 5% of variation in the ES index. The significant variables in this group are the influence of manufacturing on business/marketing strategies and ISO14001 certification which have positive relationships to strategic environmental management salience. While ISO14001 has a moderate influence on the change in performance index component (standardized coefficient = .232) this effect is diluted to some extent in the ES index model (.172).

None of the other indicators proved to be significant in terms of predicting the ES model: quality & efficiency, external integration, employee compensation and size/internationalization/ sector. Some variables have an influence on individual index components. In the quality and efficiency variables, only throughput time efficiency has an influence on any index component. The effect on the improvement goal item is positive and significant. Although not significant, the effect of throughput time efficiency on the other three index components is negative. The impact on the ES index is almost zero.

In the external integration group of variables, customer co-ordination has also an influence on the improvement goal item while supplier co-ordination has a negative influence on the action programme item. Use of workgroup incentives is negatively associated with reported change in performance (-.137).

Finally, the adjusted model includes only the three significant variables on the ES index and shows that investment in R&D (-), influence of manufacturing on business/marketing strategies and ISO14001 have a role in predicting the ES index. However, they account for only 8% of variance in the index (adjusted R^2 = .067, $F = 10.125$, $p < .001$) and the coefficients remain weak (-1.69, .126 & .166), indicating that the model has a poor predictive capacity.

In conclusion, although there are some significant predictors among the innovation and performance variables, the results indicate that these are weak and account for small variances in the dependent ES index. The results of the comparative analyses indicate the same significant variables and they give a better picture of the relationships with the ES index.

The final section of this chapter presents some results specific to the Irish respondents relating to environmental management and used in conjunction with the IMSS environment index and innovation variables to assist in the selection of cases for further analysis.

The next chapter (6) presents the six cases. The findings are then discussed and analysed in Chapter 7.

Table 5.3.9
Results of Regression Analyses Predicting Environmental Strategic Salience ^{a b}

Four Index Components					Environmental Index		
Variables	Competitive Priority	Action Programme	Change in Performance	Improvement Goal		Adjusted Model ^c	
Innovation							
Operations Technology	.087	-.136*	.131*	-.040	.046	-.169*	
ERP	-.024	-.008	.043	-.026	-.015		
R & D	-.075	-.079	-.145*	-.167**	-.192**		
Process Equipment	-.046	-.006	-.080	-.062	-.079		
Training	.047	.001	.042	.050	.061		
Manufacturing Overheads	-.073	.027	-.017	.053	-.010		
Co-ordination of Design & Manufacturing	.034	.085	.129*	.041	.015		
Product Development Cycle	-.061	.056	-.103	.008	-.081		
R ²	.017	.035	.053	.037	.05		
Adjusted R ²	-.006	0.12	.031	0.14	.027		
F(d.f.8)	.749	1.544	2.374*	1.625	2.201*		
Formalisation							
Formal Strategy	.106†	-.051	.056	.094	.072	.126**	
Business/marketing goals translate to manufacturing	-.022	.018	.082	-.099	-.013		
Manufacturing influence on business/marketing strategies	.060	.028	-.038	.166***	.107*		
ISO9000	-.027	-.082	.016	.026	-.015		
ISO14001	.029	.062	.232***	.082	.172***		
R ²	0.16	.010	.079	.042	.050		
Adjusted R ²	.007	.000	.070	.033	.040		
F(d.f.5)	1.693	1.023	8.574***	4.527***	4.944***		
Quality & Efficiency							
Inspection costs	.028	.045	.113	.044	.088		.166**
Internal quality costs	-.035	-.036	.068	.091	.033		
Preventive costs	.045	.078	.038	.033	.073		
Throughput Time Efficiency	-.020	-.083	-.064	.151**	-.001		
R ²	.005	.013	.012	.026	.006		
Adjusted R ²	-.006	.003	.002	.016	-.005		
F(d.f.5)	.444	1.252	1.145	2.492*	.562		
External Integration							
Co-design	.062	.057	-.041	.047	.044	.166**	
Customer Co-ordination	.045	.044	-.018	.147**	.090		
Supplier Co-ordination	.021	-.154**	.021	.055	-.049		
R ²	.008	.023	.002	.021	.009		
Adjusted R ²	.002	.017	-.004	.015	.003		
F(d.f.3)	1.362	3.726*	.376	3.477*	1.474		
Employee Compensation							
Workgroup incentives	.019	-.050	-.137**	-.001	-.062	.166**	
Individual incentives	-.052	.083	-.047	-.011	-.093		
Companywide incentives	-.031	.062	.049	-.020	.046		
R ²	.004	.014	.025	.000	.016		
Adjusted R ²	-.002	-.008	.019	-.006	.009		
F(d.f.3)	.645	2.229 †	4.128**	.021	2.461†		
Size, International, Sector							
No. employees - Plant	.049	-.043	.136	.165	.136	.166**	
No. employees - World-wide	-.002	-.051	.069	-.129	-.065		
Sales (2000)	-.100	-.034	.029	-.083	-.085		
Purchases from region ^d	.044	-.043	-.032	.037	.010		
Sales to region	-.072	.025	.019	-.030	-.042		
Purchases from other regions	-.018	.022	.074	.016	.041		
Sales to other regions	-.004	-.036	.026	-.062	-.030		
Foreign origin	.046	.004	-.094	.037	.016		
ISIC 381 ^e	.160	.472	.228	-.182	.203		
ISIC 382	.145	.462	.140	-.234	.128		
ISIC 383	.022	.442	.183	-.193	.171		
ISIC 384	.198	.274	.162	-.068	.212		
ISIC 385	.109	.269	.103	-.078	.142		
R ²	.025	.022	.050	.041	.033		
Adjusted R ²	-.050	-.054	-.024	-.034	-.042		
F(d.f.13)	.336	.285	.675	.547	.436		

^a Results presented show separate models for each of the 5 dependent variables by 6 groups of independent variables

^b Values shown are standardized regression coefficients.

^c Adjusted model containing only the three significant variables

^d Firm's own Economic Region: (e.g. EU, NAFTA, Mercosur, Pacific Rim)

^e ISIC rev 2: 381 - Metal products, except machinery & equipment; 382 - Machinery, except electrical; 383 - Electrical equipment apparatus, appliances & supplies; 384 - Transportation equipment; 385 - Professional & scientific, measuring & controlling equipment n.e.c. & photographic & optical goods

† p<0.1; * p<0.05; ** p<0.01; *** p<0.001

5.4 IMSS Survey – Irish Data – Environmental Management

As well as answering the main IMSS questionnaire, Irish respondents answered additional questions regarding environmental management and practices (see Appendix: IMSS Questionnaire - Section E). These included questions on: waste management; inclusion of environmental considerations in manufacturing processes, product design, energy use, transport etc.; innovations/innovative practices; and environmental certification. Finally, Irish respondents were asked how they viewed their firm's situation compared in general to their European competitors in the context of environmental regulations. These results are outlined in this section and they are then used collectively as another assessment criterion for selecting cases in an Irish Environmental Index. The index results are also compared with the manufacturing strategy variables and the environment in strategy (ES) index as well as innovation and performance variables from the main questionnaire.

Product Recovery and Waste Management

Fourteen (44%) of respondents have some kind of system in operation to recover products from end-users. The majority of these firms either operate the system themselves (36%) or employ contractors to do so (43%). One firm is involved in a group scheme and a distributor manages the recovery system for one other. The most popular methods to deal with recovered product are to recycle (64%) followed by disposal (48%), re-use and disassembly (43% each). Twenty percent of firms sell waste product. One quarter of respondents recover packaging from end-users.

Twenty-six firms (81%) operate a waste management system. Half of these have a system in place to manage manufacturing by-products. Sixteen firms have a waste packaging management system and fifteen have a waste paper management system in operation. Other waste systems mentioned deal with oils and solvents, batteries, metals, cans, bottles toner cartridges and hazardous waste.

Seventeen (53%) respondents believed they would be affected by the then forthcoming WEEE legislation. Only five of these (30%) had any action plan in place at the time.

Environmental Audits

Three-quarters of firms conduct environmental audits. These are mainly done on a yearly or half-yearly basis. Few firms publish results externally.

Environmental Impacts, Innovations and Initiatives

Respondents were asked to indicate the extent to which their firms consider the environmental impact in all areas of activity (Table 5.4.1). The environmental impacts of manufacturing process and emissions are most considered with 37% and 38% of firms always assessing these and approximately another third regularly doing so. Energy use is also assessed either regularly or always by two thirds of firms. However, one quarter of firms never consider the environmental impacts of energy use. The environmental impacts of packaging are considered regularly by 55% of firms and always by three firms (10%).

While one third of firms either regularly or always consider the environmental impacts of distribution and transport, large proportions (48% and 56% respectively) never make these considerations. Product design and

product recovery are also areas where a large proportion, over half, of firms either never (33%) or only sometimes (19%) consider the environmental implications.

Table 5.4.1
Consideration of Environmental Impacts by Irish Respondents (N=32) (% Firms)

Area of Impact	Never	Sometimes	Regularly	Always
Product design	33	19	33	11
Manufacturing process	17	13	33	37
Energy Use	26	6	43	23
Emissions	17	7	38	38
Packaging	17	14	55	10
Distribution	48	15	26	7
Transport	56	7	26	7
Recovery	33	19	41	7

Firms were asked to indicate any environmentally related innovations or initiatives which they implement. The range of responses is very varied. These mostly relate to manufacturing process, energy use, packaging and emissions and examples are presented in Table 5.4.2 below.

Table 5.4.2
Examples of Some Reported Environmental Innovations & Initiatives by Irish Respondents (N=32)

Product design	life-cycle analysis	low voltage products	replace manuals with CDs	pallet sizing
Manufacturing process	elimination of solvents	reduction of scrap to landfill	upgrading of machinery	replace acrylic for water based paints
Energy Use	low energy lighting	use of timers	natural gas heating	awareness programmes
Emissions	new wash process to reduce emissions		awareness programmes	
Packaging	all Bio-degradable	recycled / recyclable reusable /returnable	reduction in packaging	reduction in size
Distribution	none			
Transport	consolidation of shipments			
Recovery	recycling of 85% of waste	recovery from customers	recycling of oils, PCBs, cartridges	

Environmental Certification

Forty-one percent of Irish respondents have ISO14000 certification. Other certifications are poorly represented: only one firm is a member of Repak, one has Eco-label, two have the GreenDot symbol while none are certified by EMAS or others.

5.4.1 Irish Environment (IE) Index

In order to assist in identifying broadly progressive or active firms in the area of environmental management respondents are classified by their composite responses to the Irish environmental questions with an Irish Environmental (IE) index. The IE index was compiled as described in the methods chapter (page 93). In summary, one point was given for each of the following: each waste management programme; for having an action plan in place for the then forthcoming WEEE legislation; for each environmental certification including ISO14000; for use of environmental audits and for each inclusion of environmental considerations in operations. In cases where such consideration is always given two points were awarded. In all these gave a possible IE score of 29. Additionally, three points were given for specification of a practice which has positive environmental impact and is a reflection of initiative and innovative behaviour. The four environment in strategy variables from the main IMSS questionnaire were not included. The mean score for the IE index is 13.8 (Table 5.4.3). Over one quarter of firms have a relatively high score (11 firms scored 20 - 23 points and 1 firm scored 34) and one third of respondents scored less than 10 points.

Table 5.4.3
Irish Environment (IE) Index Scores (N=32)

	IE Index Score	
Lowest	1	
Highest	34	
Median	14	
Mean	13.8	
(std dev)	(8.6)	

IE Index Groups	No. Firms	% Firms
Low (1-9)	11	34
Medium (10-19)	9	28
High (20+)	12	38

Manufacturing Strategy

The IE index groups are compared according to the four manufacturing strategy questions from the main IMSS questionnaire: competitive priorities, action programmes, performance improvement and improvement goals.

Several competitive priorities differ between IE index groups (Table 5.4.4). Although the mean importance of product design and quality differs significantly between high score group (4.8) and the low/medium score group (4.1) both groups rank this the highest priority. The order of the top four priorities does not differ between the groups. Both groups ranked environmentally sound products lowest.

The reported use of action programmes tends to be higher in general among the high score group. However the order of use also differs. Process focus/streamlining was the most used action programmes in the high score group compared to expanding manufacturing capacity in the low/medium group. Quality improvement ranked second in both groups although the mean use was higher in the high score group. The high score group ranked use of action programmes for environmental compatibility / health & safety in fourth place and the low score group ranked it in second place.

Among the areas of performance improvement and improvement goals the only difference between groups was in the greater importance assigned to mix flexibility by the high score group (Table 5.4.5). This group ranked mix flexibility among the top improvement goals and ranked overhead costs first. The low/medium group ranked mix flexibility in the lowest three goals and ranked labour productivity first. Both groups ranked product customisation ability and environmental performance lowest.

Table 5.4.4
Competitive Priorities and Use of Action Programmes over previous 3 years by Score on Irish Environment Index (N=32)

Competitive Priorities Mean Importance (1-5)	IE Index Score		
	Low/Medium	High	All Irish
Product design and quality	4.1	4.8*	4.3
Conformance quality	4.0	4.6	4.2
Dependable deliveries	3.9	4.1	4.0
Superior customer service	3.8	4.0	3.9
Faster deliveries	3.6	3.7	3.6
Wider product range	3.3	3.9	3.6
Lower selling prices	3.6	3.5	3.5
Newer products more frequently	3.0	3.8*	3.3
Greater order size flexibility	2.8	3.5*	3.1
<i>Environmentally sound products</i>	2.6	3.5*	3.0
Action Programmes			
Mean Use (1-5)			
Expanding manufacturing capacity	3.8	3.8	3.8
Quality improvement	3.2	4.3**	3.6
<i>Environmental compatibility / health & safety</i>	3.3	3.9	3.6
Process focus & streamlining	3.1	4.4**	3.6
Updating process equipment	3.1	4.1*	3.5
Information/communication technologies/ERP	3.3	3.6	3.4
Implementing pull-production	3.1	3.6	3.3
Restructuring supply strategy	3.0	3.5	3.2
Delegation & knowledge of workforce	2.9	3.5	3.1
New product development improvement	2.7	3.2	2.9
Equipment productivity improvement	2.3	3.4*	2.8
Process automation	2.1	3.4*	2.6
Reorganizing for e-commerce	2.2	2.9	2.5
Outsourcing non-core activities	2.4	2.1	2.3

* p<0.05, ** p<0.01

5.4.2 IE Index, Environment in Strategy Index and the Innovation Score

This chapter concludes with a look at the relationship of the IE index to the environment in strategy (ES) index and the innovation score from the main IMSS questionnaire. The ES index was generated from the four environmental items in the manufacturing strategy questions. The innovation score was generated from variables related to innovation. The IE index of the Irish respondents is significantly correlated to both the ES index ($r=0.431$, $p<0.05$) and the innovation score ($r=0.441$, $p<0.05$). This is despite that the ES index and the innovation score are not significantly correlated with each other ($r=0.191$). The innovation score of the high IE index group is significantly higher (3.3) than for the low and medium groups (1.8 and 2.3 respectively) (Table 5.4.6).

Table 5.4.5

Performance Improvement over previous 3 years and Importance of Improvement Goals for next 3 years by Score on Irish Environment Index (N=32)

	Performance Improvement Mean Improvement (1-5)			Improvement Goals Mean Importance (1-5)		
	Low/Medium	High	All Irish	Low/Medium	High	All Irish
Manufacturing conformance	3.7	3.8	3.7	4.1	3.6	3.9
Product quality & reliability	3.8	3.9	3.8	4.3	4.0	4.2
Product customisation ability	3.3	3.6	3.4	3.1	3.5	3.3
Volume flexibility	4.1	4.1	4.1	3.8	4.1	3.9
Mix flexibility	3.5	3.9	3.7	3.4	4.3*	3.7
Time to market	3.4	3.8	3.6	4.0	4.3	4.1
Superior customer service	3.8	4.0	3.9	4.4	4.2	4.3
Delivery speed	3.6	3.6	3.6	3.7	4.1	3.9
Delivery reliability	3.9	3.7	3.8	4.1	4.2	4.1
Manufacturing lead time	3.9	3.7	3.8	4.2	4.3	4.2
Procurement lead time	3.2	3.7	3.4	4.2	4.0	4.1
Procurement costs	3.2	3.6	3.3	4.4	4.3	4.3
Labour productivity	3.7	4.2*	3.9	4.5	4.3	4.4
Inventory turnover	3.6	3.9	3.7	3.9	4.3	4.0
Capacity utilisation	3.7	3.9	3.8	4.1	4.1	4.1
Overhead costs	3.3	3.3	3.3	4.3	4.7	4.4
<i>Environmental performance</i>	3.6	3.9	3.7	3.4	3.9	3.6

** p<0.01, * p<0.05, † p<=0.05

Table 5.4.6

Irish Environmental Index Groups - Environment in Strategy (ES) and Innovation (N=32)

	IE Index Group				difference
	Low	Medium	High	Total	
Environment in Strategy (ES) Index Score	-2.1	-0.4	-0.4	-0.9	
Innovation Score (8max)	1.8	2.3	3.3	2.5	*
ES Group	% IE Group				
Negative	80	44	33	52	
Neutral	20	11	42	26	
Positive	0	44	25	23	
Innovation Group					
Low Score	46	44	25	38	
Medium Score	46	33	17	31	
High Score	9	22	58	31	

Performance related variables which are significantly higher among the high IE index group are: ISO14001 certification, supplier co-ordination, plant size and sales. Other significant variables in Table 5.4.7 which are higher in the medium IE index group are: the influence of manufacturing on business/marketing strategies, throughput time efficiency, employees worldwide, purchases from other regions. Finally, internal quality costs are significantly higher in the low scoring IE index group.

Table 5.4.7
Summary of Irish Environmental Index – Mean or Percent ^a (N=32)

Innovation	IE Index Group				difference
	Low	Medium	High	Total	
Operations Technology (max 65)	22	24	26	24	
ERP (max 35)	23	26	28	26	
R & D (% revenues)	4	2	7	5	
Process Equipment (% revenues)	6	3	4	4	
Training (% revenues)	2	3	3	3	
Manufacturing Overheads (%)	19	13	23	19	
Co-ordination of Design & Manufacturing	-0.444	0.408	0.615	0.193	*
Product Development Cycle	-0.453	0.314	0.600	0.153	*
<i>Innovation Score (8max)</i>	1.8	2.3	3.3	2.5	*
Formalisation					
Formal Strategy (1-5)	3.1	3.3	4.0	3.5	
Business/marketing goals translate to manufacturing (1-5)	3.3	3.9	3.8	3.7	
Manufacturing influence on business/marketing strategies(1-5)	2.4	3.6	3.0	2.9	*
ISO9000 (% index group)	100	100	100	100	
ISO14001 (% index group)	18	44	58	41	
ISO14001 (% of certified)	15	31	54	100	
ISO14001 (% of non-certified)	47	26	26	100	
Quality & Efficiency					
Inspection costs	35	37	40	38	
Internal quality costs	37	17	15	23	*
Preventive costs	20	31	36	30	
External quality costs	8	14	9	10	
Throughput Time Efficiency	23	62	46	42	*
External Integration					
Co-design (max 21)	3	3	3	3	
Customer Co-ordination (max 35)	15	18	20	18	
Supplier Co-ordination (max 35)	15	18	25	20	*
Employee Compensation					
Workgroup incentives (% index group)	9	11	33	19	
Individual incentives (% index group)	27	22	25	25	
Companywide incentives (% index group)	36	33	67	47	
Size, International, Sector					
No. employees– Plant (n=495 ^b)	210	209	757	415	*
No. employees - World-wide (n=301 ^b)	6,373	50,589	23,895	24,975	*
Foreign headquarters (% group)	55	78	100	78	
Sales ^b (millions US\$, 2000)(outliers included)	180	48	838	361	*
Sales (millions US\$, 2000) (outliers excluded)	40	48	74	50	
% Purchases from own region ^b	38	62	30	41	
% Sales to own region ^b	32	23	53	38	
% Purchases from other regions ^b	57	66	57	59	*
% Sales to other regions ^b	21	28	41	31	
ISIC_381 (% sector) ^c	67	17	17	100	
ISIC_382 (% sector)	0	100	0	100	
ISIC_383 (% sector)	27	29	43	100	
ISIC_384 (% sector)	-	-	-	-	
ISIC_385 (% sector)	25	25	50	100	

^a Figures rounded so some additions not exactly to 100%

^b Means include outliers

^c ISIC (rev.2) Division 38: 381 metal products except machinery & equipment; 382 machinery except electrical; 383 electrical equipment, apparatus, appliances & supplies; 384 transportation equipment; 385 professional, scientific & measuring, photographic & optical equipment.

* p<0.05 (ANOVA, Kruskal-Wallis)

The relationship of the IE index with innovation and performance variables from the main IMSS questionnaire is presented in Table 5.4.7. It can be seen from the table that the significant variables within the innovation score are Co-ordination of Design & Manufacturing and Product Development Cycle both of which are higher among the high IE score group. Since these are both composite variables their components are presented separately in Table 5.4.8. However, it may be seen from this tables that no single component of these is significantly related to the IE index and it is the combined effect in the composite variables which makes them significant.

Table 5.4.8
Product Development Variables – ‘Overall’ Composite variables used for Innovation Score (factor scores) Irish Environment (IE) Index Groups (N=32)

Innovation	IE Index Group				difference
	Low	Medium	High	Total	
Use of rules and standards	3.6	3.9	4.2	3.9	
Use of cross-functional teams	3.2	4.4	3.9	3.6	
Use of job rotation	1.6	1.5	2.0	3.7	
<i>Overall Co-ordination of Design & Manufacturing (factor score)</i>	-0.444	0.408	0.615	0.193	*
Early involvement of the manufacturing function	3.2	3.6	3.9	3.6	
Use of concurrent engineering	3.1	3.5	4.0	3.6	
Use of tests and prototypes	3.2	4.0	4.0	3.7	
<i>Overall Management of Product Development Cycle (factor score)</i>	-0.453	0.314	0.600	0.153	*
<i>Innovation Score (8max)</i>	1.8	2.3	3.3	2.5	*

5.5 Conclusions from Survey Analyses

This chapter presented the results from the analysis of the IMSS survey data. First some general results of variables relating to the environment in strategy, innovation and performance were given and the results of the Irish respondents were highlighted. Next, results of the ES index - a measure of the prominence of environmental management in strategy – were presented. The final section of this chapter presented results specific to the Irish respondents pertaining to environmental management and used in conjunction with the IMSS ES index and innovation variables to assist in the selection of cases for further analysis.

The IMSS survey comprised 558 respondents from 17 countries. Innovation and performance related variables were identified based on the literature. A measure of the salience of the environment in manufacturing strategy was determined - the environment in strategy (ES) index. This was developed using the relative position of the environmental item within four key manufacturing strategy questions. Negative, neutral and positive ES groups are identified.

There are some significant relationships between the ES index and the innovation and performance variables. However, regression models identify only three variables predicting the ES index: R&D, influence of manufacturing on business/marketing strategies and ISO14001. The results also indicate that these are weak and account for small variances in the ES index meaning the innovation and performance variables have poor predictive capacity. The results of the comparative analyses indicate the same significant variables and they

give a better picture of the relationships with the ES index. However, links between the ES index and the innovation and performance variables remain inconclusive.

For example, ISO14001 is the most significant variable identified. Thirty percent of the positive ES group have this certification compared to only 13% of the negative ES group. However, of all the firms with ISO14001 more are in the negative group (37%) than either the neutral (29%) or positive (34%) groups. Several explanations are possible. Perhaps the most obvious is that while a firm may have ISO14001, environmental management may not be a prominent feature of manufacturing strategy. For example, it may be equally considered with others as a priority or it may be an order qualifier rather than an order winner. Or a firm may have a well established environmental management system (EMS) and therefore did not need to invest significantly in action programmes over the previous three years or did not improve upon already superior performance. In addition, 19% of non-certified firms are in the positive ES group. Perhaps these firms have an alternative EMS or environmental policy in place. The IMSS questionnaire does not ask whether there is an EMS in place certified or not, it only asks about ISO14001. Also, there are no actual measures of environmental performance in the IMSS questionnaire against which to compare the ES index.

Limitations of using the IMSS survey may also arise in regarding the innovation and performance related variables. These were selected for this analysis from the already existing questionnaire rather than being a part of its original design. It is always possible that prominence in environmental management is unrelated to these identified variables and thus such hypothesis could be rejected. However, given the limitations of the questionnaire in relation to environmental management the hypothesis should not yet be rejected and further investigation is required.

The final section of this chapter presents some results specific to the 32 Irish based IMSS respondents relating to environmental management. An Irish environment (IE) index was created using the additional questions regarding environmental practices. These questions are also limited but they are more specific and yield better results in relation to links with the innovation and performance variables in the main IMSS questionnaire. For example, firms with a high IE score also have a higher innovation score. Therefore this part of the survey analysis provides some support for the hypotheses linking the prominence of environmental management with innovation and performance in other areas of manufacturing.

In order to further investigate these relationships and to illuminate these results a qualitative approach was adopted for the next phase of the research. As explained in the methods chapter, mixed methods and adaptive theory were adopted in this study. Mixed methods enables both quantitative and qualitative data collection and triangulation to take place within the same study to increase validity (Grix, 2004). Adaptive theory allows for both deduction and induction through open theorising in the course of the research (Layder, 1998). Following the survey analysis, complementary case studies are used to enlighten and gain insight into causal processes (Yin, 2003). Six firms were selected for case analysis. Four of these were selected based on the IMSS survey data and results and two other firms were selected through recommendation of experts in the field of environmental management. The selection process is described in the methods chapter 4.5 (page 97). The next chapter (6) presents the six cases and concludes with a cross case analysis. The findings are then discussed and analysed in Chapter 7.

RESULTS

PART 2 – Case Analyses

6. RESULTS
PART 2 – Case Analyses

6.1 Introduction

Complementing the survey, case analysis was chosen to further illuminate the role of environmental management in manufacturing firms and its relationships with innovation and other processes. This chapter briefly describes the selection of firms for case analysis (a template is given in the methods chapter 4, page 101). It then presents the six cases individually and concludes with a cross case analysis. Findings are discussed in Chapter 7.

6.2 Selection of Cases

The selection criteria for case analyses are described in full in the methods chapter 4.5 (page 97). Essentially, three firms (A, B and C) meeting two of the following criteria from the first IMSS survey were chosen: high innovation score, high IMSS Environment in Strategy (ES) score, high Irish Environment (IE) score and ISO 14001 certification. One firm meeting only one criterion (D), a high Irish Environment score, and none of the other criteria was chosen as either a possible confirmatory or negative example. Also, this firm is widely known for innovation in its products. Two firms (X and Y) each recommended by two experts were also chosen as another source of triangulation apart from the survey data. The six firms accepting to participate in interviews and their selection criteria are summarised in Table 6.2.1.

Table 6.2.1
Case Firms & their Selection Criteria

Firm	A	B	C	D	X	Y
Product	Measuring equipment	ICT parts / supplies	networks / cables	audio systems	mainframe computers	electronic car components
ISIC (rev 3.1)	33	30	32	32	30	34
No. Employees: on-site	150	2,000	220	230	2,500	280
No. Employees: worldwide	1,754	150,000	4,000	8,000	355,000	320
Ownership	public	public	public	private	public	private
Headquarters	UK	USA	USA	USA	USA	Ireland
IMSS III – 1 st survey	✓	✓	✓	✓	x	x
IMSS IV – 2 nd survey	✓	x	✓	✓	✓	✓
IMSS Environment in Strategy (ES) Group	positive	neutral	neutral	negative	-	-
Irish Environment (IE) Index Group	medium	high	high	high	-	-
Selection Criteria						
High Innovation Score	✓	✓			-	-
High IMSS Environment in Strategy (ES) score	✓				-	-
High Irish Environment (IE) index score		✓	✓	✓	-	-
ISO14000		✓	✓		✓	✓
Recommendation of Experts		✓			✓✓	✓✓

6.3 Case Results: Firms A, B, C, D, X and Y

6.3.1 Firm A

Description: Manufacturer of precision industrial measurement and spectroscopy instruments

Location: Dublin (since 1981)

Corporate Headquarters: England

Sales: Year ending June 2004 Group Sales were £128m

Employees: 140 on-site in Dublin and 1,754 employees worldwide including 1,279 in UK and 335 elsewhere (by 2006 the worldwide employment rose to 1,900 with 140 still in Dublin).

IMSS Surveys: Firm A participated in both IMSS surveys which were completed by the Managing Director.

Selection for Further Analysis: This firm was selected because the IMSS survey data analysis classified it as an innovation leader and it had a high IMSS environmental score.

Interviews: Main interview conducted on-site with Managing Director on 25th November 2004 accompanied by shorter interviews with: Facilities Manager, Engineering Manager and Materials Manager. A subsequent telephone interview was conducted with the Group Quality Manager based in the Headquarters, England, on 2nd December 2004.

General Profile: Firm A is an innovation driven manufacturer of high precision measuring metrology equipment & probes. Ninety percent of the world market for the product is manufactured in the Dublin plant. Standard and customised products are manufactured. Demand is very high particularly with car manufacturers. Customised products include a reverse engineering service which can create an exact mould of any object using extremely high resolution scanning technology. Firm A takes particular pride in the quality of the product. All sales go to Firm A subsidiaries around the world – these are wholly owned and responsible for sales, market development, technical support etc. Most R&D and process development is conducted in the UK.

Manufacturing: The current manufacturing facility was built in 1998. It was designed in consultation with staff: plenty of windows to see out, high ceiling with very bright day-lights, no pillars or service columns (all these run through the floor), there are few offices and these are windowed and open directly onto factory floor. From the outside the facility looks like a large house not like a factory or warehouse – it has a brick facade with a false sloped roof. The building is designed for efficient heating and cooling which are the main energy uses.

Firm A operates in a cellular process with each cell having a team of 10 employees on average. Each cell receives customer orders from the central planning system and is responsible for everything to do with the order including quality and packing for shipment (except for sales to Japan where quality is checked again before shipping). Shipping also operates as a separate cell. Cells manage their own inventory which is kept low and there is no storage warehouse. Firm A manufactures its own cables etc for control of high specification and quality. Firm A also creates its own robotics for which there is a separate cell. Clean air on work benches is generated through a pressure differential control system.

The co-ordination of design and manufacturing in *Firm A* contributed to its high innovation score in the earlier analysis. Organisationally, design and manufacturing are co-ordinated through the high use of rules and standards, formal meetings and cross-functional/multi-skilled teams as well as moderate use of informal discussions and communications. The product and process designs are mainly co-ordinated through prototyping and testing at the early stages of product design as well as the use of early involvement of manufacturing in the product design and concurrent engineering.

In Dublin, the engineering emphasis is on process improvements without affecting product design. When the design of a product is affected there is a need to involve others and refer back to the UK design teams. Co-design occurs with both suppliers and customers. Engineering and process design are conducted more with the supplier. Product development and testing is mainly with the customer. Overall, *Firm A* has a high level of co-ordination of planning decisions and flow of goods with both suppliers and customers classing it as outward facing on the arc of integration.

Innovation & Technology

Firm A is a technology driven organisation. Innovation is an “essential value” and the focus is on patents. It only manufactures its own patented and original products. Patents finance all activities. Most UK employees (1,279) are employed in R&D. Investment in R&D is 20% of sales per annum (compared to an IMSS mean of 7%). *Firm A* has won many innovation and product related awards. The Dublin plant does not have its own R&D budget.

Firm A operates a comprehensive ERP system through which everything may be linked and all information is readily available. There is particularly a high use of ERP systems in the areas of production, supply chain, sales and financial. Manufacturing operations employ a wide range of technologies. Both the use of ERP and technologies contribute to the firm’s high innovation score.

Innovation, Technology & Environment

Firm A does not produce any products specifically linked to the environment. Environmental management is seen as normal natural constraint just like anything else e.g. safe products and is accepted as common sense. Products are designed with environmental consideration. Environment is included from earliest stages of R&D and at the design for manufacture stage. It is inherent in design and a Life-Cycle-Analysis is conducted. However, there is no specific environment related R&D nor does *Firm A* specifically dedicate a proportion of the R&D budget to environment related issues. Although *Firm A* did not identify any environmentally differentiated products or processes (in either IMSS III or IV) it has researched environmentally improved processes. New challenges are mainly in processes.

Training

Sixty percent of production employees are multi-skilled. Cross-functionality is encouraged but tasks are highly specialized and training can take up to one year. New employees mostly start with three months training. Due to intensive nature of training and high level of autonomy employees are very committed which contributes to the low turnover of staff.

No specific training in environmental management is undertaken. A “common sense” approach is adopted and it is seen as “good housekeeping”. Cleanliness, tidiness etc is a part of the induction training and part of

Firm A's culture. The Dublin plant is particularly good at this compared to others in group. Employees are proactive, for example, all paper and ink cartridges are recycled due to employee initiatives.

Incentives

Profit sharing bonuses are company-wide. There are no environment related bonuses. *Firm A* operates a philosophy of caring for the employees to motivate and to nurture pride and loyalty. Employees are highly trained and investment in staff is important to protect. Excellent on-site facilities such as gym, shower and canteens all contribute to support this philosophy.

Waste Management

All waste is recycled except they could not get plastic bottles collected although tried (this has since changed the interview due to new waste collection regulations and facilities for recycling of plastic bottles). Hazardous waste is managed by a contractor. A small amount of waste glue is generated and this is returned to manufacturer – this was *Firm A's* own initiative. Waste from cleaning products, aracyl, is used for fuel. Lighting – all bulbs are recycled (mercury etc). Cost of disposal is a major driver in waste management and reduction. Coat of waste is tracked through the supply chain.

Packaging

All packaging is either reused or recycled. Moulded foam is being replaced by cardboard cut-outs designed for each product (packaging also serves as display units for products). The use of cardboard also results in greater use of space as it comes in flat sheets. Some biodegradable foam is used. Use wooden pallets for bulk transport (these must use fumigated for Far East and also do for US). *Firm A* sees no need to be member of Repak because all waste is recycled anyway.

WEEE & RoHS

Prior to the legislation *Firm A* was very proactive in this area. *Firm A* likes to be “ahead of the game”. Even though it was not required to do so ‘lead-free’ was a priority due to customer demands in Japan. *Firm A* was also preparing to implement ‘lead-free’ for all markets. A special team working on ‘lead-free’ includes two people in Dublin. Even when exempt they were implementing RoHS for all products.

Firm A anticipated that WEEE & RoHS regulations will probably not affect its manufacturing as much as the 1987 Montreal Protocol on Substances That Deplete the Ozone Layer namely chlorofluorocarbons (CFCs). This resulted in changes to many processes particularly cleaning which is extremely important in instrumentation manufacture.

Energy Use

Firm A monitors overall energy use on a weekly basis but not at individual cell/operation level. Main energy use is for heating and cooling. Although energy costs are very small relative to turnover which is very high *Firm A* actively manages energy use to reduce waste and costs. *Firm A* changed supplier to avoid penalties but basic service is same. This is not purchased from a renewable source. *Firm A* is not engaged in the Emissions Trading Scheme nor does it need a Greenhouse Gas Emission Permit.

Environmental Strategy

There is no formalisation of environmental strategy. Environmental and Corporate Social Responsibility Policies as well as environmental performance indicators and goals are determined by corporate headquarters. When the Group Profile Statement available on the website was mentioned by the interviewer the Managing Director responded that this was probably only place where it was written and that probably most employees were not aware of it. The environmental policy, goal setting, training, external auditing, accounting and benchmarking are all undertaken by the Group headquarters. Internal audits, public environmental reports and tracking of waste through the supply chain are conducted by the Dublin plant.

Currently *Firm A* is fully compliant with regulations and often is actively complying prior to the implementation of new regulations. Nevertheless the clear goal is to go beyond compliance as stated in the environmental policy statement and as is evident in some practices. The board is very keen to drive and support this and environmental management is not seen as strategically different to quality.

Since *Firm A* has a monopoly for many of its products because of patents, it has “a moral duty to the customer” and needs to be “irreproachable” in relation to quality, environmental and ethical standards etc. If the firm fails in its moral contract with the customer it will loose - the customer will look for a competitor. Therefore it makes good business sense to uphold high standards and it will not do anything to jeopardise its reputation.

Firm A “is in business to make profit but will not do so by cutting corners but rather through top quality innovation, for example by using efficient processes and not wasting. It does not go for quick short term profits but has a long-term outlook and insists on maintaining high standards”.

These policy statements were taken from *Firm A*’s corporate website:

Mission Statement

Firm A will design, manufacture and supply metrology systems of the highest quality and reliability to enable customers worldwide to carry out dimensional measurements to traceable standards.

Our product offerings will enhance quality and productivity, and we will strive for total customer satisfaction through superior customer service.

Our aim is to provide leading edge technology by encouraging innovation to address our customers' needs.

We are committed to sustained growth through continued investment in product development and manufacturing methods.

Firm A wish to be recognised collectively and individually as leaders and contributors in our field and our community.

We wish to achieve our aims in a way that is caring, open and honest. *Firm A* is an environmentally conscious and responsible company. We will strive to ensure that all aspects of the business have the least harmful effect on the environment.”

Corporate Environmental Policy

The corporate environmental policy is an integral part of *Firm A*’s business strategy. The responsibility for managing and maintaining the policy lies with the Board of *Firm A*.

“*Firm A* is an environmentally conscious and responsible company. To carry out this commitment, it is *Firm A*’s policy to strive to ensure that all aspects of the business have the least harmful effect on the environment by implementing an environmental management system to:

- Be fully aware of all environmental legislation and ensure that regulatory requirements are met and, where feasible, improved upon.
- Monitor the implementation of the policy by carrying out periodic audits of compliance and, when appropriate, introduce remedial measures.
- Ensure all employees, in the course of their duties, act in accordance with the environmental policy.
- Encourage suppliers, contractors and vendors to act in accordance with our environmental standards.

In addition, areas of particular attention within the business will be the selection of non-polluting technology, waste minimisation, reuse/recycling and the reduction of energy consumption. *Firm A* also makes a positive environmental contribution in the local community by encouraging open communication, general environmental awareness and the promotion of community projects.”

Overall responsibility for environmental management at corporate level is the responsibility of the Group Quality Manager. In Dublin, the Facilities Manager has overall explicit responsibility for environmental management area and issues in each functional area such as engineering and materials are covered by the relevant managers. Environmental management issues are quite linked to health and safety. When questioned on EMS the Managing Director’s answer referred to weekly Health and Safety meetings which “include all things – accidents, exposure to chemicals etc.”

Environmental Management System - ISO14001

The view of the Managing Director in Dublin was that they were already probably doing all the ISO requires and more without having an actual certificate and that even so there would be work involved in obtaining the ISO14001 certification. They already had ISO9000:2002.

However, the Group Quality manager explained that the firm is in the process of getting ISO14001 certification. They are doing it on a site-by-site basis rather than companywide which may explain the unawareness of Dublin. The view of this manager was also that the firm was already doing many of the ISO requirements for a long time. Basic activities such as recycling and more proactive ones such as the development of sites to encourage wildlife were already part of the *Firm A*’s strategy which they wish to formalise.

The main driver for the ISO14001 is the customer. While customers are not demanding it they are increasingly asking about it. Certification would give confidence and clarity to the customer. There is less concern on the supplier side. While *Firm A* will encourage suppliers as part of the EMS it has less clout with them since it is a small firm. The exception is with specialist sub-contractor which will be analysed as part of the EMS “but not in spirit of evangelism but rather in business sense”. *Firm A* depends on the supplier and if supplier goes down or has problem it would not be good for business. However, the main issues are not so much in products buy but in processing.

Firm A is adopting the same approach to ISO14001 as for quality, health and safety etc just with a different audit. The view is that the same management tools apply.

The reason for certifying on a site basis is that some sites have different quality and general management systems for historical reasons. Sites with the same set up will certify first. Other sites will follow and the aim is for all systems to converge. The Dublin site is built on the desired model but some other sites in the UK are very different and the firm is keen to make these the same and employ the same models for quality and other systems across all sites.

An intranet is being developed to support the EMS.

The main barriers envisaged related to the use of resources which are “stolen” from other activities such as time. While *Firm A* recognises that the process of EMS is not easy this is not seen as problem. The EMS is a self-imposed target and can be implemented at a rate that is suitable.

Certification

Certification in itself is not an important issue for *Firm A* in general. The firm relies on the quality of its product and does not see a need “to blow our own trumpet” in areas unrelated to the product. This is in contrast to the numerous product and innovation awards which the firm has won and which it readily promotes.

Environmental Management Budget

Firm A operates based on projects and all environmental matters are included within each project as a cost. No specific budget exists for environmental management in general or in particular at the functional or project level and nor it is this likely in the foreseeable future.

Drivers

Corporate headquarters and the regulatory authorities are seen as having the most influence in determining environmental practices. The chairman, based in the UK but with Irish connections, who founded the company, and his wife are very environmentally concerned and proactive. This has been a major driver of *Firm A*'s philosophy and the board is very keen to perform at the best environmental standards possible.

Cost is also a major driver in the environmental management at *Firm A* particularly for waste and energy management.

Customer demands drive a lot of the environmental management initiatives at *Firm A*. Japan and Germany stand out as being particularly strong in this area. Environmental measures are order qualifiers for example in the instances of lead-free manufacture for Japan and recyclable packaging for Germany. Customer interest in ISO14001 is also an incentive for attaining certification.

The regulatory authorities are also a major driver for environmental management. The legal team at corporate headquarters are vigilant in keeping the firm up-to-date on developments and forthcoming regulations in all relevant countries. The aim is to be always prepared for new legislation in advance of its implementation and in many cases it complies in advance. Such was the case of the RoHS ‘lead-free’ Directive which also conformed with the requirements of the Japanese market and which was being implemented for all markets.

Employees and suppliers also exert some influence on environmental policy and practices at *Firm A* (Dublin). Non-management employees have considerably influenced environmental practices at the Dublin plant while management employees have also had some influence. As noted above, employees are proactive

in this regard. Local organisations, environmental organisation or others exert little influence in determining policy and practices.

Networking

Firm A (Dublin) engages in virtually no networking of any kind. It is involved to some degree in the industrial estate to keep the place tidy and secure. Also, it has prevented some industries entering the estate through planning objections on environmental grounds e.g. woodturning which creates a lot of sawdust which would have affected its clean manufacturing requirements. *Firm A* views itself as very self-contained and is not interested in external networking or ‘in meeting for chats’ etc. It is not interested in a network group for environment as the belief is that it is ‘already doing all that it can do’. However, this is not a corporate policy. For example, at the group headquarters there is a considerable amount of networking conducted especially in the area of quality management. In Ireland *Firm A* is engaged with third level institutes through funding of engineering research programmes. Elsewhere it sponsors an educational environmental innovation competition at school level and is engaged with local community projects.

6.3.2 Firm B

Description: This site manufactures supplies for the firm's own electronic equipment in the EMEA region (Europe, Middle East and Africa).

Location: Greater Dublin Area - Firm B established operations in Ireland in 1971 and this facility was built in 1995.

Corporate Headquarters: USA

Sales: Year ending October 31 2005 global revenues were US\$86.7 billion.

Employees: 2,000 on-site and approximately 150,000 employees in over 900 sites in 70 countries (October 2005).

IMSS Surveys: Firm B participated in the first IMSS survey which was completed by the Managing Director but did not respond to the second IMSS survey.

Selection for Further Analysis: This firm was selected based on the IMSS survey data analysis which classified it as an innovation leader, it is ISO14001 certified and it was recommended by an expert. It had a neutral IMSS environmental score.

Interview: Interview held on-site with the Environmental Programme Manager on 24th February 2005.

General Profile: Firm B is one of the world's largest information technology organisations. It prides itself as an innovation driven organisation.

Firm B has a very positive international reputation for environmental initiatives. This is rooted in an explicit commitment to social responsibility which has been part of the firm's philosophy since its inception. Extensive and comprehensive information on environmental and social matters is available publicly on the corporate website. Clear statements of policy as well as access to many reports and data are possible through the website. The Global Reporting Initiative (GRI) guidelines are followed where possible and the firm's GRI index is published. Due to its size and global distribution the impact of Firm B and its products on the environment is widespread and vast. The primary areas of environmental impact, identified by the firm itself, arising from its operations are climate change, energy use and waste.

Firm B has over 2,000 employees on this Irish site which is its largest manufacturing operation outside of the USA. Other sites in Ireland are responsible for sales, marketing and customer care etc. There are similar operations in Singapore and Puerto Rico. All three sites manufacture similar products but each one has special expertise and capability for a particular range of products. In the past the Irish site competed on cost & productivity but now the site is also conducting higher value activities. For example, some R&D is now being conducted on-site. Co-ordination of planning decisions and flow of goods with customers and suppliers classified Firm B as outward-facing on the arc of integration.

Innovation & Technology

In 2005, the firm invested US\$3.5 billion on research and development. It has won many innovation awards internationally and holds thousands of patents. In 2005 alone it was awarded 1,797 patents and it ranked third in the number of patents awarded by the US Patent and Trademark Office in the same year. Design is

conducted centrally at specific sites within the firm mainly in the US with some minor R&D taking place elsewhere for example in the Dublin site which is gradually increasing its R&D activities.

Innovation, Technology & Environment

Design teams will design a product and then assess the environmental impact by examining materials, life cycle, recyclability etc. The firm also operates a Design for Environment programme which researches ways of using materials more efficiently, alternatives for designated materials, design for energy efficiency, and design of products that can be easily recycled (as elaborated below).

In 1998, *Firm B* introduced a standard restricting or prohibiting certain chemical compounds or materials in its products and manufacturing processes. Called the General Specification for the Environment (GSE) it applies for all product content globally and along the whole supply chain.

Design for Recycling Standards

The firm has integrated its own guidelines into the design of products specifically to facilitate their recycling. These standards were developed and continue to be developed based on the experience of *Firm B's* own recovery and recycling operations which identifies effective design features for recycling such as:

- Using modular design to allow components to be removed, upgraded or replaced
- Eliminating glues and adhesives by using, for example, snap-in features
- Marking plastic parts weighing more than 25g according to ISO 11469 international standards, to speed up materials identification during recycling
- Reducing the number and types of materials used
- Using single plastic polymers
- Using molded-in colors and finishes instead of paint, coatings or plating

The interviewee was not aware of innovative biodegradable machine designs for which *Firm B* won an award and which the author saw on internet the previous week. He surmised that this reflected the size of *Firm B* where design is far removed from the manufacturing conducted at this site and that so much is happening at the design centre it is not feasible to keep informed of every development there.

Packaging

At corporate level *Firm B* has a clear policy of minimising the environmental impact of packaging in a manner that is cost effective. It operates under the following guidelines:

- Design to reduce packaging material use while protecting products
- Eliminate the use of restricted materials such as lead, chromium, mercury and cadmium in packaging
- Eliminate the use of ozone-depleting substances in packaging materials
- Design packaging components for ease of disassembly by the end-user
- Maximize the use of post-consumer recycled content in packaging materials
- Use readily recyclable packaging materials such as pulp, paper and corrugated materials
- Reduce packaging size and weight to improve transportation fuel efficiency

Firm B has developed a tool for measuring the amount and cost of packaging as well as the efficient loading of the product onto pallets for shipping. This enables engineers to measure the packaging and transport costs of each unit. Using this tool has enabled *Firm B* to achieve considerable reductions in both weight and size of packaging which have led to many cost savings in the packaging itself as well as in the transport of goods. The environmental impact has been in the reduced packaging material, use of recycled material and reduced energy expenditure for both the manufacture of packaging and the shipment of goods.

For lightweight and some heavier products *Firm B* is replacing expanded polystyrene foam (EPS) with moulded pulp made from old newspapers. It has set clear targets in relation to the replacement of EPS for more fragile products.

In the United States *Firm B* works closely with third level institutions to develop industry standards and with the Institute of Packaging Professionals to develop a certification system for packaging designers and engineers. Packaging is designed at corporate level to have consistency worldwide. The only differences are in language or some recycling options.

The product from the Dublin site is relatively small and light. It requires only cardboard packaging. Pressure against reduced packaging comes from retail customers who would prefer bulky packaging for security reasons.

With regard to the transport of goods euro-pallets are used in a closed loop with large suppliers. Otherwise wooden pallets are used and these are reused and recycled as appropriate.

Waste Management

On site all possible recycling measures are implemented. Simple measures have been effective, such as a ban on bins at desks. Staff must go to segregated bins. Initially, this met with some resistance but the introduction of domestic per weight charges heightened staff awareness.

Hydrofluorocarbon (HFC) cleaning solvents are the main hazardous waste from manufacturing. These are sent to the Netherlands to be cleaned for reuse.

Firm B has committed to removing of HFCs from manufacturing and to replace them with a water-based process. This is a voluntary agreement with a group of large manufacturers. The cost for *Firm B* will be about €3 million to update equipment. Even though this is a voluntary agreement the Environmental Protection Agency (EPA) will monitor progress to ensure that the firm is meeting its commitments. This also helps with the firm's relationship with the EPA by showing that it is proactive.

Globally, progress in many areas of waste reduction was achieved in 2005 compared to 2004. For example, solid waste volumes were reduced by 7% and hazardous waste volumes by 5%.

Post-consumer Recycling

In all countries consumers can return the products after use. In some countries with a high population (e.g. Germany, France, UK) an envelope is included in the package to return the used product to the firm for recycling and 10% of these envelopes are used. *Firm B* intends to introduce the enclosed envelope to smaller markets like Ireland in the near future. In Ireland it expects the level of recycling to increase rapidly due to the combined effect of the WEEE regulation and the introduction of domestic waste charges.

Apart from the societal and environmental benefits, *Firm B* believes it makes sense for the firm itself to recycle both in terms of cost and market image. However, it will recycle the product rather than re-use it due to perceived quality impairments of re-use by consumers.

Measured recycling targets for the site and also for EMEA region are enforced and contribute to corporate reporting.

WEEE & RoHS

WEEE legislation does not affect products from this Irish site as consumable supplies are not covered by the regulation. However, the EH&S team is very aware of WEEE requirements in order to inform marketing and sales teams and to deal with customer queries etc.

At corporate level *Firm B* was very active in engaging with the industry representative organisations and with both the EU and national regulators in the development of the WEEE legislation. *Firm B* had considerable experience in the return and recycling of its electronic and electric products was already a leader in this area.

Firm B is an innovative industry leader and operates its own return and recycling programme worldwide for its electronic and electric products as well as returnable supplies. This offers the customer a range of services to encourage the return, reuse and recycling of its products. This includes facilitating the customer to return or donate its functional products after use when upgrading to a new product.

With regard to RoHS, *Firm B* intends to implement this worldwide as part of its product harmonisation programme and also as other countries are likely to implement similar legislation. It is investing significantly in researching substitutes for lead and other hazardous substances. In 2001, an engineering and computing team was established to build and test lead-free product prototypes. It already meets the EU RoHS requirements and the equivalent in Japan but the target is to implement these requirements worldwide in 2006. In 2003 it established a company-wide RoHS team to enable a global response to be implemented. This is also consistent with the standardisation of its products in all markets.

Energy Use & Emissions Trading

Energy use and emissions are closely monitored. In Ireland *Firm B* is not engaged in the Emissions Trading Scheme nor does it need a Greenhouse Gas Emission Permit as it does not reach the minimum level of emissions or energy use. As each machine is set up its performance in terms of energy use, emissions and waste production is known. Globally, however, energy use accounts for 87% of *Firm B*'s impact on climate change and despite increased efficiency overall energy use increased by 4% from 2004 to 2006 due to expansion of facilities. For example, electricity use during 2005 increased by 4% compared to 2004. However, natural gas use was reduced by 1.3% during the same year.

Environmental Strategy

Corporate Environment, Health and Safety Policy

The Environment, Health and Safety Policy, available on the corporate website, states that *Firm B* will “...conduct [our] operations in an environmentally responsible manner, and create health and safety practices and work environments that enable employees to work injury-free”. The policy specifies goals that the firm will:

- Meet or exceed all applicable legal requirements;

- Proactively reduce occupational injury and illness risks, and promote employee health and well-being;
- Aggressively pursue pollution prevention, energy conservation and waste reduction in [our] operations;
- Design and manufacture [our] products to be safe to use and to minimize their environmental impact;
- Offer [our] customers environmentally responsible end-of-life management services for [our] products; and
- Require [our] suppliers to conduct their operations in a socially and environmentally responsible manner.

Environmental Management System (EMS)

Environmental, Health and Safety Management System

The Environmental Management System is integrated with the Health and Safety System and managed by the same department: Environment, Health and Safety (EH&S). It is based on international models including ISO 14001 and OHSAS 18001 and is implemented globally, regionally and locally as an integral part of operations. The global EH&S team collaborates with the appropriate departments and sites to identify priorities, meet internal and external requirements, control risk and to recommend performance improvement goals. The EH&S management system requires sites to monitor performance, conduct audits and management reviews and to implement corrective and preventive actions.

In Dublin, as the H&S system evolved it made sense to integrate it with ISO14001 which was already established. The EH&S team includes chemists, EH&S officers, environmental compliance consultants and occupational nurses. There is one team for Ireland.

Certification

As noted above, the EH&S management system is based on recognized international models including ISO 14001 and OHSAS 18001. *Firm B* was one of the first multinational businesses to obtain a single, global ISO 14001 certification for worldwide manufacturing operations.

ISO14001 was an initiative of the Irish operations. This site was the first in *Firm B* to be certified. Originally, the Irish site tried to get the corporate headquarters to adopt ISO14001 but no interest was shown at that level although the Irish site was given clearance to implement it. However, after a couple of large contracts were lost due to lack of ISO14001 certification the headquarters responded by adopting it globally. The initial resistance to certification at corporate level was that *Firm B* already had its own sophisticated system in place [with their own standards and guidelines which included the environment in strategic decision making, the use of champions and product stewards and integration of environment into normal business processes etc]. It had been viewed and had viewed itself as a leader in the area of natural environment management. Despite this it was realised that a more widely recognised system of standards was needed both for clarity to the customer and to comply with customers' own certification.

Originally the Dublin site intended to integrate ISO14001 with ISO9000 and the quality system but this did not work and the reason given was that the site was too large making a unified system unwieldy. However the integration of the two certification systems works successfully at another smaller *Firm B* site in Ireland.

As well as ISO system the Department Balance Scorecard has measurement criteria for EH&S (injury rates, non-compliance etc.). There are continuous self-assessments against corporate and statutory standards.

Training

All staff receives induction training in environment. Continuous training & education is encouraged with specific training for the EH&S team.

Drivers

The three major drivers identified by the interviewee are customers, cost and corporate headquarters:

Customers are especially effective in some markets such as Germany and Scandanavia where recyclable product is seen as desirable. On the contrary in Japan this is seen as a negative attribute. An example of a customer driven initiative is the reduction and removal of flame retardants in plastics even though scientific evidence from the World Health Organization (WHO) showed that these do not pose a health threat. These have been reduced over the past ten years and will be removed from all products by the end of 2006. As noted above, customer demands were also the main driver for the company-wide adoption of ISO14001.

Cost is a particularly strong driver as for example waste charges driver much of the waste reduction and recycling. Improvements targets are linked to costs (as for all things) and budgets are tightly controlled.

Corporate headquarters drives a very strong philosophy of good citizenship and environmental responsibility which is viewed as a core element of the firm's identity.

As well as the consumer, the corporate website identified legislation and scientific data as other drivers for material substitution. The firm is committed to comply with all regulations and actively sets compliance targets to be in place prior to the implementation of new regulations. It also aims to apply the best practice in all its operations, for example, the world-wide application of RoHS. Where scientific data indicates changes should be made the firm strives to introduce these.

Reporting

Firm B provides extensive and extremely detailed reports on most activities to the public over the internet under the auspices of its Global Citizenship policy. These include many measurable items such as energy use, emissions, waste production, use of materials as well as extent of regulation compliance. These data are mainly on a global or regional level and are not available by site. The full Global Reporting Initiative (GRI) index is available which indicates the level of information provided for each GRI topic.

Networking

Networking is very active within *Firm B*. All EH&S managers in EMEA hold a conference call every 2 weeks and all the international teams meet with each other about twice a year.

External networking also occurs and EH&S team members will sometimes meet with other similar large manufacturers in Ireland. Other networking activities include participation in conferences and trade associations. *Firm B* is very active in Irish Business and Employers Confederation (IBEC) and Irish Chemical & Pharmaceutical Manufacturers Group among others. IBEC is the source of updates for new legislation and *Firm B* responds and liaises through IBEC. *Firm B* uses IBEC's legal expertise for Irish and European regulations and refers to US teams for other international/US focused laws.

Apart from the example of the initiative to remove solvents, the interviewee could not think of any initiative adopted or diffused due to networking.

6.3.3 Firm C

Description: Firm C manufactures high quality communications networks.

Location: Greater Dublin area. The facility was established in 1961 by a USA multinational. The firm has been the subject of 4 takeovers since then: 1982, 1996, 2000 & 2004. Each takeover was by USA firm.

Corporate Headquarters: USA

Sales: Year ending 2004 US\$150million

Employees: 220 on-site (in Ireland) and 4,000 worldwide. In 2001, when the first IMSS survey was administered, the worldwide employment was 28,000.

IMSS Surveys: Firm C participated in both IMSS surveys which were completed by the Manufacturing Manager

Selection for Further Analysis: Firm C was selected for further analysis based its high score on the Irish environment index and ISO14001 certification. Firm C was classified as an innovation progressor on the innovation index.

Interview: Interview was held on-site with the Manufacturing Manager and the Business Excellence Team Leader/EH&S Coordinator (referred to as EQHS Coordinator below) on 25th February 2005

General Profile: Firm C manufactures communications networks. It offers an extremely high quality product and only provides complete networks which are under guarantee for 20 years. These are the product's marketing differentiators. They manufacture for the EMEA region and sell into a distribution hub in the Netherlands. However, it is a global product and this site often gets orders to ship to other regions to make up shortfalls. Since they are manufacturing a global product they must provide a product consistent with other sites: two in USA and one in Australia. This facility sees itself as dynamic and very autonomous which has enabled it to deal with considerable changes in corporate personnel arising from numerous takeovers. The parent corporations have varied in size. At one stage Firm C was part of a multinational corporation employing 400,000 worldwide. At the time of the first IMSS survey in 2001 there were 176 on-site, 215 in Ireland, 2,000 in Firm C worldwide and 28,000 in the entire parent corporation. The current owners employed 2,000 in total at the time they bought Firm C which also employed 2,000. Hence, the current worldwide size is 4,000 employees. Apart from size, some other differences between the current and previous owners emerged when comparing the data from the two IMSS surveys. These include, for example, less formalisation of manufacturing strategy and greater emphasis on product innovativeness, design and quality.

The interviewees view this site as a very distinct plant within group and have been given a lot of autonomy by default over the years as there have been so many new owners. They see themselves as very dynamic and proactive. A relatively unique achievement of this site is that it has fully integrated its Environment (ISO14001), Health and Safety (ISO2000 & OHSAS18001) and Quality (ISO9000:2000) systems. It holds a separate certificate for each of these Standards but these are managed and audited as one fully integrated system. It adopts a whole systems management approach and is widely used as a benchmark by other firms in this regard. In 2000 Firm C won a European Business Excellence Award.

Innovation & Technology

Firm C has a very strong tradition of technological innovation and is a world leader in the design, development and manufacture of new products for communications networks. Its parent company holds over 1,000 patents and continues to place innovation as a priority with high investment in R&D with the aim of being 'first to market for next generation innovative systems'. It combines innovative technology with extremely high quality standards enabling it to give a 20 year guarantee of its product. In the past *Firm C* conducted R&D on site but this is now done centrally in the USA. The design centre works closely with this site on developing processes to ensure feasibility of manufacturing however this is a limited R&D role. Three other facilities like this one, two in the USA and one in Australia, manufacture the same products. The Global Engineering Group comprising R&D and manufacturing personnel ensure consistency of production and packaging across the three sites. Some localised products exist: for example to comply with different standards in different markets e.g. this site manufactures low smoke product for this region [toxic fumes are not emitted if it goes on fire/flame retardant cable jacket]. However, it is primarily a global product.

Innovation, Technology & Environment

Environmental benefits and business requirements are inextricably linked in the view of *Firm C*. This equally applies to quality, health and safety. The view of *Firm C* is if anything is been done in an unsafe manner then it is probably not good for business either. If anything is not efficient from a business perspective then it is probably not efficient from an environmental, quality or health and safety (EQHS) perspective either. If all efforts are directed towards making a good product, on-time and efficiently then is most likely also efficient from an EQHS standpoint.

Life Cycle Analysis (LCA) is not incorporated much into product development. However, the materials used (PVC plastics & copper), although difficult to recover, are fully recyclable and the product can be renewed. Recently, the WEEE directive is driving *Firm C* look closely at this issue. Cabling is not covered officially under WEEE but *Firm C*'s strategists believe it is possible that customers will require it. They are also considering that it is possible to change the product parameters and, for example, construct cabling that will last forever – not with a view that it will need to be replaced in 50 years time. The RoHS directive impacts on the use of lead-based stabilisers in the PVC coating. (The challenge to produce a PVC coating while maintaining superior performance was achieved and incorporated into all products globally in 2006).

An environmental innovation of *Firm C* is the development and installation of equipment for the recycling of PVC plastic directly from the operating machines during the manufacturing process. This is an integral part of the manufacturing process and does not entail the previously required additional separation, collection and re-introduction processes.

Packaging

Outward packaging has been identified by the EQHS coordinator as a major issue to address. Currently *Firm C* uses cardboard, a small amount of light polystyrene foam and plastic bags – the latter two are not biodegradable and, although they can be recycled, this depends both on the customer and on the facilities available to them for recycling plastics. Moves are currently being made towards reducing the use of polystyrene.

Of particular need for attention are the plastic spools used to package long cables. It is not cost effective to return them empty to the factory for re-use therefore there is a necessity to look at alternative method of disposal or collection at building sites. Small cables are packaged in loose plastic bags. The cable cannot be packed tightly or it will buckle and affect its functionality so the bag is quite big. The cables get tangled if the plastic bags are removed.

All packaging must be suitable for all markets and the same as produced in other sites. Although this site services the EMEA region there is sometimes a requirement to ship to different regions if a shortfall exists. Therefore all products are branded and packaged for the global market.

All incoming packaging is recycled – including incoming spools which are very large and made from cardboard. Most components are manufactured by *Firm C's* sister company in Omaha and all packaging from them is recycled.

Firm C will not compromise on quality of customer packaging which could lead to quality problems and disputes over whether problems are in the product itself or created by the installer. Therefore this has been the area of least change from an environmental perspective but the intention of *Firm C* was to examine this issue.

Sometimes customers ask for changes in packaging but not for environmental reasons rather for simple practical reasons such as ease of opening.

Waste Management

All waste is segregated and clear bins are used. Several different waste streams exist: packaging and paper; manufacturing; and other site waste. Cost of waste is tracked through the supply chain.

All cardboard is baled and recycled. Delivery methods were changed to reduce cardboard to an absolute minimum. Bulk storage and re-usage containers are used. All incoming packaging is recycled. Paper recycling facilities are located in all office areas. All rubbish bins were removed. This required changes in behaviour but it is now well accepted.

Manufacturing waste includes scrap, cable off cuts and cables not meeting quality standards. These are sent for recycling and recovery of metals. A company is contracted to do this. The waste has value, namely PVC and copper, which can be reused once recovered. Quality standards are very high due to the lifetime guarantee. Equipment for the recycling of PVC directly from the operating machines was developed and installed. This is an integral part of the manufacturing process.

Water is used for cooling in the manufacturing process and is recycled in a closed system. It is changed once a year and the discharge is perfectly clean. MEK (Methyl ethyl ketone) is a hazardous chemical used for printing on the cables. Engineering changes were made to reduce its consumption and waste generation.

Use of polystyrene cups which are non-recyclable and non-biodegradable has been eliminated. Previously, 4,500 were used per week at a cost of €10,000 per year (including disposal). In order to facilitate people bringing hot liquids to their desks (which posed a safety risk) 'Travel Mugs' were sold on site at a subsidised price of €3 per mug. The money raised was used to plant trees in the grounds.

WEEE & RoHS

As mentioned above *Firm C's* product is not covered by the WEEE Directive although they foresee a drive for WEEE compliance from EU customers. However, it is a complex issue and *Firm C* could not make an alteration to comply with WEEE that was not adopted by the other factories or that could not apply globally since the main product is for the global market. Also, raw materials are bought by global purchasing agreements so if a compound is changed this has an effect in other regions. RoHS on the other hand has prompted the development of coatings with reduced lead-based stabilisers. These are manufactured for the global market as *Firm C's* product is the same worldwide and also because *Firm C* envisages that similar regulations will become standard in most countries.

Energy Use & Emissions Trading

An energy management team aims to increase efficiency and reduce energy usage which is monitored on a weekly basis. Energy source is non-renewable. Emissions are also monitored. There is no requirement for a Greenhouse Gas Emissions Permit or emissions trading.

Environmental Strategy

The key strategy of business as a whole in *Firm C* is a systems approach. This includes a systems approach to environmental management as well as integration of the environmental management system (EMS) with other systems and clear links to business requirements. The EMS is ISO14001 certified. It is fully integrated with the health & safety and quality systems including auditing and certification. This system is referred to here as the EQHS (Environment, Quality, Health & Safety).

Links to Business Requirements

The approach of *Firm C* is to ensure that all actions link to business requirements. If some action or implementation process is not working from a business point of view then it is probably not the correct approach. For example, the system for rating the firm's environmental impacts always classifies waste first with factory waste being the most important. In order to address this, the efficiency of various stages of the manufacturing process is always being improved upon. Improving efficiency entails using less raw material, therefore less goes into production and, as well as reducing scrap and waste production, input costs are also reduced. Less waste goes into landfill and for recycling also reducing those associated costs. Using less means the bottom line also improves and so there is a business benefit.

The auditor of *Firm C's* certifications also adopts this view. This is reflected in the 'register of aspects' in which EQHS goals and targets are very strongly linked to business requirements. This also enables a supportive and positive relationship with the auditor.

There is an emphasis on continuous improvement. When a new process is being implemented, for example when new product being introduced, there is a focus on getting everything correct and in place from the start. There are then continual efforts to see if improvements can be made – statistical improvements in terms of the rating systems and improvements in efficiencies – to see if processes can be better streamlined, less raw materials used, maintenance requirements of machines improved etc. Any failure or error in the process is analysed and investigated.

Environmental Management System (EMS)

A key feature of Firm C's Environmental Management System (EMS) is the integration of environmental management with health & safety and quality management.

Environmental, Quality and Health & Safety (EQHS) Management System - Integration Process

Firm C operates a highly integrated systems approach comprising three base systems with recognised Standards: Quality (1992 – ISO9000), Environment (1997 – ISO 14001) and Health & Safety (1999 – ISA 2000/OHSAS18001). In 1999, Firm C was one of the first organisations in Ireland to attain all three Standards. Initially these were controlled as three separate entities with separate accreditation. The ISO9000 was managed through the Quality Department and two separate people looked after environment and H&S in the Facilities Department. Implementation of the systems was completely separate and uncoordinated.

The confluence of two events around the year 2000 drove the move towards integration of the three systems: the downturn in the economy and fall of the 'dot.coms' industry meant that an embargo was placed on hiring new staff and replacing staff that left or retired and the human resources were not available to dedicate people to particular systems; and the advent of ISO9000:2000 quality system which was more process based rather than the prescriptive procedural base of the 1996 Standard.

The drive towards looking at processes rather than standards & clauses presented an opportunity to examine the overall situation of systems management. The separate Standards each required separate documentation. When examining the processes the EQHS Coordinator saw an opportunity for synergy. A lot of overlap and similarities exist between the different systems of the various Standards for example the documentation control loop, the corrective action systems and the management review systems were all the same. Operational details from various sections are very specific to each standard such as process realisation, register of aspects, risk assessment but otherwise they are essentially the same. Therefore the decision was taken to try to amalgamate the systems together into one management system.

The process began in 2001 took 1-2 years to tease out and pull the elements together and to redraft the whole document library into a process based format. This was facilitated somewhat in that when ISO14001 system was being established in 1998 a lot of consultation was done with the already established quality system ISO9000 and many chapters of the quality manuals were cross-referenced. Similarly, with the introduction of the Health and Safety Standard ISA 2000/OHSAS18001 similarities and cross-references with the other systems were sought.

When the redrafting of the Standards was completed a knowledge management system (trade name Livelink) was established as a vehicle for recording all data in the process.

The integration of the environment, quality and health & safety systems into one management system (EQHS) and the installation of the knowledge management system to support it were achieved independently of the Standards auditing and certification procedures.

Integrated Audits

After integrating the environment, quality and health & safety systems into one management system and establishing the knowledge management system to facilitate it, the next stage was to get an integrated audit. Previously even though the Standards were audited by the same auditing agency three different auditors were

sent every year and everything was reviewed three times. This agency would not alter the auditing policy. Therefore *Firm C* approached other agencies in search of an integrated audit. Some agencies said they would audit the integrated system but would still conduct three separate audits and charge three fees. However one agency agreed to conduct an integrated audit. This is done twice yearly. Each audit covers all the Standards and lasts two or three days. For example, the most recent audit included a visit to the factory floor. Here questions were asked about process realisation and traceability; ease of locating WIP (work-in-progress) and non-conforming material; whether people wearing personal protective equipment (PPE) and safety glasses; what was the risk assessment for this area; where was the recycling for this area etc. And in an interview with the purchasing & materials manager the auditor asked about control of materials, workplace inspection records, risk assessment and training for environmental management etc.

It is important to retain separate certificates as they are requested by customers but these are managed and audited as one system. One visit by the auditor covers all Standards and incurs only one fee therefore by conducting the three audits simultaneously the integrated system is less disruptive and very effective in terms of time management and costs of auditing.

Apart from the redrafting of the Standards, difficulties encountered in the integration process were with people with vested interests in keeping the systems separate - not the auditors but internally where functional areas were territorial and people claimed ownership of certain processes etc. Negotiation and decisions were required about which change procedures to implement and who would have responsibility for various processes etc.

Firm C had already achieved considerable alignment between the quality system and the environmental system when implementing the ISO14001 and this facilitated the move towards complete integration which would have been much more difficult had totally independent parallel systems been in place.

Firm C attained these standards and achieved integration independently of the parent corporations. It is their view that it would have been very difficult to accomplish if alignment with the parent was necessary due to the numerous changes in ownership over recent years.

EQHS System Management

There is a dedicated EQHS Team and individuals look at various aspects of the systems but nobody works exclusively on any one of the three areas. Team members are not dedicated to one functional area since this is not necessary and also the human resources are not available for it. One of the team's weekly activities is an EQHS inspection. This entails looking at various conformance activities in areas where standards may be slipping or areas of non-conformance etc. The inspection examines e.g. waste segregation, conformance of personal protective equipment (PPE), guarding of machines, chemical storage.

The knowledge management system (trade name Livelink) to support the EQHS System was established as a vehicle for recording all data in the process. This is a web-based knowledge management system for the control of documents and workflows. An integrated system flowchart was developed which is essentially an amalgamation of the three manuals for the environment, quality and health & safety systems. It links the three systems as one unit directly into the manufacturing and business processes and work flows.

The EQHS System is well established and is part of every employee's routine. Team leaders in every department know exactly what is required at all stages in the work process. Team leaders may nominate

production associates to take responsibility of a particular activity/process in order to create awareness at whichever level it is needed.

The manufacturing and operational team have to 'live by' risk assessment (RA). Training is centred around RA. If a new machine is being installed a new RA is done as an integral part of the installation process. The EQHS Coordinator checks that new RA done and if waste segregation is in place and if the system is conforming to requirements etc.

The EQHS system has reached a level of maturity whereby the EQHS Coordinator can adopt a 'watchdog' approach and if something crops up about which there is concern the team can focus on it etc.

There is a constant checking and reviewing of processes to ensure compliance and to keep awareness levels high as well as seeking opportunities for improvement. The EQHS Coordinator stated that it can be difficult to maintain the high standards required to retain the certificates. The challenge is to keep the process fresh and to ensure that it is always operating. Every so often there is a need to prompt and remind people of requirements.

EQHS Coordinator is also constantly alert to legislative aspects and any new regulations or changes are that on the horizon or what is happening within corporation and the EU etc.

Systems Management

In 1999, *Firm C* became one of first in Ireland as well as the first in its own corporation to have the three Standards. *Firm C* adopts a systems approach to its business and various other systems exist in addition to the EQHS System e.g. Materials Management system and Financial Controls system. These systems support each other. *Firm C* is regarded as a benchmark in Systems Management and won an Irish Business Excellence Award in 1998 and a European Business Excellence Award in 2000. *Firm C* was one of the first organisations to receive ISO9000:2000 certification.

The systems based approach provided a framework for strategic change and was used to achieve improvements for the Business Excellence Awards. The discipline of the quality system was used to capture the objectives e.g. the objective to improve revenue by 5% was brought in as Quality Inspection Report (QIR) or corrective action within the quality system and assigned to the Manufacturing Manager to manage and track through the system.

The discipline of the management system enabled a very integrated approach from the start and was the mechanism to drive the objectives whatever they related to e.g. quality, environment, Business Excellence.

Firm C is aiming for one integrated management system that will cover all aspects of the business.

We had foresight to build things up – rather than do each one separately

We benchmarked a lot before we started – we learned from others' mistakes

System runs itself now – but CD v busy!!!

Environmental Management

Environmental operations at *Firm C* are grouped into the following areas:

- Chemical management
- Chemical & fuel spills

- Hazardous waste disposal
- Waste electrical equipment disposal
- Waste management
- Trade effluent
- Monitoring of air & noise emissions, energy

Key environmental objectives which have been achieved in *Firm C* to date are:

- Waste
 - Reduction in scrap, increase efficiency (PVC, Copper, Plastic Parts)
 - Reduction in land fill contribution (Cardboard, general rubbish, Polystyrene Cups, Paper)
 - PVC recycler installed
- Chemical Consumption – MEK usage reduced
- Energy Usage – energy management team

Other environmental initiatives and activities at *Firm C*:

- Recycling of aluminium / steel cans, batteries, printer cartridges and mobile phones (latter in aid of Temple Street Children's Hospital).
- Use of internal communication system to promote environmental awareness etc.
- Review EH&S implications upfront for new or modified machinery / process.
- Use of electronic systems: conference rooms with digital projectors, removal of individual printers (where possible), e-mail reports etc. (where possible), electronic document control and management, electronic factory process records.

Training

The induction programme is extensive and consists primarily of EH&S training. It is done in three phases: first day of employment includes a half day on EH&S comprising videos and presentations on obligations under relevant acts, safety, using machinery, guarding, reporting of issues/accidents, what to do in case of an accident etc.

Firm C's main Risk Assessment is to do with moving materials – that where an accident is most likely to occur and there is a lot of movement in factory. Training hones in on manual handling, pallet trucks, wheels etc specifically on first day. Within one month other half day training on manual handling takes place followed by a third half day a month later on more specific aspects. Other training is provided to employees regularly and as the need arises in relation to new processes or machinery etc

Drivers

At first the process was driven to some extent by customers. Customers in Nordic countries, although not major customers, started asking very probing questions during a visit. Although the EQHS Coordinator was aware that they may have an environmental interest and had prepared to talk about basic initiatives such as cardboard and oil recycling etc., he was not thinking about a systems level approach. The customer created awareness at that level so the EQHS Coordinator examined to the ISO14001 system. The regulatory authorities were identified as the main influence on environmental practices in the IMSS survey followed by corporate headquarters and suppliers. (*Firm C* was classified as supplier-facing in the arc of integration.)

Networking

Prior to attaining certification *Firm C* conducted a lot of benchmarking and visited several other organisations in Ireland. Managers were able to learn a lot through this process especially from the mistakes made by others which they could then avoid. *Firm C* is highly regarded in Systems Management and held as a benchmark. After gaining the Business Excellence Award *Firm C* hosted numerous visitors from other organisations to the extent that it became quite time consuming and counter-productive and they were obliged to reduce the number of visits. Also *Firm C* is now part of a much smaller organisation which is not so interested in promoting these types of awards etc. The EQHS Coordinator engages in networking and has given presentations on the environmental system.

6.3.4 Firm D

Description: Firm D manufactures high quality loudspeakers and sound systems for the domestic market and other sites manufacture for business markets, the music industry and car manufacturers.

Location: Midlands/Border region since 1980.

Corporate Headquarters: USA

Sales: Undisclosed - Firm D is a private company.

Employees: Approximately 230 at this facility and 8,000 in the organisation worldwide.

IMSS Surveys: Firm D participated in both IMSS surveys which were completed by the Materials / Production Manager.

Selection for Further Analysis: Firm D had a high Irish environmental score but a negative IMSS environmental score. It was classified as an innovation trailer in the cluster analysis. It was selected for case analysis because of the contrasting environmental scores and the contrasting innovation score. It does not have ISO14001 certification but at the time of the interview was beginning to plan for it.

Interview: Interviews held on-site with the Quality Systems Manager and the Materials / Production Manager on 12th April 2005.

General Profile: Firm D is a renowned innovator in audio technology and manufacturer of high quality sound systems. It prides itself as being innovation driven and a leader in its field. This facility mainly does manual assembly and a little is fabricated from scratch. Seventy percent of supplies come from other Firm D sites. This is the only site in Europe and there are three core manufacturing sites - two in Mexico and one in the USA. This site is relatively small and services the European market. It delivers its products to a central facility in Belgium and does not deal directly with end customers. The European market is quite different to the USA market. It is very fragmented and at the time of the interview it was not growing. Electronics are very sensitive to economic changes. Germany was once one of its largest markets but demand levelled after German reunification. The product is competing with other luxury goods such as plasma screen televisions. However, there were signs of an upturn in demand as the first quarter of the year, which is usually the quietest, was busier than it had been for the previous few years. In the past 30% of customers were corporate now this is 70%.

This plant/facility manufactures for the home entertainment market. There are four major product lines with four or five versions of each. Some minor variations exist for different markets e.g. plugs for Ireland/UK and continental Europe. The safety requirements are the same across Europe so legislation and standards are not an issue. Some requirements differ in the USA or other countries e.g. voltage. In the past it was a relatively low technology product but over the years it has become more sophisticated and now includes whole systems with hard drives etc. Printed circuit boards (PCBs) used to be fabricated at this facility but with the increasing complexity this is now done by another site. All products are finalised and no customisation/localisation is done elsewhere.

This facility sees itself as very independent in terms of management and has a very trusting relationship with headquarters. They are given the requirements e.g. to reach a certain quality standard, they know the expectations and are then left to manage the process. Over the past decade there has been increasing

integration between all *Firm D* plants. Communication is very open and the setup is essentially the same in all plants. Costs have been a major driver in the integration process especially as this facility is small compared to the core manufacturing plants e.g. costs of tooling. Supplies are now coordinated by headquarters and mainly come from US suppliers with very few local suppliers from Ireland. *Firm D* is classified as supplier facing on the arc of integration.

Innovation & Technology

Firm D is an innovation driven firm and this has been a key feature of its success. It is a leader in audio technology and has developed a wide range of products from sound systems for cars to medical devices. R&D is conducted at the headquarters in the USA. It is a private firm and supports research and innovation by re-investing all of its profits back into the firm.

This facility has some input into the development of the manufacturing process but very limited input into product development. This facility is relatively small in the corporation and the engineers from R&D tend to work more closely with the larger manufacturing plants. This facility is only really involved during the piloting of the products.

The plant doubled in size in 1991 and it has not grown much since. However, the value of production increased with higher technology electronics. This shift did not affect the basic skills required in the main assembly. Skills changed in the area of testing.

Innovation, Technology & Environment

There is no explicit integration of the environment into product design. Some aspects are environmentally favourable by chance e.g. chipboard is from sustainable forests. According to the quality manager this just happens to be case and it is not something *Firm D* specifically aimed to use.

Packaging

Outgoing packaging has no particular environmental design. It consists mainly of cardboard and Expanded Polystyrene (EPS). A few years previously *Firm D* examined its packaging and found that EPS best suited the products which are heavy (EPS is recyclable). Incoming packaging is segregated for recycling. *Firm D* also receives incoming packaging from products returned for remanufacture. Supplies from the USA are on wooden pallets which are sent for grinding. Europallets (EU standard size) are bought for outgoing goods. Since this facility has only one customer, transport is very straightforward and all goods go out in containers.

Waste Management

The waste management system is managed by a HR person who was trained in this and the Engineering Manager monitors the system. *Firm D* has the Green Dot.

Incoming packaging is segregated for recycling. All cardboard is recycled. This was driven by cost savings and thousands of euro are saved annually compared to sending all waste to landfill. This is seen as a business saving not an environmental one and the environmental costs or benefits of different systems were not a factor in the decision.

There is no waste water from the manufacturing process. Waste from dyes, chemicals and adhesives are managed by a contractor. Another contractor takes dust, wood, cardboard and pallets.

Other recycled waste includes canteen waste, office paper, plastic wrap, batteries and flux (clean-off from solder which can be recovered and recycled).

Firm D receives supplies on wooden pallets from the USA which cannot be used for outgoing goods. Approximately 200-250 of these pallets are sent for grinding per week at a cost of €1 per pallet.

Post-consumer Recycling

Faulty products and any other products from the distribution centre are received for remanufacture. These are then sold as factory remanufactured goods. At moment the customer cannot upgrade the product. They would have to buy a whole new product but it is the visual element that changes most.

WEEE & RoHS

At the time of the interview the interviewees did not know that WEEE would apply to *Firm D*'s products. This facility essentially has only one customer - the central distribution centre in Belgium - although there are service centres in different countries. Since the centre deals directly with customers all WEEE issues are dealt with there. This facility is not sure of any implications WEEE may have on the product or costs. However, it was envisaged the WEEE would have an impact. As with most consumer electronics, it has become easier to replace the product rather than repair it as it has become more sophisticated. *Firm D* will now have to consider implications of WEEE. For example, the interviewees identified printed circuits boards (PCBs) as probably be the greatest liability although they were not sure whether PCBs were included in WEEE (which they are for the recovery of precious metals).

RoSH was identified as having significant impact on *Firm D*'s products. This would involve a complete change in equipment and product parameters and some board design etc. A lot of work was being done on this in the USA R&D centre. The PCBs are manufactured in the USA and the same ones are used in all markets. Therefore if there has to be a change for Europe this will apply to all *Firm D*'s PCBs. The intention was to look at these issues in process of ISO14001.

The USA headquarters looks after all legislation and regulatory information. *Firm D* is always looking at the market and tends to be forward thinking in terms of legislation compliance and impact in all markets. RoSH is the EU regulation with greatest impact back to USA headquarters and other plants.

Energy Use & Emissions Trading

Energy use is monitored monthly by the engineering department. This is an area of low priority. The Green House Gas Emissions Permit and Emissions Trading are not applicable.

Cost is the driver for energy saving initiatives: use of low energy lighting and the installation of an alternative air compressor which cut energy use by 20-30%

Environmental Strategy

Corporate policy is to ensure that all legislative requirements are met. The USA regulations are enforced unless a European one is stricter in which case this would apply. The planned introduction of ISO14001 is viewed as a step towards the car manufacturing industry's quality standard TS16949.

Environmental Management System (EMS) and Certification

Currently there is no EMS in place although it is planned to introduce ISO14001. Informally, the quality manager is the main contact person for environmental issues as she is undertaking the implementation of ISO14001. The ISO14001 was assigned to the quality manager due to her experience of managing the ISO9000 quality system. It is expected that from a systems management point of view ISO9000 certification and processes will facilitate ISO14001 in terms of preparing documentation and policies etc.

At this early stage the impact of ISO14001 was not yet determined. The main areas are probably: waste management, noise and dust. The assembly/production line will probably not really be affected. Some environmental practices are already implemented from business standpoint of cost savings e.g. management of packaging and waste, energy use etc. Therefore the procedures of writing and complying with the ISO14001 Standard are not expected to cause problems.

Firm D was looking at how the Standard can best be leveraged to get some added benefit from of it. In this regard they make a distinction between using the Standard and complying with it.

Quality System

As mentioned above, the responsibility for ISO 14001 is with the quality manager not so much because it is seen as being linked to quality or part of the quality department's responsibility but because of the experience of systems and from a system management point of view is similar. The quality manager sees that there may possibly be a fit with ISO9000 but this is a vague notion that it is not so much a remove from ISO 9000.

Quality has always been a priority for *Firm D* - if the assembly line runs correctly quality will follow as everything will be done correctly in first place etc.

From the corporate point of view the ISO 9000 system was initially seen as 'something nice to have' but since *Firm D* started manufacturing for the automotive industry it became essential to progress towards the TS16949 standard. The internal *Firm D* system was phased out however it was very compatible with ISO 9000 and many of the systems and procedures were in place anyhow for example the computerised system, internal audits system and materials planning package. The headquarters also wanted to get all plants on the same system and other more high technology plants already had ISO 9000 certification. The core plants which manufacture for the car industry already have the TS16949 standard but this plant manufactures for the home entertainment market. If it were to manufacture for the automotive industry it would have major impact. Corporate headquarters wants all plants to have the same quality system and standard.

ISO9000 suited the existing *Firm D* system whereas the move to TS16949 involves a whole different set of resources that *Firm D* will have to have in place from quality management and quality maintenance points of view. It will be a big change - the quality implications of manufacturing for the car industry are quite different to those for the domestic or single end-user. E.g. ten or twelve units are placed in each car -if any one of these units is faulty the consequences of halting or delaying the production line in the car industry are very costly (€500,000). Therefore the quality criteria of manufacturing for this industry are very rigorous and demand reject rates of ten parts per million.

ISO14001 is another essential step towards the TS16949 standard.

Health & Safety Management System

H&S is a separate system from environmental management. Again, the quality manager is not sure if the systems will overlap although she imagines there is long list of items which should be already covered by existing H&S procedures: emissions, noise levels, dust levels, lead compounds toxins, employee safety and the internal environment's impact on people etc. H&S will probably have a low impact on ISO because already many requirements are being fulfilled. There is nothing unusual or different from normal industry at the facility. What goes outside the facility is not covered by H&S. In this aspect ISO14001 will look more at the external environment e.g. disposal, air monitoring.

Training

New employees are instructed on environmental aspects including waste management and segregation of wood, metals, EPS, paper etc. They mainly receive H&S training – use of safety glasses, lifting skills etc. Some minor quality training is done at induction but it does not mean much to people at that stage. Quality training is mostly done on the job when people can see the impact of quality on assembly and the quality aspects of each step in the process.

Drivers

The regulatory authorities and corporate headquarters exert the most influence on environmental practices. Safety has driven a lot of environmental practices and what compliance is needed to deliver into any particular market e.g. use of glues, key environmental checks for all in-coming hazardous substances and material datasheet system. Chipboard machining is also another safety driven issue – disposal of dust and grades of chipboard etc.

There have been no specific customer demands relating to the environment. Sometimes there are enquiries made e.g. a distributor in Germany sent a questionnaire recently regarding stance on products.

There is no real driver for ISO14001 in itself - it is a stepping stone to the car industry quality standard TS16949. The three major plants already have it as part of their TS16949 certification. ISO14001 is a very small part of TS16949 but it is needed to progress.

Other customers expect high quality but do not ask for specific Standards. High quality goes without saying and in this regard *Firm D* sees itself as self-regulating. It does not feel the impact directly from customers but has to ensure that all decisions etc will meet customer requirements and expectations.

Reporting

Due to being a private firm, no environmental or other public reporting is done although *Firm D* will naturally comply with any certification or legal reporting requirements.

Networking

The quality manager has taken part in the EU INTERREG sponsored programme – Ecosmart. This is a cross-border initiative on product design and environmental issues and includes a network and seminars as well as access to resources such as audit days to look at specific environmental aspects to help identify areas to where work is needed.

Firm D is engaged in numerous initiatives with the local community - local small businesses and schools, junior achievement programmes etc. Employees are all from local the community so are very involved in fund-raising to which *Firm D* contributes. There is no formal programme.

6.3.5 Firm X

Description: This site manufactures main frame server computers to order for clients in Europe, Middle East and Africa (EMEA) and Asia Pacific. It also tests, ships and manages the worldwide supply chain of the firm's computer chips. Services provided by this site include: global procurement, global technical support and business consulting services.

Location: Greater Dublin Area - Firm X established operations in Ireland in the 1950s and this campus-type facility was opened in 1997.

Corporate Headquarters: USA

Sales: Year ending 2006 worldwide revenues: US\$91.4 billion

Employees: 2,500 at this facility, 3,500 in Ireland and 355,000 worldwide

IMSS Surveys: Firm X did not participate in the original IMSS survey but did respond to the second. This was completed by the Cost and Planning Programme Manager, Business Operations.

Selection for Further Analysis: Firm X was selected for case analysis based on the recommendation of two experts.

Interview: Interviews held on-site with the Business & Innovation Manager and the Country Environmental Affairs Manager on 18th November 2004.

General Profile: Firm X is one of the world's longest established and largest information technology organisations. It has nine manufacturing locations: three in the USA, one in Mexico, three in Europe and two in Asia. This facility is very large in within the corporation. As well as serving all mainframe server customers in EMEA and most in Asia Pacific and it serves about 15% of US customers. In 2003 Firm X had 14,500 customers in 120 countries for these high level products. The product has life cycle of about 5 years which is considered relatively long compared to other market segments. The product is customised and there are fifty to sixty models each offering in the range of 2,500 features which the customer can order. Each unit costs up to US\$5million. Firm X has a very proud tradition in innovation, not only in technology but also in organisation, management, employment practices and customer relations. Firm X is viewed as a global leader in many of these business aspects as well as in the business case for environmental management, sustainable practices and corporate social responsibility. Corporate citizenship is viewed as strategically aligned to the core value of innovation in the organisation. Firm X has been widely recognised and has won many awards for its corporate citizenship including environmental stewardship.

Innovation & Technology

Innovation has always been a core value of Firm X. However, the current CEO has renewed emphasis on innovation making it a key word throughout every facet of the organisation and the prerogative of every employee. For example, this facility recently launched a website for its 2,500 employees to post suggestions for innovation. Any type of innovation is considered and prizes are awarded. There are five categories with a winner in each category every quarter and an annual overall winner. The five categories are: customer satisfaction; shareholder value; technical; teamwork; people/client. As well as financial rewards there is promotion of ideas, employees are given the opportunity to present their ideas to executives and to develop it also giving an opportunity for employees to shape their own future.

In addition there are 17 volunteer innovation coaches. These are high level managers who encourage, support, guide & help realise ideas. Cross functional innovation is promoted. At the time of the interview this was a new initiative based on a successful similar programme in Scotland. There is no environmental category although an environmental innovation may be included in any of the categories. The environmental affairs team also runs a competition.

There is particular emphasis on collaborative innovation both internally and externally with customers, suppliers and also with any interested parties via the corporate website.

Innovation, Technology & Environment

Product Stewardship & Design for Recycling

Firm X established a product stewardship programme - Environmentally Conscious Products Strategy – in 1991 which focuses on developing leading practices in design for the environment, product environmental metrics and product recycling. Its objectives are to:

- improve ability to upgrade, reuse and recycle product at the end of life
- develop products that can safely be disposed of at the end of life
- use recycled materials where they are technically and economically justifiable
- improve energy efficiency and/or reduce consumption of energy of products and processes
- minimise resource use and environmental impacts of materials and finishes.

Firm X's product stewardship requirements are included in an integrated product development process, a strategic tool used by process and product development engineers. Design for Environment (DfE) specialists are incorporated in each design team and given substantial technical support resulting in many improvements to products such as suitability for disassembly and increased energy efficiency. The product stewardship requirements are extended to suppliers through engineering specifications and the use of a Product Content Declaration. The design standards prohibit the use of certain hazardous materials in products such as asbestos, PCBs, and ozone depleting substances. They also restrict the use of potentially hazardous metals such as lead, chromium, cadmium, and mercury in non-critical applications such as plastic housings, paints, and packaging. There is proactive evaluation and identification of suitable replacements that are environmentally favourable.

The Product Stewardship programme provides a proactive and strategic approach to the worldwide environmental management of products for *Firm X* and product design is included in its ISO 14001 certification.

At the operational level each of the major product lines has an environmental team of experts which identifies product attributes, environmental considerations and impacts of their products. The product lines then establish objectives and targets to support the corporate goals, as well as a management programme to achieve the targets and objectives. The teams provide training to product designers. They perform design for the environment assessments, life cycle analyses and work towards the continuous improvement of environmental attributes. *Firm X* has incorporated its ISO 14001 requirements into the formal framework of the product development process.

Packaging

There is a dedicated team in the corporation to focus on packaging - design etc – and there is also person in at this facility who works closely with local suppliers.

Packaging is highly influenced by market. E.g. for Germany all packaging must be reusable and recycled. For China wooden crates are required to be fumigated and certified by the Irish Government. These are shipped to Hong Kong. Sometimes it is difficult to get the government witness for fumigation which causes delays and often panic especially if product is not shipped in a given quarter.

Plywood is used for other packaging and there is no need to fumigate or certify this. These are large wooden crates (2.5m tall). Incoming material (server parts) comes from France for assembly in these crates which are then used to ship product to the customer. The empty crates are shipped back (free of charge to customer) to France. The crates are valuable enough to ship back empty for reuse and they are used to breaking point. Environment is a driver but also cost because the packaging is so expensive

Most packaging is straightforward to address - cardboard, crates and europallets. E.g. smaller parts previously packaged with shrink wrap, cardboard and pallets are now packaged in shrink wrap only. The main problem is with foams particularly in Germany and especially since the Greens have been in government there. It is not problem to address these issues but it has to be done. The problem is making the change. There is a need to prove that alternative materials will give the same protection e.g. pink foam – used particularly for smaller shipments such as hard drives - will not compress and so was difficult to replace. This was replaced with recycled HDPE plastic cushions which can be reused. Other foam cushions are being replaced by paper-based designs some of which are being patented. There is a need to extensively test new packaging with drop tests etc.

Cost is a major driver in the design of packaging - €20m per annum is spent on packaging at this facility alone. *Firm X* works very closely with suppliers in Ireland on design etc. The procurement team works very well with their major supplier who have a proactive design team and who send people on-site with proposals etc. Customers are not really drivers in this area. The main worry for customers is that product arrives intact.

A recent initiative in relation to packaging involved the reuse of pallets. Previously incoming pallets were left for collection after being emptied. A contractor sold the europallets back into circulation and then recycled, reused, sold or disposed of the remaining pallets. Outgoing freight is all on europallets and these were delivered to the facility by the same contractor. Each time there was a cost involved – costs for collection and for delivery and for the europallets. This has been changed and incoming europallets are now separated and used again for outgoing freight. The change in the transfer of pallets caused some disruption on the floor, however, the cost saving justified it to the operations manager. (The contractor was dissatisfied).

Waste Management

Waste management is very stringent at *Firm X* with each unit being given clear targets in terms of costs. In 2005 several targets were exceeded. E.g. only 1.59% of the product end-of-life waste processed was sent to landfills worldwide (compared to its goal of no more than 3%) and recycled 77% of its non-hazardous waste (exceeding its goal of 67%). Hazardous waste was reduced by 19% (relative to output) in 2005 on top of a 33% reduction in 2004.

At this facility although production increased in the previous year non-hazardous waste was reduced. *Firm X* is a member of and works closely with Repak to reduce and recycle waste etc. The environment team is constantly looking for ways to reduce and recycle etc. Many limitations are due to the lack of infrastructure in Ireland for waste management e.g. at time of interview no contractor was able to take plastic bottles. A project in development is to remove individual waste bins to ensure everybody has to go to central bin to encourage waste segregation and facilitate recycling etc. This will entail behavioural change and will require widespread support.

Cost is a key driver and the environment team is given clear targets for waste reduction in terms of costs each year. Often there is a double cost saving where purchasing or production will not buy or use something which is then not entered into the waste stream. Cost of waste is tracked through the supply chain.

WEEE & RoHS

The environment team at *Firm X* have been heavily engaged in the WEEE directive. Particularly in Ireland the development of WEEE has been in close conjunction with industry in order to make it more effective and practical.

From a supply chain perspective the short term impact of WEEE & RoHS is that it could lead to a 'logistical nightmare' by adding to the complexity of an already very complex supply chain and the very large volumes involved. Many logistics staff are dealing with this issue. *Firm X* will use a third party supplier to dismantle, remove lead and other scrap, reuse etc. maybe in Romania. The identification of lead alternatives is not done at this site as this is a fulfilment site and the R&D is done in the USA.

It is seen as a question of costs and how to deal with regulations cost effectively. Development will continue in this area regardless of regulation. However, cost effectiveness does not affect the customer. The competitive advantage regarding the customer is in the technology. It is a cost to the firm. Competitive advantage does not come through cost for a large organisation such as *Firm X* with extensive resources, skills and power. It is surmised that WEEE may affect smaller competitors. While there will be costs there will also be opportunities e.g. to salvage materials which will still be good even if the technology is old.

Energy Use & Emissions Trading

Energy use is constantly being monitored and greater efficiencies sought. Manufacturing energy use not really affected as the product must be tested in certain processes. Therefore particular emphasis is placed on other energy uses such as cooling, heating, water etc. E.g. one recent project significantly reduced the energy requirements of air driers which were being used excessively and the efficiency of individual driers varied considerably. The most efficient ones were placed in the most critical production areas which require clean dry air and the less efficient ones were placed in areas where they are used less. Control and monitoring are key elements for managing energy use.

The energy team ensures the cooperation of the business and productions managers. The team does not simply dictate what energy reductions should take place. Environment goals are always linked to business objectives to ensure support from other managers and this is usually achieved through cost reductions.

Currently, the energy team is considering employing performance contractors for energy savings (a contractor will survey the facility and deliver predicted savings based on a fixed capital investment). At this

facility energy use is monitored mainly by calculating but the environment team is currently working on getting minute by minute or hourly monitoring of actual usage for each product line and piece of equipment e.g. each dryer. The business case is strong for this and it is expected that it should be relatively easy to implement. It has already been successfully implemented in some other sites resulting in savings of US\$1.4million.

Firm X is engaged in emissions trading but the goal is emissions reduction. In 2005, the firm achieved a CO₂ emissions reduction of 5.5% associated with its annual fuel and electricity use (exceeding the firm's own goal of 4% reduction). Globally, over three years *Firm X* avoided an average of 174,000 tons of CO₂ emissions and saved US\$12.8 million per year. Also globally, *Firm X* increased the use of renewable energy from 2.5% of energy use in 2004 to approximately 6% in 2006.

Environmental Strategy

Corporate Environment, Health and Safety Policy

Firm X strives to provide environmental leadership and has had a formal corporate policy for protection of the environment since 1971. This is in the context of the development of similar policies for health and safety in the workplace (1967) and the conservation of energy and natural resources (1974).

These policies are developed by corporate headquarters and provide the strategic framework for the environmental management system. The following objectives are published on the corporate website (adapted here to remove identity):

- Provide a safe and healthy workplace and ensure that personnel are properly trained and have appropriate safety and emergency equipment.
- Be an environmentally responsible neighbour in the communities where we operate, and act promptly and responsibly to correct incidents or conditions that endanger health, safety, or the environment. Report them to authorities promptly and inform affected parties as appropriate.
- Conserve natural resources by reusing and recycling materials, purchasing recycled materials, and using recyclable packaging and other materials.
- Develop, manufacture, and market products that are safe for their intended use, efficient in their use of energy, protective of the environment, and that can be reused, recycled or disposed of safely.
- Use development and manufacturing processes that do not adversely affect the environment, including developing and improving operations and technologies to minimize waste, prevent air, water, and other pollution, minimize health and safety risks, and dispose of waste safely and responsibly.
- Ensure the responsible use of energy throughout our business, including conserving energy, improving energy efficiency, and giving preference to renewable over non-renewable energy sources when feasible.
- Participate in efforts to improve environmental protection and understanding around the world and share appropriate pollution prevention technology, knowledge and methods.
- Utilize our products, services and expertise around the world to assist in the development of solutions to environmental problems.
- Meet or exceed all applicable government requirements and voluntary requirements to which we subscribe. Set and adhere to stringent requirements of our own no matter where in the world the company does business.
- Strive to continually improve our environmental management system and performance, and periodically issue progress reports to the general public.
- Conduct rigorous audits and self-assessments of compliance with this policy, measure progress of environmental affairs performance, and report periodically to the Board of Directors.

- Every employee and every contractor on our premises is expected to follow this policy and to report any environmental, health, or safety concern to management. Managers are expected to take prompt action.

A key feature of *Firm X's* environmental strategy is to clearly link to business goals and the bottom line. Cost savings are closely tracked and many environmental targets are expressed in terms of cost savings such as reduction and management of energy and waste.

Environmental Management System (EMS)

Firm X has over thirty year's experience of effectively using an EMS covering all corporate operations worldwide. The global environmental policy and objectives described above are reinforced by corporate instructions, practices and standards that govern all operations worldwide. These cover areas such as chemical and waste management, energy management, environmental evaluation of suppliers, product stewardship, incident prevention and reporting, and environmental impact assessment for property transactions.

Firm X employs a variety of mechanisms to monitor and measure the effective implementation of its EMS. These include:

- Professional Self-Assessment Programme – firm specific environmental checklists which cover both manufacturing and hardware development locations and non-manufacturing locations by geographic levels, product groups and service activities.
- Environmental Performance Database (EPD) - an internal measurement and tracking system which measures environmental performance in such areas as water effluents, chemical use and emissions, hazardous and non-hazardous waste management, recycling, energy conservation, environmental expenditures and progress toward meeting product stewardship objectives. The EPD provides the data used in *Firm X's* environmental and corporate responsibility reporting as well as in periodic updates on performance and programmes that go to senior management. Business units also make use of the database in analyzing their environmental performance and identifying areas for improvement.
- Environmental Audit Programme – an audit independent of the Corporate Environmental Affairs staff and implemented by the corporate internal audit organization. Five to seven locations are audited by corporate internal audit every year.

Certification

Firm X has a single worldwide ISO 14001 certificate. This was relatively easily achieved due its already long established global EMS and EMAS certification in some EU sites. Most particularly, *Firm X* played an active role in the development and refinement of the Standard based on its experience. It began registering some individual sites in 1996 and in 1997 became the first major multinational organization to achieve a single registration for operations worldwide. The registration covers all manufacturing, product design and hardware development operations and chemical-using research locations as well as several non-manufacturing locations. Approximately 15 of *Firm X's* ISO 14001 registered manufacturing and hardware development locations as well as the Corporate Environmental Affairs staff are audited each year. The single

registration ensures a more effective and efficient EMS and that *Firm X* executes the same EMS consistently worldwide.

Despite the comprehensive nature of the pre-existing EMS the formalisation through the ISO14001 led to the identification of gaps in the system and the implementation of ISO14001 led to immediate improvements in waste reduction, water use and packaging.

The decision to integrate the new ISO 14001 system with pre-existing ISO9000 certifications was at the discretion of each site as they differed in their systems and consequently faced different practical implications.

Environmental Affairs Team

The environment team looks after all *Firm X* sites in the country. It is cross-functional to some extent and it liaises closely with other functional areas. There is an environment representative in each business/functional area with whom the team holds regular meetings and with whom there is open two-way communication. 'Everything is matrixed' in *Firm X* and while this may seem that there are 'many bosses' it ensures good integration and cross-functional communication both formally and informally.

The country team works closely with other country teams. There is an annual environmental leadership meeting in the USA. and anyone in the corporation who might impact on environmental issues will attend - packaging, product design etc.

Many environmental operations are outsourced and the environment team oversees these in conjunction with the relevant functional area.

Training & Awareness

Employee training is an important element of *Firm X*'s corporate responsibility. Environmental training is provided for all staff at induction and whenever deemed necessary for the introduction of new processes etc such as reduce, reuse, recycle initiatives. The training is part of the ISO14001 system. Part of this is creating a culture where employees are attuned to environmental issues and will be enabled take on board and implement new information. Television screens are used throughout the facility for general information, education and awareness-raising. Environmental information and topics are often communicated in this manner. Part of the training encourages people to suggest ideas and the environment team run regular competitions for this. All employees were recently given mugs to avoid use of disposable cups and to raise awareness. The initiative to remove individual waste bins will entail considerable change in individual behaviour and necessitate awareness training and input from all functional managers.

Drivers

Cost is the main driver for environmental initiatives. Members of the environmental team are given annual targets e.g. by how much to reduce waste costs etc. This is how the business case is made to other functional areas. Corporate policy is a more fundamental driver and the ambition to remain a leader in the field of environmental management and to maintain its positive image with shareholders etc. Customers are seen as less of a driver as the technology is the main reason for purchasing *Firm X* products although an after purchase 'feel-good' factor may be considered desirable. The IMSS survey respondent identified the

regulatory authorities and corporate headquarters as well as local/community groups and organisations having the main influences on environmental practices.

Reporting

Annual environmental reporting began in 1990. It is now incorporated into the Corporate Responsibility Report which was first launched in 2003 as a companion document to the annual financial report. Environmental and corporate responsibility information is extensively reported on *Firm X's* website.

Networking

Globally *Firm X* is engaged in many environmental initiatives from research to education. In Ireland *Firm X* is also extensively involved in numerous industry networks and trade organisations with environmental aims such as IBEC and the WEEE lobby group. *Firm X* is an award winner for Corporate Social Responsibility. Particularly noteworthy are its commitment to community education, environment, entrepreneurship and social cohesion initiatives. The strong industry networking has been a good source of ideas for the environment team especially for 'low-hanging fruit' – initiatives which are relatively easy to achieve.

6.3.6 Firm Y

Description: Manufacture of electronic car components and supplies

Location: West of Ireland since 1982

Corporate Headquarters: on-site

Sales: Unavailable – Firm Y is a private company

Employees: 280 on-site in Ireland - 320 in total worldwide including 25 in the Czech Republic

IMSS Survey: Firm Y did not participate in the first IMSS survey but did participate in the second one. The questionnaire was completed by the Operations Manager.

Selection for Further Analysis: Recommendation of experts.

Interview: Interviews held on-site on 24th March 2005 with the Environment, Health & Safety Officer and the Project Manager for ISO14001 Implementation/Environmentally Superior Products Project/Cleaner Greener Production Programme.

General Profile: Firm Y was established in the 1982 to manufacture car security products for the consumer market. During the 1990's focus changed to original equipment manufacturing (OEM) and the direct and indirect supply of parts to the automotive industry. Some products are generic and are supplied to various customers and may involve some customisation. Other products are specific to customer requirements. In 2005 Firm Y established a manufacturing facility in Central/Eastern Europe. The reasons for this were labour and overhead cost advantages as well as the location which is close to significant customer base of manufacturing facilities. Firm Y has gained a reputation for design excellence and superior quality. Firm Y achieves world class manufacturing status through Total Quality Management (TQM), delivery performance and flexible manufacturing reflecting a continuous improvement approach to customer service. One of the core principles of TQM is the use of team-based manufacturing. Firm Y believes this empowers employees and ensures that all employees take ownership of the product, know its destination and receive feedback from the customers. All employees are encouraged to make an active contribution to continuous improvement of processes, products and services. Safety and environmental standards, supplier consolidation and advances in electronics are other key elements of its manufacturing strategy. The company also believes that its success is due to a global outlook combined with flexibility to respond quickly to specific requirements of customers. Firm Y has received a number of awards including an environmental product award and an EU eco-design award. Firm Y has a particular commitment to environmental management and was an early participant in ISO14001. Firm Y has participated in the Environmentally Superior Products Project sponsored by Enterprise Ireland (EI) and the Cleaner Greener Production Programme sponsored by the Environmental Protection Agency (EPA).

Mission Statement on Firm Y's website:

With our employee's expertise, flexibility and management skills, we strive to continuously improve customer service. We give innovation priority while maintaining a high quality, low cost, world class manufacturing environment. We will not delay for a moment, any action that will improve our process or products for our customer's benefit.

Firm Y's Quality Statement is: "Do it Right Now for the Customer". Firm Y has achieved TS16949 accreditation - the automotive industry's very rigorous quality certification.

Innovation & Technology

Innovation is a priority for *Firm Y* with a focus on the design, development and manufacture of technologically advanced products for the automotive industry. *Firm Y* has a reputation as a key player in the development of telemetry systems and of radio frequency applications, particularly in the area of remote access, security and general body control electronics. *Firm Y* was also one of the first firms worldwide to develop a microwave intrusion sensor. Recently, *Firm Y* developed camera systems for driver safety and assistance which is a growing segment of the automotive market. There is an extensive R&D team on-site.

Customers are very specific about product requirements for example the materials and constituent parts as well as the weight of the product. R&D engages in close liaison with customers on functionality, design etc. A lot of consultation takes place in the initial stages with visits both ways.

Innovation, Technology & Environment

Although *Firm Y* had been committed to improving environmental performance and had ISO14001 certification since 1999, it had not applied the principles to product development. In 2002, *Firm Y* undertook the redesign of a product under the Environmentally Superior Product Programme (ESPP) run by Enterprise Ireland. Initial stages of the project involved examining the product range and identifying potential environmental improvements rather than the design of a new product. After selecting one product, an electronic key, and conducting some research in-house and costing the design, *Firm Y* presented it for participation in the ESPP programme. The material content, weight and lead content as well as the number of components of the product were reduced. The redesign of the product also involved cost savings and made business sense. The environmental case alone would not have justified the project. The firm was quoting for new business at the time and the ESP programme coincided with a business opportunity. The project also resulted in an ECO-Design award from the EU Environment Commissioner.

Following the success of this project *Firm Y* decided to participate in the Cleaner Greener Production Programme (CGPP) sponsored by the Environmental Protection Agency (EPA) and is now engaged in a second CGPP project. The CGPP takes a holistic approach to examine all areas of production starting with product design. The design is crucial as 80% of product cost is decided at this stage. The objectives of the CGPP are to reduce consumption of materials and prevent the generation of waste and pollution. Product designers are trained in eco-design.

The first CGPP involved the evaluation of water-based coating as a potential replacement for product coatings based on Volatile Organic Compounds (VOC). This was done in anticipation of legislation being introduced in 2005 on the management of VOC. The water-based compound proved easier to manage during production requiring less blending and checking as well as generating less odour which was a Health & Safety benefit. The factory tests showed it to be equally as effective as the VOC coating in protecting the product. However, at the time of this study *Firm Y* was awaiting confirmation on its use following extensive testing by the customers. The project also addressed packaging and energy use both resulting in considerable cost savings. These are described further under the relevant sections below.

Based on the success of the first project a second CGPP project is currently underway. This includes the training of product designers in eco-design/Design for Environment (DfE) and the use of an eco-design checklist.

The objectives are to:

- reduce the size of the chosen product – a microwave sensor - by 20%, delivering material savings
- reduce energy requirements of the product over its life-cycle
- explore the potential for further savings - 20% on materials and 30% on cost which could significantly increase market share
- investigate and demonstrate the use of 'Smart Plastics' to facilitate disassembly of product - 'Smart Plastics' can be designed to open and improve disassembly efficiency when passed through an oven at a specified temperature e.g. 80°C.
- improve resource utilisation of operator and machine by 10% by applying lean and six sigma principles
- improve product yield by 3% thus eliminating scrap by applying six sigma and 8D problem solving principles
- examine the feasibility of incorporating 10% recycle material into plastic housing - recycle refers to processed recycled plastic that is ready for second use
- demonstrate effective use of eco-indicators to measure improved performance

To date the current CGPP is very successful. *Firm Y* believes that it aligns better with the objectives for the product which must be designed smaller and cheaper with improved yield and facilitate disassembly of cars. Also, 5% recycle will become law to create market for recycled plastic so *Firm Y* will have the advantage of being ready ahead of the legislation.

All on the R&D team are knowledgeable and very aware of regulations and what may be required in the future e.g. lead free. *Firm Y* aims to be one step ahead and ready to implement prior to or immediately when legislation is enacted. Information is gained from industry, customer requirements etc.

R&D is very aware of DfE and researchers were to be formally trained in DfE later in the year. Also, the R&D team consults the CGPP Manager much earlier in design life cycle than would have previously. However R&D must balance environmental attributes with technological advances and customer requirements:

- e.g. car camera must be waterproof therefore the use of glue for the casing means that it must be broken rather than disassembled after use.
- e.g. the R&D team recently developed a product which involved a mixture of plastics creating fumes and waste. The product could not be made without these so it was bought in instead. Although it was not manufactured in-house, the environmental impact was just moved down the supply chain.

Product design does not yet examine the inputs/outputs of every manufacturing process although some was done initially for audits. It is envisaged that this will be achieved in the future. *Firm Y* will also consider another product in the forthcoming months for the Environmentally Superior Products programme.

Packaging

Returnable packaging was designed, tested and used to send product to a new customer under the CGPP. Life Cycle Analysis (LCA) was undertaken to compare the environmental impact of plastic and cardboard boxes. This study showed a lower Eco Index (environmental impact) when using returnable plastic packaging rather than non-returnable cardboard. Seven hundred returnable boxes are currently each used about used eight

times per year in a continuous loop between *Firm Y* and customers in Poland. Return on Investment is achieved after 2.2 years which results in significant savings over the course of the five year contract with the customer. Some other packaging that is sent to customers is returned and reused as often as possible.

Waste Management

Currently there are several contractors for waste and *Firm Y* plans to streamline waste management in the future with only one or two contractors. The EH&S Officer can call on the contractors as required. Usually non-hazardous waste is collected weekly and hazardous once every two weeks or once per month depending on production. Maintenance person also looks after waste management. Hazardous waste consists of waste coating (VOC) & thinners used in coating processes, wipes and clinical waste as well as waste solder drop which can be recycled and is reconstituted by Irish Metals. A lot of documentation is involved but this provides management figures and volumes which enables the identification of ways to improve.

Cost is an issue and is driving the waste project to source one contractor to manage all waste more efficiently and at a better price (cost is driving many different projects throughout plant). There are quite a few contractors so there is competition in market. It is also expected to reduce the time needed to manage waste.

All contractors must have licenses, traceability etc. This is emphasised by customer audits. Waste management scandals in Ireland over past few years have highlighted this issue.

Firm Y has a Trade effluent License from the County Council and consultants do the required environmental monitoring. There is the potential for some lead in the water however, water usage is minimal. It does not have an IPC license from the EPA.

All paper is recycled. Some incoming packaging is returned to suppliers where it is cost effective enough to send back. Plastic trays and reels and cardboard are reused or recycled.

WEEE & RoHS and End-of-Life Vehicle (ELV)

WEEE and RoHS Directives will not directly affect *Firm Y* as all its business is as a supplier of electrical components which are specifically designed to be used in cars and are therefore not covered by the directive. However, it sees WEEE as an opportunity to develop innovative products e.g. the use of Smart Plastics to facilitate disassembly as described above under the CGPP project.

The RoHS (lead-free) Directive has a more immediate impact and *Firm Y* believes that the market will be ahead of the legislation. When the legislation was being enacted the lead-free solder technology was not proven to last over the life-time of a car (15 years). However the technology is now proving to be robust and many lead-free products are already available. In addition, car manufacturers are trying to reduce the lead content of cars and *Firm Y* sees this as an opportunity to develop new and improved products and to be advanced in the use of lead-free manufacturing when the legislation takes effect.

The implications of ELV are that all plastics must be marked and parts labelled and recycled material must be included – apart from these requirements ELV does not have much affect on *Firm Y*. Again, ELV provides an opportunity for *Firm Y* to develop innovative products such as the use of Smart Plastics to facilitate disassembly as described above under the CGPP project.

The International Material Data System (IMDS) was established by a group of car manufacturers to facilitate compliance with regulations such as ELV, WEEE and RoHS. This system keeps a register of all car parts and components and all the materials of which they are made. Many of car manufacturers which *Firm Y* deals with have signed up to IMDS. *Firm Y* must login and list all materials of each component it supplies and its constituent parts. In order to comply with this, *Firm Y* must get all details from its own suppliers. This can sometimes be difficult as some information is propriety but most suppliers are compliant (exceptions are made where real intellectual property is involved).

Energy Use & Emissions Trading

Energy is from a renewable source and use is monitored on a weekly basis. The Maintenance Department is very aware of potential benefits and cost savings to be achieved. Cost is a major driver including for the change of electricity supplier. Significant energy savings were achieved under the CGPP through the upgrading of air compressor for greater efficiency as well as widespread use of timers on equipment. A new variable speed compressor which could adjust to fluctuating factory demands resulted in an energy cost savings of almost €9,000 in its first year. Other energy (and cost) savings were achieved through the use of timers on various machines and on the chiller and air-conditioning systems to facilitate shutdown at predetermined times and at weekends. The factory operates 24 hours a day with less activity at night time and weekends. A project is underway to monitor the energy use of each production line and all heat extraction pipes have been insulated.

Emissions are also monitored but there is no requirement for a Greenhouse Gas Emissions Permit or for engagement in Emissions Trading.

Environmental Strategy

Corporate Environment, Health and Safety Policy

Firm Y prides itself on being an environmentally responsible producer and is well respected in this regard. It clearly identifies environmental production with business opportunities. From its inception it has continuously improved and developed its environmental policies and practices. *Firm Y* was an early recipient of ISO14001 in 1999 and it views this as conferring competitive advantage as it can enter projects more easily. The commitment to environmental management means that the senior management team is very aware of environmental issues.

Links to Business Requirements

Environmental management is viewed as good business. However, quality standards and cost effectiveness will not be compromised. For example, the project leading to the award winning product would not have been undertaken had the environmental objectives not coincided with business objectives of a product of reduced size and cost for a new customer. Likewise the Environmental Management System (EMS) is not integrated with the quality system. *Firm Y* is accredited with the very rigorous quality TS16949 certification which is specific to the automotive industry. The possibility of integrating the two systems has been discussed on numerous occasions within the firm. However, given the importance of quality to the business there is a fear of jeopardising or diluting its effectiveness therefore the two systems remain distinct.

Environmental Management System (EMS) & Certification

The Environmental Management System (EMS) is managed by the Environment, Health & Safety Officer and certified by ISO14001. Although they are managed by the same person, the Health & Safety (H&S) system (OHSAS 18001) is not integrated with the EMS. This person divides her time between the two areas depending on current requirements e.g. if there is an upcoming audit. There are separate manuals and procedures for the two systems. Some linkage and overlap exists e.g. emergency preparedness & response.

Many of the internal EMS auditors are also quality auditors and in this sense the EMS is more linked to the quality system and schedule. However, as discussed above, the EMS remains distinct from the quality system which is managed by another department and functional areas.

Environmental audits of suppliers are not yet required yet but there are plans to have trained auditors to incorporate audits by suppliers and waste contractors in the future. This will involve more staff and require training.

The EMS is seen as a useful tool for management however it is also recognised that it is only as good as the work put into it and the ISO requirements can be minimal or fundamental depending on the firm's drive. The implementation project manager believes that the firm manages its environmental aspects better than if the ISO14001 EMS was not in place. It controls some things that may not otherwise be controlled but it also depends on how the firm drives the system to push for improvements. The initial drive to get certification came from the firm's commitment to environmental management. Afterwards the process of continuous improvement and re-auditing drives improvements as every six or seven months some improvement must be addressed. The process of continuous improvement fits well with *Firm Y's* general approach.

Training & Awareness

All employees are aware of the environmental focus of the company. The general introduction to the company will include this information. This is seen as an inherent part of *Firm Y's* activities and people are generally interested and supportive especially with when engaged with particular projects such as waste segregation. Employees are proactive and will suggest very practical ideas or point out anything amiss.

Induction training in Environmental Awareness covers the following areas:

- general information and products
- why the EMS system is in place
- positive aspects
- effects of not doing something
- waste management: waste segregation, reduce, recycle etc
- energy use etc

The number of production staff fluctuates considerably depending on demand but all employees receive induction training which is incorporated into H&S training. The local population will also be generally aware of *Firm Y's* environmental interests and achievements through newsletters and the local media etc.

Drivers

The main driver for environmental management and policy is the senior management team at *Firm Y*. The team is committed to environmental management and very aware of relevant issues. For example, the team was very disappointed with the delay in applying RoHS to car components. This meant that customers did not wish to employ the available lead-free technology in their components even though *Firm Y* was ready to do so. This commitment to environmental management has been inherent to *Firm Y's* approach since the beginning. It is also reflected in the employment of a manufacturing technology engineer who is a champion for environmental management and employed as a dedicated manager for environmental projects which are supported and well resourced. Although it may not have already been fulfilling all requirements, it was relatively easy for *Firm Y* to attain ISO14001 as it fitted well with existing policy and practices. As well as management employees, the IMSS survey respondent also identified regulatory authorities and environmental organisations as having the most influence in determining practices.

The external drivers for environmental management include the ISO accreditation system which demands continuous rechecking which in turn helps to maintain the momentum and focus for improvement. Other external drivers have been the availability of state support and resources namely the ESPP and CGPP. For example, the ESPP was the initial driver to work on product development which was an area previously not addressed. That these programmes coincided with *Firm Y's* business objectives also meant that they were supported and well resourced.

In the opinion of the interviewees, customers have not been such an important a driver for *Firm Y's* environmental management. The customer base is small with one customer accounting for 30% of business (although the intention is to increase the number of customers). In the past some requested ISO14001 which gave *Firm Y* an advantage and an opportunity and marketing tool. However, very little is currently coming from the customers according to *Firm Y*.

On the other hand, some customer and industry requirements are related to environmental issues. For example, product specifications will generally be very precise about allowable weight for reasons of fuel efficiency and in many cases tenders cannot be submitted unless the product's expected weight is below a given threshold. Also, car manufacturers are looking towards car disassembly in the context of ELV and *Firm Y* is developing its products to facilitate this process and give it an advantage in the future. Notional costs of e.g. 17 cents per kilo will be charged to the component manufacturers therefore the component's materials and weight will be important cost factors.

One final and unexpected influence or driver has been the experience of *Firm Y* in establishing a fully owned manufacturing facility with two production lines in the Czech Republic. This was built on a greenfield site to free up space and resources at headquarters. An entire manufacturing line was transferred to the new site. All R&D will continue to take place at headquarters. Environmental, Health and Safety training was conducted on the new site and the EH&S Officer went out from headquarters. An environmental consultant is employed there. The quality engineer has experience in environmental systems and spent some time at headquarters. The site was applying for ISO14001 at the time of the interviews and the preliminary audit had passed very quickly. The manufacturing is low impact with no use of chemicals etc and the plant is very well designed making it easier to control. The experience of *Firm Y* is that environmental regulations in the Czech Republic are very strict and probably more advanced than in Ireland. They are well developed and very clear

regarding practices. Initial environmental examinations by different authorities are conducted before production is permitted e.g. must have filters and monitoring in place, drinking water is tested etc. The relevant authorities have more powers. For example, a fire officer can walk onto the site to examine it without notice and drinking water is tested every 2 or 3 years.

Some practices from the new operation will be adopted by headquarters. For example, the register of aspects goes through every process recording all inputs and outputs from each process. Each production line has a list of waste and is monitored separately. This is currently done in a more general way and in less detail at headquarters. Otherwise the waste management system is similar with one main contractor.

Networking

Firm Y engages in a lot of networking: attendance at seminars throughout the country, courses as well as informal networking through contacts in the industry and EH&S professionals. Regional networking is particularly good. Legislation updates are received from IBEC. A lot of contact is maintained with Enterprise Ireland (EI) and the Environment Project Manager has given many external presentations for EI, Shannon Development and EPA. Suppliers and consultants also provide a lot of training, advice and information. EH&S conduct school visits and there is a lot of support for local community projects: some informal initiatives such as the provision of a collection point for the recycling of Christmas cards and some other more formal projects such as work experience for transition year students and sponsorship of the junior achievement programme.

6.4 Cross Case Analysis and Thematic Presentation of Case Results

This chapter presents a comparative cross-case analysis of the six cases. It begins with a brief summary of each case. The cases are then compared in terms of the major themes which emerged from the data: innovation, formalisation, quality, links to business requirements (e.g. costs), corporate policy, regulations, individuals and others. Finally, models are presented for each case. Discussion is conducted in Chapter 7.

6.4.1 Outline of cases

Firm A manufactures measuring equipment and was selected for further analysis because it had a high IMSS environment in strategy (ES) score and a high innovation score. This case data show that *Firm A* did not get a high Irish environment (IE) score because it did not identify any of its environmental initiatives in the survey (e.g. packaging, waste management, lead-free products and energy use). The firm has a policy of environmental responsibility supported by an open and adaptable attitude to new ideas, initiatives and regulations. This is a pragmatic business approach and is not ideological or marketing driven. Wastage is abhorred and cost management is rigorous. However, while there is an explicit desire to be environmentally responsible and forward thinking this remains an informal strategy. *Firm A* epitomises a common sense matter of fact approach to environmental management, informal yet pragmatic. High standards are achieved due to the alignment with other firm values namely innovation, quality, customer service, efficiency and cleanliness. On the other hand, the lack of a formal environmental management system leads to deficiencies and unrealised potential as shall be outlined below.

Firm B manufactures parts and supplies for its own ICT products. *Firm B* was selected for analysis because it achieved a high innovation score, a high Irish environment (IE) index score and has ISO 14001. Furthermore, it was mentioned by one of the expert interviewees as an example of best practice in environmental management. The case data support these results and show that *Firm B* has a comprehensive environmental management system (EMS) in place to which it dedicates substantial resources. While the majority of policy and strategy is corporate driven, the adoption of ISO14001 was an initiative of the Irish subsidiary. *Firm B* operates its EMS within the same department as the health and safety system.

Firm C manufactures networks and cables. It was selected for analysis because of a high Irish Environment (IE) index score and ISO14001 certification. *Firm C* adopts a systems approach and is a Business Excellence Award winner. *Firm C* has uniquely integrated the environmental management system with the quality and health & safety systems. Environmental benefits are clearly linked to business requirements.

Firm D is one of two privately owned case firms. It produces sound systems for the domestic and retail markets. It attained a high Irish Environment (IE) index score but had low environment in strategy (ES) and innovation scores. It was selected due to these contrasting scores as a possible confirmatory or negative case. *Firm D* is widely recognised for its products and innovation in audio technology. The case data reveal that *Firm D* is compliant rather than innovative in terms of environmental management which does not feature prominently in manufacturing strategy. Nevertheless, costs, safety and quality initiatives have resulted in environmental improvements.

Firm X was recommended by experts as an example of best practice in environmental management. *Firm X* is a global leader in the manufacture of mainframe computers. As with *Firm B*, *Firm X* has a comprehensive environmental management system in place to which it dedicates substantial resources. Environmental

management is a distinct department within *Firm X* although it is integrated across all functions. Corporate policy is a main driver. At local level, the establishment of clear targets, particularly in relation to cost savings, facilitates implementation of environmental improvements across different functions.

Firm Y is the only indigenous Irish case firm and it is also privately owned. *Firm Y* manufactures electronic car components. It was recommended by experts as an example of best practice and achievement in environmental management. *Firm Y* has won several environmental product awards. While environmental sustainability is a clear business strategy in *Firm Y* it is mediated by cost and quality requirements. A systematic approach to general environmental management is accompanied by targeted initiatives in product development.

Firms A, B, C and *D* responded to the first IMSS survey. *Firms X* and *Y* were recommended by experts and both responded to the second survey. Table 6.4.1 presents some summary data of the case firms.

Table 6.4.1 Case Firms & their Selection Criteria							
	Firm	A	B	C	D	X	Y
Survey Data	Products	Measuring equipment	ICT parts / supplies	cables / networks	audio systems	mainframe computers	electronic car components
	ISIC (rev 3.1)	33	30	32	32	30	34
	No. Employees: on-site	150	2,000	220	230	2,500	280
	No. Employees: worldwide	1,754	150,000	4,000	8,000	355,000	320
	Ownership	public	public	public	private	public	private
	Headquarters	UK	USA	USA	USA	USA	Ireland
	IMSS III – 1 st survey	✓	✓	✓	✓	x	x
	IMSS IV – 2 nd survey	✓	x	✓	✓	✓	✓
	IMSS Environment in Strategy (ES) Group	positive	neutral	neutral	negative		
	Irish Environment (IE) Index Group	medium	high	high	high		
Case Selection Criteria							
High Innovation Score	✓	✓			-	-	
High IMSS Environment in Strategy (ES) score	✓				-	-	
High Irish Environment (IE) index score		✓	✓	✓	-	-	
ISO14000		✓	✓		✓	✓	
Recommendation of Experts		✓			✓✓	✓✓	
Other							
Formal Environmental Management System	no	yes	yes	no	yes	yes	
Integration with Quality System	some	alot	total	little	alot	none	
Arc of Integration (facing position)	outward	outward	supplier	supplier	supplier	customer	

6.4.2 Innovation

One purpose of this study was to examine the integration of the environment with innovation and whether capacity for and leadership in innovation and general innovativeness of a firm could be viewed as resources which could be applied to or reflected in environmental management.

Each of the six case firms is a global leader in its field. Each has developed new technologies and has effectively applied these to new products which have been successful in the marketplace. Innovation (process and product) and design are priorities in all of these firms and considerable investment is directed towards R&D at corporate level. Therefore, in terms of new product development, all of the case firms may be described as innovative. However, differences emerge in relation to the application of these innovation resources to environmental ends as well as in the variables associated with innovation.

The pattern across the five case firms which are multinational subsidiaries is that R&D is primarily conducted off-site at corporate headquarters or other sites. The main impact of R&D in all five cases is in the manufacturing process. In situations where R&D is conducted on-site it is limited and relates mainly to the improvement of manufacturing processes. Nevertheless, the two larger multinational subsidiaries can dedicate some resources to innovation. *Firm B* (ICT parts) is striving to increase its R&D activities to move up the value chain and spent 15% of its revenues on R&D in 2000. *Firm X* (mainframe computers) is striving to generate a culture of innovation in all areas of the organisation and is therefore creating an open and inclusive system of innovation. However, in all cases the off-site R&D teams drive the integration of manufacturing in the design process and, for example as reported in *Firm A* (measuring equipment), any changes in manufacturing which may affect the product design must be referred back to R&D as a quality control measure. *Firm A* has no R&D budget and all R&D is conducted at corporate headquarters. Likewise, all R&D is conducted elsewhere in *Firms C* and *D*.

The survey data also show some differences between the four respondent firms (*A, B, C & D*). For example, *Firms A* and *B* have a high innovation scores reflecting particularly high use of technologies for operational activities as well as higher than average levels of co-ordination of design and manufacturing and management of the product development cycle¹⁵. In the survey, *Firms C* and *D* report average use of technologies and lower than average use of co-ordination of design and manufacturing as well as product development cycle, giving them lower innovation scores. There are nevertheless strong links with R&D in design of the manufacturing processes in these firms. In *Firm C* (networks and cables) there is constant liaison with the Global Engineering Group and in *Firm D*, new audio systems and products are piloted at this site with teams from the central design centre.

The indigenous Irish case, *Firm Y*, a global leader in the development of electronic car components, also shows strong links between R&D and manufacturing. This is naturally facilitated by having an extensive R&D team on-site. This case also illustrates a focussed application of R&D capacity to environmental products and processes. While superior environmental management is a core value at *Firm Y* and evident in all other areas of the organisation it did not apply to new product development until recently. The availability of a state supported programme prompted a look at potential redesign of products and eventually led to the design of an award winning new product which coincided with business and customer requirements.

¹⁵ Co-ordination of design and manufacturing (use of rules and standards, cross-functional teams) and Management of the product development cycle (early involvement of manufacturing and use of tests/prototypes).

However, the associated environmental/innovation learning is being assimilated incrementally in a targeted manner with one product line being examined at a time. Each case must be justified in business terms – materials and costs savings, customer requirements etc. The next stage, the training of all R&D staff in Design for Environment (DfE) principles, will encompass all future new product development.

On the other hand the two large multinationals, *Firms B* and *X* have extensive resources dedicated to DfE. In spite of this the core products have short life spans (in environmental terms: 1- 5 years). These firms are viewed as global leaders in innovation and in environmental management and both operate comprehensive product development programmes. Although they apply DfE principles, the products are in the end better designed for ease of replacement and recycling rather than for durability or upgrading. This is currently the nature of the computer and electronics industries where the pace of product development is driven by the rapid development of new technologies and consumerism. In both cases, significant resources are dedicated to product materials and process improvements and these firms are viewed as proactive leaders in this regard. Continuous and incremental improvements are made to products. Additionally, these large organisations can also dedicate substantial resources to more unusual environment oriented product development solutions and inventions which may be cost effective to manufacture in the future and which can generate significant positive publicity. In both instances the corporate policy is to remain global leaders in this area and in the area of corporate citizenship in general.

In contrast, *Firm C* designs its networks for durability and offers a 20 year guarantee with the likelihood that this may increase. However, design for environment is not explicit in either *Firm C* or *D*. *Firm C* has an advantage in that, as well as being durable, its products are inherently easily recyclable - core materials are PVC and copper (although PVC is toxic if disposed of). *Firm C* developed an innovative process of recovery and recycling of PVC plastics during the manufacturing process. R&D at *Firm C* is also actively striving to produce high performance products which are environmentally friendly and meet the requirement of new regulations e.g. implementing EU RoHS to reduce lead-based stabilisers in the PVC coatings. *Firm D* (audio systems) does not have any explicit integration of the environment into its product design although there are some inadvertent instances e.g. chipboard from sustainable forests and reverse logistics where returned/rejected goods are remanufactured. However, its approach to compliance is always to be prepared ahead of implementation and R&D will work towards compliance to future legislation. *Firm A* (measuring equipment) also adopts this approach whereas *Firms B* and *X* become actively engaged in the development of legislation such as WEEE.

Finally, *Firm A*, is also a global leader which espouses environmentally conscientious principles and aims for clean technology. *Firm A* is an innovation driven organisation which focuses on R&D and patents and prides itself on its quality products and production systems. Environmental innovation is evident in the proactive nature of packaging, waste and energy management. *Firm A* is especially proactive in its advance preparation and compliance with regulations. R&D conducts life cycle analyses and incorporates environmental considerations into the design of products and manufacturing processes. However, the extent of this is unclear and there is no explicit environmentally oriented product or product enhancement. As shall be outlined below, while high quality standards facilitate this process it is hampered by the lack of a formal environmental management system.

In summary, all the six case firms are innovative and global leaders in their respective fields. However, differences emerge in relation to the links of innovation with environmental management. In some cases

environmental management is very explicitly linked to innovation (*Firms B, X and Y*). In other cases environmental management is more subtle (*Firms A and C*). And in the case of *Firm D* environmental management in the innovation processes is either inadvertent or compliance driven. These differences probably reflect corporate policy and formalisation as discussed below.

6.4.3 Formalisation

Formalisation of strategies and fit between strategies were identified in the literature as promoting innovation and firm performance. Similarly, environmental performance is improved where an accredited EMS is in place. The survey data highlighted this link between formalisation and environmental management. This is also partly supported by the cases. Four of the six cases have adopted ISO 14001 (*Firms B, C, X and Y*). The remaining two firms (*A and D*) do not have any formal EMS in place.

The role of ISO14001 differs across the four accredited firms. In the case of *Firms B* and *X* the certification itself, rather than the process or system, was a main element. Both firms already had comprehensive EMSs in place which were effective and recognised as being proactive. They differed from each other in their approach to third-party certified systems. Initially, several European sites of *Firm X* (mainframe computers) registered for EMAS. While these were successful their usefulness was confined to EU countries. Then *Firm X* used its experience to become actively involved in the development of ISO14001. This led to the first single registration for an organisation of all its sites worldwide. However, when the internationally recognised ISO system became available corporate headquarters at *Firm B* (ICT parts) did not believe it was necessary as their own EMS was sophisticated and effective. However, customer demands led them to follow the initiative of their Dublin site to gain a global registration. *Firm B* followed *Firm X* and became one of the first organisations to obtain a single worldwide certificate. And, while it may be true that both firms have their own elaborated EMSs, which in many ways surpass the ISO14001, the certification through a recognised third party publicly verified the EMSs and brought to light some deficiencies in the pre-existing systems. In both firms the formalised and structured approach to EMS identifies clear and measurable improvement targets e.g materials and waste reduction. In *Firm X*, in particular, many of these targets are expressed in terms of cost savings which provide distinct business incentives.

In the other two ISO14001 accredited cases, *Firms C* and *Y*, the certification process was a key element in the development of the firms' EMSs. Both these firms may be viewed as small-medium sized with limited resources to dedicate to an EMS - *Firm C* was operating at site level and *Firm Y* is the indigenous Irish case. Both firms were early recipients of ISO14001 (1997 and 1999 respectively) and are examples of how a formal EMS can bring opportunity for innovation through systematic look at the organisation's activities, products and processes and the search for improvement possibilities.

In the case of *Firm C* (cables/networks) a formal EMS was a natural development from the success of its systems based approach to management. Formalisation of the system facilitated the identification of clear links to business requirements which in turn contributed to its successful establishment and implementation within operations. Again, the role of formalisation in identifying clear measurable processes and targets and in the identification weaknesses is important in facilitating implementation and continuous improvement. The evolution of the system, and its ultimate integration with the quality and health & safety systems, was also steered through a close relationship with the auditors and through extensive benchmarking.

Firm Y (car components) has a clear policy commitment to environmental management. Having an externally audited system helps to keep this to the fore and to keep up the momentum for continuous improvement. The formalisation through ISO14001 also brought clear business advantages as it is often a requirement of customers and since *Firm Y* was an early recipient of ISO14001 this brought competitive advantage. *Firm Y* has also exceeded the certification of its EMS through formal participation in supported programmes (Environmentally Superior Products (ESP) and Cleaner Greener Production (CGPP)) which brought improvements and recognition which may otherwise have been difficult to achieve.

The remaining two cases (*Firms A* and *D*) have no formal EMS in place. This reflects the lower level of formalisation of manufacturing strategy in general. While they both are rigorously compliant with regulations and aim to implement them ahead of enactment of legislation, they differ in their approaches to environmental management. *Firm D* (audio systems) has no environmental system, either formal or informal, although it is currently preparing for ISO14001 certification as part of the process of attaining the automotive industry's quality certification. This process is being managed by the quality manager due to her experience of systems implementation and not due to any particular link with quality *per se*. An environmental management system is not a goal in itself.

Firm A (measuring equipment) is an especially interesting case in that it espouses a clear commitment to environmental management and incorporates environmental consideration into many aspects of its operations. However, there is no formal system in place either certified or not. Without a formal environmental strategy and management system, implementation remains ad hoc and depends to a large degree on employee initiatives and on compliance (even if in advance) to regulations. While the facilities manager has responsibility for environmental management this effectively is in relation to waste and energy. In practice, environmental management takes place within each functional area and any broader discussion which may occur is in the context of meetings on other issues such as health and safety. Measurement of environmental performance occurs at the level of each individual function without overall co-ordination or higher level monitoring. The informal nature of the management means that there are no performance targets, goals or clear demarcation of environmental responsibility. Consequently, while the performance of identified actions is positive, other issues and areas may be overlooked. The lack of a comprehensive integrated overarching system means that consistent and continuous performance enhancement may neither be equal nor coordinated across different functional areas. The desired formalisation of the current informal system is a recognition at corporate level of these weaknesses. Formalisation is also being driven by the customer albeit in the form of certification queries rather than demands as well as a desire to inspire confidence in the customer through clear and authoritative standards. While the Group headquarters were proceeding with plans for ISO14001 the Dublin plant was unaware of the plans. This is partly because the Dublin plant is already seen as being proactive and successful in achieving environmental management and partly because the certification is being done on a site by site basis. ISO14001 is viewed as a self-imposed target. Although nothing is specified or identified as environmental management in budgets, each project can factor in such related costs. However, more explicit budgeting would enable clearer targeting of environmental issues with the advantages of cost and resource management. These and other advantages of a more formal system can occur independently of the ISO certification.

There exists a belief in *Firm A* that they are doing all that they can without actually verifying this in any systematic regular or continuous manner and, although they have conducted internal audits in the past, there

is no independent measure of performance beyond compliance. This belief also invites complacency although there was no evidence to suggest this was happening. The firm willingly rises to the challenges of market demands, legislation and regulations. Wishes to become more proactive were clearly expressed at corporate level. This could be enhanced with formalisation of environmental management and integration with other processes particularly innovation and design.

In summary, the evidence from the cases provides support for formalisation of an environmental management system as a source of improved practice and performance and particularly as a source of innovation. Formalisation enables clarification, measurement and communication not only of environmental improvements and targets but also of the related business benefits such as costs and materials savings, process efficiencies and product enhancements. Additionally, the certification of an EMS through a third party further enhances the rewards of formalisation as opportunities for improvement and innovation are more likely to be identified and there is an incentive for continuous improvement. Although, as one interviewee noted, the improvement may be minimal e.g. for ISO14001, some improvement must be shown on a regular basis. Supported programmes or projects such as the ESP and CGPP of state agencies also show how effective formalisation can be in achieving results and promoting environmental management as a source of innovation with clear business benefits. The formalisation process gives clear targets and measures of performance both in terms of environmental achievements and costs. They enable a focussed approach for the dedication of resources to specific outcomes and create organisational learning and capabilities.

6.4.4 Quality

Quality is one of the strongest themes throughout the case analyses. Each firm is uncompromising in its commitment to quality. This may be seen in the emphasis the four survey respondents place on product design and quality and manufacturing conformance quality in their competitive priorities and in the significantly higher than average expenditure on preventive over corrective maintenance. However, the relationship between environmental and quality management differs among firms.

In terms of certification, given that all Irish based firms have ISO9000, it is not surprising that a higher than average number also have ISO14001 (41% compared to 18% for all IMSS firms) as consistent with the literature. Also, the learning and system capabilities of ISO9000 facilitate adoption of ISO14001. And, as noted above, four of the six cases have ISO14001. However, whether or not the firms have ISO14001, there exist differences between the cases in the relationship of environmental management and quality.

For example, although *Firm D* (audio systems) is currently preparing for ISO14001 certification, this is being done as part of the process for attaining the automotive industry's quality certification TS16949. Other *Firm D* sites have TS16949 and this is being done part of the standardisation of systems across the organisation. Currently, this site manufactures for the domestic market and not for the automotive industry therefore having that industry's certification would create the possibility of expanding the product range of this site. The process of ISO14001 is being managed by the quality manager due to her experience in systems implementation rather than environmental management experience or an explicit identified link to quality.

The case which already has TS16949 is *Firm Y*. This firm operates a Total Quality Management System (TQM) and embraces its philosophy of team based manufacturing and whole systems approach. This conceptually and practically facilitates successful implementation of an EMS. However, the EMS remains distinct from the quality system. The topic of integration has been discussed within *Firm Y* but the quality

demands are viewed as so rigorous and essential to the business in the car components industry that any possible compromise cannot be countenanced. And, given the EMS is itself highly successful, there exists no motivation or justifiable reason to integrate the EMS with quality system. The EMS remains independent of quality and is managed in a separate department by the same officer as for Health and Safety.

Another case which links the EMS to Health and Safety is *Firm B* (ICT parts). The two systems are integrated in that they are managed by the same department. The EH&S department scorecard provides metrics for both systems. However, when the ISO14001 was being introduced an attempt was made to integrate it with the existing ISO9000. It proved unfeasible at this site although they are integrated successfully at other smaller sites. There is no conflicting ideology or operational aspects to integration of environment and quality. Environmental management, as with quality, is seen as integral to all operations. However, there are some instances of conflicting priorities. For example, *Firm B* operates a highly regarded recycling facility for its products but it does this instead of re-using its products which would be the environmentally superior option. The view is that this would be seen to impair quality and affect *Firm B*'s brand image of quality.

Firm X (mainframe computers) also views environmental management as integral to all operations. Given that it is extremely large, like *Firm B*, environmental management teams are discrete units. However, major product lines and design teams all have individuals with relevant environmental expertise who also work directly with quality and other personnel. This has also resulted in some product enhancements which have both quality and environmental benefits (e.g. finishing coatings). Also, the organisation operates a matrix structure enabling cross-referencing of all activities and functions including quality. Regarding ISO14001 certification, some sites have totally integrated systems and others do not. Corporate headquarters left the decision to integrate the new ISO system with existing ones at the discretion of each site as they differed in their ISO9000 certifications with consequently different practical implications.

Environmental management in *Firm A* (measuring equipment) is seen a good practice. Environmental responsibility fits well with a culture of quality and efficient production and this is an important element in the success of the informal strategy. The rhetoric of managers reflects duty to customers, a contract of quality and reliability. They see no point in fulfilling this role in manner which may be environmentally or otherwise negative. Good environmental management is aligned to good quality and quality is viewed as an essential responsibility to the customer and to do justice to the product patents. Environmental management is the responsibility of the facilities manager but, as mentioned above under formalisation, this mainly entails waste and energy. Other environmental issues are dealt with at functional level and issues are often raised in the context of weekly H&S meetings. At corporate level the pursuit of ISO14001 is being managed by the Quality Manager. The approach being adopted is the same as for quality and H&S with the view that the same management tools apply the difference being in the audit.

Firm C has the most explicit integration of its systems. As with the other cases, quality and continuous improvement are core values of *Firm C*. It provides an extended guarantee for its networks and it only supplies entire networks in order to maintain control over the quality of all parts. Employees at all levels are encouraged to continually improve and optimise processes. *Firm C* is widely regarded for its systems management approach and enterprise networking. It has won Irish and European quality awards in recognition of its achievements and commitment to improving business performance and competitiveness. At the time of winning the European Business Excellence Award it viewed quality, environmental management

and H&S as the ‘three key systems of its operations’. However, as discussed in the case analysis, the systems have since been integrated into one with an integrated audit for the three associated certificates. The environment and quality systems have always been closely aligned. When the ISO14001 was being introduced extensive reference was made to the ISO9000 manuals and system. All instances of overlap and possible mutual support in the systems were identified and this facilitated the introduction of the integrated system. Environmental management, H&S and quality are all integral elements of the manufacturing process and business operations. Systematically they are intertwined and managed as one unit. And, as with *Firm A*, ideologically they are viewed as naturally aligned to continuous improvement and good practice. However, there remain instances in *Firm C* where quality dominates over environmental considerations notably in the packaging of loose cables in plastic bags and the use of plastic spools which could be re-used but which are discarded by the customer. These have been identified by *Firm C* as areas requiring research and improvement.

In summary, all six cases have very clear commitment to quality and improved performance. However, the relationship with environmental management varies. The diverse approaches reflect the spectrum from complete independence (*Firm Y*) to complete integration (*Firm C*) (Figure 6.4.1).

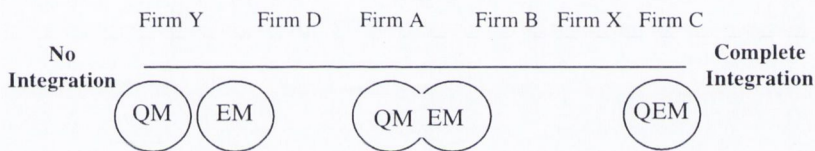


Figure 6.4.1: Quality and Environmental Management - Spectrum of Integration

Firm Y (car components) represents the independence end of the spectrum. While environmental management is integrated into different functions it remains distinct from the quality management system. Quality is viewed as so important and sensitive in the business that it is protected from any possible diversion or impingement. *Firms A, B, D* and *X* represent the mid-spectrum. While *Firms A* (measuring equipment) and *D* (audio systems) do not have formal environmental systems their introduction is being linked to quality. *Firm A* views environmental management as inherently aligned to quality and good practice as well as needing a similar management approach whereas *Firm D* sees the similarities between environmental management and quality from a systems perspective.

Firms B (ICT parts) and *X* (mainframe computers) have well integrated systems. However, environment and quality remain distinct systems with separate information management. The level of integration also varies across sites in these large organisations. For example, certification and audits may be done separately or together depending on site circumstances. Integration is by means of cross-referencing, communication and co-ordination. This appears to be done to a greater degree in *Firm X*. *Firm C* (cables) represents the complete integration end of the spectrum and has its environmental and quality systems totally integrated. Along with H&S they operate as one system with unified information management. Effectively it is a single system with environmental, quality and H&S metrics.

Although the relationship between environmental and quality management differs across cases, the emphasis on superior quality management is notable in all firms.

6.4.5 Other Influences

Other internal and external influences on environmental management are evident from the cases. Internal influences include business requirements such as cost savings and product specifications; corporate policy; and individuals. External influences include regulations; external integration, customers and suppliers; supported programmes; and other stakeholders.

6.4.5.1 Links to Costs and Business Requirements

The ability to link environmental initiatives to costs/business requirements has been a key success factor in all firms. In particular, costs savings are distinct drivers for many initiatives. Reduced waste and increased recycling in all firms reflect the substantial inflation in the cost of waste disposal in recent years. Likewise, energy efficiencies lead to significant savings in all firms. In addition to waste and energy, savings in materials and packaging were particularly noted.

Firm X (mainframe computers) sets clear targets in term of cost savings. These cost savings can also be used to promote initiatives with different functions and departments e.g. packaging. Many annual personal goals of the environment team are expressed in terms of cost savings. In *Firm B* (ICT parts) cost is also seen as a major driver and improvement targets are linked to costs. Both *Firms B* and *X* see environmental management as integral to their corporate image, brand and their promotion of corporate citizenship. *Firm C* (cables) clearly links its improvement goals to business requirements. It sees the two as inherently complimentary and finds the auditor particularly supportive of this approach. *Firm Y* (car components) achieved many product enhancements due to clear identification of business benefits e.g. materials reduction and product enhancements such as fewer components and reduced weight. Significant research and investment into reusable packaging also led to considerable cost savings. As above, cost was a driver for many initiatives in *Firms A* (measuring) and *D* (audio systems) e.g. waste reduction and recycling, energy efficiency. However, rather than being managed as environmental initiatives with business or cost related targets and savings, these are business initiatives and cost savings with environmental benefits. In this sense any broader environmental implications or opportunities may not be recognized. Moreover, if the possibility for additional cost savings cannot be seen, further potential environmental improvements may also be overlooked.

6.4.5.2 Links to Corporate Policy

The relationship of each case site to the parent or corporate headquarters is also diverse. *Firms A, B* and *X* all have clear corporate policies which affect environmental management. Although responsible environmental management is a policy of *Firm A* there is no formal system in place. On the other hand *Firms B* and *X* have their own elaborate corporate EMSs which dictate many practices. They are directed by clear policies on environmental performance and corporate citizenship in general. *Firm D* has no explicit or public corporate policy on environmental management or corporate citizenship although the adoption of ISO14001 is being driven by corporate policy to standardize system across all sites. *Firm C* has experienced different relationships with corporate headquarters since it has been the subject of numerous takeovers. Although the initial systems management and environmental initiatives were by the first corporate owners, this site has always operated quite autonomously and views itself as the main driver for environmental management and other systems initiatives rather than any particular corporate policy. Corporate headquarters have always been

quite supportive and the previous owners actively promoted *Firm C's* achievements and awards. The current owners are more modest and discrete and do not particularly promote these although they do recognise the adherence to voluntary codes of practice as part of their R&D.

Finally, *Firm Y*, the Irish indigenous case, has a clear corporate policy for responsible and proactive environmental management which is seen as contributing to competitive advantage.

6.4.5.3 *Individuals*

The role of individuals is apparent in the cases. Apart from the environmental management knowledge and competency resources of individuals which may be assumed, individuals play important decision-making and social functions. The choice and direction of many environmental initiatives are steered by individuals even where a formal EMS is in place. In firms such as *A* and *D* where there is no formal EMS many practices and behaviours are the results of individual initiatives. In *Firm A* (measuring equipment) where there is a corporate policy supporting such initiatives, the role of individuals, in particular non-management employees, is more prominent. The firm has a culture of promoting innovation among employees in all areas. *Firm D* (audio systems) is embarking on the process of implementing an EMS. The responsibility is assigned to the quality manager and the final system will depend greatly on her vision e.g. the extent of integration with the quality system.

In firms where there is a formal EMS the role of individuals is also important. Given that an EMS interacts with many of an organisation's activities, the people responsible for it must interact across many functions and, most crucially, must persuade others towards the EMS goals. In such situations the ability to sell business benefits such as cost savings and product enhancements is especially helpful. In large organisations such as *Firms B* and *X* teams of people are dedicated to the EMS providing excellent human resources for its success. Also, in *Firm B* (ICT parts) the initiative for ISO14001 came from the Dublin site and was followed by headquarters. In *Firm X* (mainframe computers) a culture of innovation is being nurtured and individuals are being encouraged to take initiative in all areas of the organisation. However, in smaller organisations or sites such as *Firms C* (cables) and *Y* (car components) resources are more limited and the role of individuals becomes more prominent as they must carry out other duties as well. Both time and motivation are needed to research and identify areas for continuous improvement. In *Firm C*, which has operated quite independently through numerous takeovers, the initiative of individuals resulted in the development of a comprehensive and uniquely integrated system. In *Firm Y* individual management capabilities play an important role in the successful implementation of various programmes. And, importantly, these programmes provided the resources and support ordinarily only available to larger firms such as *B* and *X*.

6.4.5.4 *External Integration, customers and suppliers*

As well as being stakeholders, both suppliers and customers are often identified as being important in the environmental performance. Therefore the level of integration with both is worth examining. With regard to co-design activities (the extent of collaboration with others in product design and development), *Firms B*, *D* and *Y* report high levels of collaboration. *Firm C* has a low level of collaboration and *Firm A* none (*Firm X* did not respond to the relevant question in the second survey).

The level of coordination with suppliers and customers for planning decisions and flow of goods is illustrated by the Arc of Integration. As seen in the IMSS survey, most firms (52%) are periphery facing with 12% each

in the inward, customer-facing, supplier-facing and outward-facing positions (Table 5.2.10 page 113). However, significantly more Irish based firms are outward facing (31%) - that is they have very high levels of integration with both suppliers and customers. All six case firms exhibit high levels of co-ordination. Both *Firms A* and *B* are outward-facing (Table 6.4.1). *Firms C, D* and *X* are supplier-facing and *Firm Y* is customer-facing.

Interestingly, the position of firms in the Arc of Integration bears some similarities to the position of firms on the Spectrum of Integration for quality and environmental management (Figure 6.4.1 page 189). *Firm Y* (car components) is customer facing. It also has distinct, separate quality and environmental management systems. *Firms A* (measuring) and *B* (ICT parts) are both outward facing and both are in the mid-range of integration of quality and environmental management. *Firm X* (mainframe computers) integrates these to a greater extent and is supplier-facing. However, it is supplier facing in that it does not need to co-ordinate flow of goods or inventory levels with customers as it manufactures one of a kind product to order. *Firm C* (cables) is also a supplier-facing firm and has totally integrated systems. Only *Firm D* (audio systems) is aberrant in that it is supplier-facing but only slightly integrates environment with quality management. However, as the case shows, *Firm D* has no environmental management system in place nor does it have an environmentally proactive approach as in *Firm A*. The introduction of ISO14000 is under the auspices of the quality manager and is being driven by the goal of attaining the car industry's quality standard. Therefore it is possible to surmise that when an environmental system is in place (whether it is accredited or not) it may be aligned to the quality system to some degree and *Firm D* would therefore move towards the mid-range or possibly the integration end of the Spectrum.

The cases show that the role of customers in influencing environmental management is mixed. Some firms experience very strong influences of customers and others none, while for others the influence is indirect. For example, in *Firm B* (ICT parts) some markets demand very high provision for recycling (e.g. Germany) while other markets require very little. *Firm B* tries to influence consumer behaviour and in some markets recycling is facilitated through a well recognised returns scheme. However, there is only about ten percent uptake. *Firm Y* (car components) experiences very strict product specifications e.g. weight and materials which influence R&D and new product development. *Firm D* (audio systems) does not currently view the customer as influencing environmental initiatives although this may change in the future if manufacturing for the automotive industry takes place at this site. *Firm C* may also experience greater customer influence in the future as they envisage customer demands similar to WEEE which does not currently apply to their product. While *Firm X* (mainframe computers) does not see the customer influencing the product from this site, it is indirectly affected through the corporate protection of the firm's brand and the image of being a leader in corporate citizenship. A similar influence of the brand (hence the customers) occurs in *Firm B*.

Suppliers have even less engagement with the environmental management. In the larger firms with ISO14001 (*Firms B, C* and *X*) supplier audits are a requirement and Life-Cycle Analyses (LCA) are conducted. In *Firm Y* (car components) supplier requirements are mainly driven by customer demands e.g. materials specifications for all parts.

6.4.5.5 Regulations

The choice and direction of many environmental initiatives are steered by regulations. In conjunction with costs, regulations particularly drive many initiatives in relation to emissions and waste. Recently, WEEE and

RoHS have had particular impact. In the absence of a formal EMS many initiatives in *Firms A* and *D* are compliance driven. *Firm A* (measuring equipment) is especially proactive in its advance preparation and compliance with regulations. Regulations are viewed as just another constraint in product development rather than a barrier. *Firm D* (audio systems) manufactures the same products for all markets (with exception essential markets specific requirements such as voltage and plugs) and applies the most stringent regulation. For example, the Irish plant meets all of the requirements of the USA legislation. However, if a particular Irish or EU regulation is stricter this will apply and will affect production in the USA also. This may be seen in the impact of the EU RoHS (lead-free) on printed circuit boards (PCBs) manufactured by *Firm D* in the USA for all markets. Both *Firms B* and *X* proactively engage with business associations and legislators in the development of legislation. In addition, *Firm B* (ICT parts) operates its own WEEE certified recycling system in cooperation with other manufacturers in Europe. *Firms C* (cables) and *Y* (car components) do not actively engage in the development of legislation but are proactive in advance preparation and readiness for implementation. In both cases the challenge of meeting the requirements of the RoHS directive while maintaining performance standards was readily embraced.

6.4.5.6 Supported Programmes

The influence of supported programmes is highlighted by *Firm Y* (car components). *Firm Y* has a clear corporate policy on proactive environmental management which made it amenable to participation in programmes such as the Environmentally Superior Products Programme (ESP) and the Cleaner Greener Production Programme (GCPP). These programmes are supported by Enterprise Ireland and the Environment Protection Agency respectively. The distinct advantage of these programmes is that they gave *Firm Y* access to resources which otherwise would have been beyond its means. Through grant aid, training and expert consultations *Firm Y* was enabled to examine and dedicate resources to its products' design and manufacture to successfully achieve environmental improvements. In addition *Firm Y* was able to build capabilities and use its learning and experience to participate in follow-up programmes as well as the training of employees for long term application of environmental design and production techniques. As mentioned above under formalisation, the experience of *Firm Y* shows how such programmes can be effective in achieving results and promoting environmental management as a source of innovation with clear business benefits.

6.5 Conclusions from the Case Analyses

The cases illustrate that environmental management in these manufacturing firms can be leveraged for competitive advantage through innovation and cost savings in particular. However, the converse that innovation or other business requirements will be leveraged for environmental management, only sometimes applies even where a formal EMS is in place. Nevertheless, the prominence of environmental management is clearly linked to formalisation and corporate policy. While environmental management is often aligned to quality and quality systems, environmental considerations are often subordinate to quality imperatives. The ability to link environmental management to business requirements such as cost savings and customer priorities is an effective way of achieving environmental improvements. Both regulations and individuals influence the direction and choice of many initiatives.

What emerges from the cases is that effective environmental management interacts with many different organisational systems, processes, functions and policies and the relationships are complex. All of these not only interact with the environment but also with each other. Therefore, from the perspective of environmental

management, the cases illustrate the manufacturing firm as a social system of activities and influences which differ in emphasis and in their relationships with each other. It may be portrayed as an open and fluid system where each activity or influence may play different roles at different times. From the perspective of environmental management there are central and peripheral activities and ones which link others. Also, as it is an open system, some activities or influences may be external such as regulations, customer requirements and supported programmes.

Environmental management operates via a system of resource sharing, and effective environmental performance depends on fit with other activities. This performance may sometimes be an obvious or immediate mutual benefit providing a shared goal such as cost and materials savings. Other times may require more coordination and searches for improvement e.g. R&D, packaging. In all cases information sharing is essential. Therefore effective organisation and system operations facilitate the process enabling decision-making and necessary action. The communication and relationship skills of individuals promoting environmental improvements are also important in identifying and selling the ideas and initiatives to others. Communication with different areas will require different 'languages' and effective communicators will be able to present environmental issues in terms best understood by the different functions. Fit with different functional areas may also require different approaches and strategies from the environmental side. Therefore environmental management must also be flexible to communication and fit well with other areas of the organisation. The management of environmental management improves not only through learning but also through enhanced interaction and relationships with other activities in the firm. For example, a system where environmental management interacts effectively with R&D will be less restricted by new regulations such as RoHS. On the other hand, excellent R&D resources will not necessarily result in improved environmental performance of products unless efficient engagement and communication exist either directly with an environmental issue or through an EMS. Or an environmental improvement may be a beneficial side-effect of another activity such as cost savings for waste and energy.

6.5.1 *Environmental Management Model of System of Activities and Influences*

One of the aims of this research is to try to identify and isolate the most important variables and relationships in the environmental management system. These have been identified in the previous discussion and the components can be used to represent a model of environmental management within the organisation. A model cannot fully convey the complexity of interrelationships between all activities and influences and, in effect, each firm is a different model. A gear model was chosen to represent dynamic nature of the system, fit between each element, fluidity to move around the system, internal and external influences, large and small influences can be represented by size, and position and fit between components can also be depicted.

While environmental management may be the focus of this study, and therefore usually placed in the centre, in practice this is not the situation. As we see in the cases, environmental management is but one area of activity in firms where there are many interacting activities, processes and functions etc. and which experience many influences both internal and external. And, environmental management may be the peripheral activity. Elements in the firm's System of Activities and Influences concerning environmental management are presented in Figure 6.4.2.

This is a descriptive rather than a prescriptive model. As can be seen in the following depictions (Figure 6.4.3), each firm shows a different pattern and system arrangement. These reflect the contingency nature of management and organisational systems.

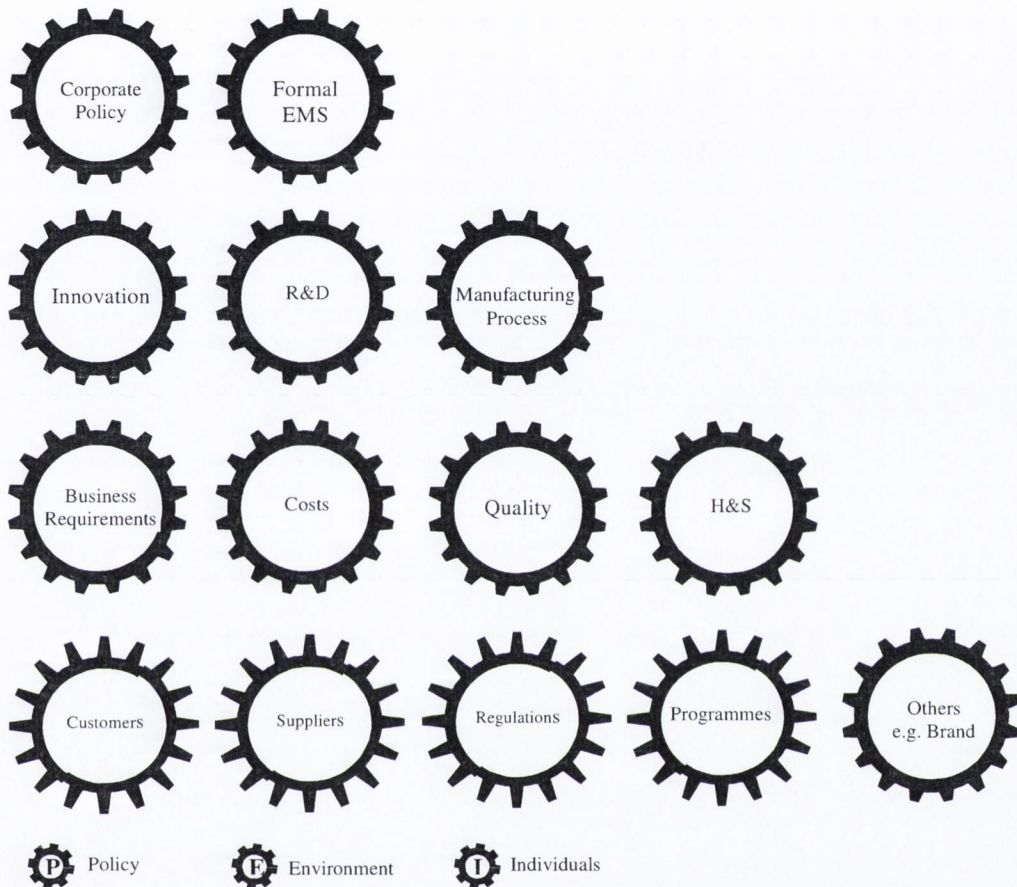


Figure 6.4.2: Elements or 'gears' in the System of Activities and influences which interact with Environmental Management

- * Corporate Policy: values, strategy, resources
- * Formal Environmental Management System (EMS)
- * Innovation: R&D, manufacturing processes, capabilities
- * Business Requirements: costs (e.g. waste, energy, materials, packaging), customers, suppliers
- * Quality, H&S
- * Regulations
- * Supported programmes
- * Where there is no formal EMS the environment (E) may interact independently with different areas
- * Individuals (I) – important in all relationships but highlighted in models if particularly noteworthy
- * Others: e.g. brand, foreign experience

System of Activities and Influences models for each of the six cases from the environmental management perspective are presented in Figure 6.4.3.

Firm A (measuring equipment) - quality, corporate policy, regulations and costs dominate. A corporate policy promotes a culture of quality and innovation to which environmental performance is aligned. Costs and regulations also drive environmental initiatives. The lack of a formal EMS enhances the role of individuals.

Firm B (ICT parts) - a comprehensive EMS driven by a strong corporate policy operates and engages with most other activities.

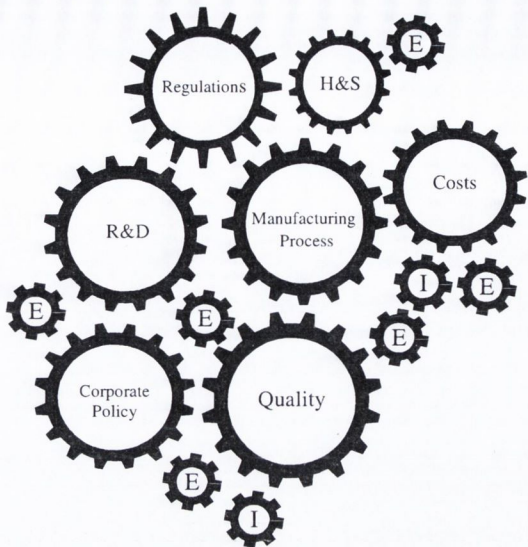
Firm C (cables/networks) - a formal EMS is integrated with quality and H&S. The role of individuals in developing the system at this site is prominent.

Firm D (audio systems) – in the absence of a formal EMS regulations and costs dominate. The role of policy is minor and the future may see the interaction with quality dominate. Loose fit in unintegrated system.

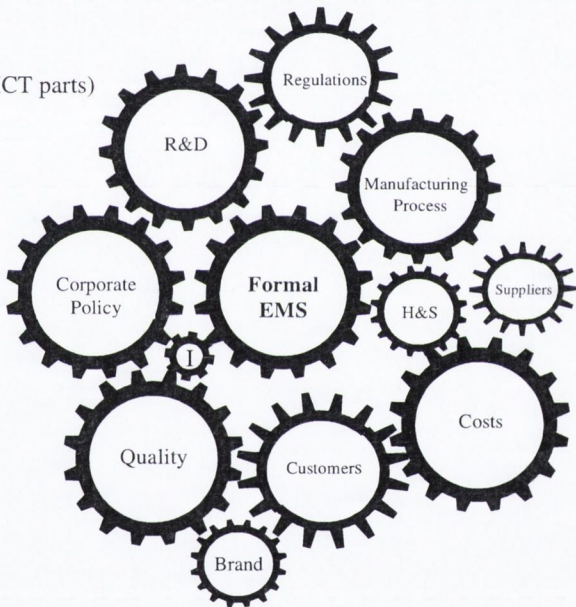
Firm X (mainframe computers) - a comprehensive EMS driven by a strong corporate policy operates and engages with most other activities.

Firm Y (car components) - a comprehensive system is in place. This is quite distinct from quality. The role of supported programmes has been very important and learning from overseas activities also plays a role.

Firm A (measuring equipment)



Firm B (ICT parts)



Firm C (cables/networks)

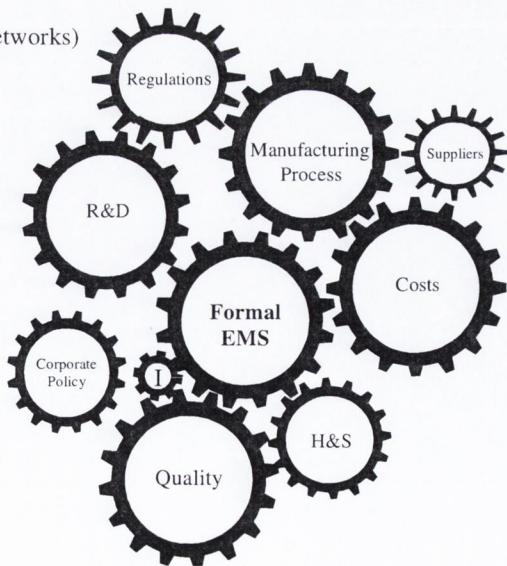
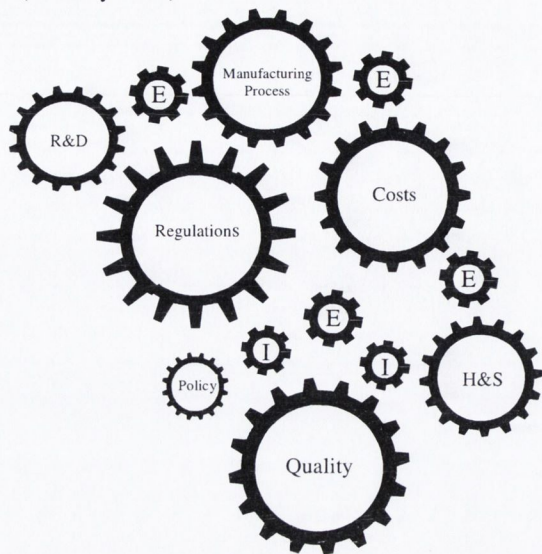
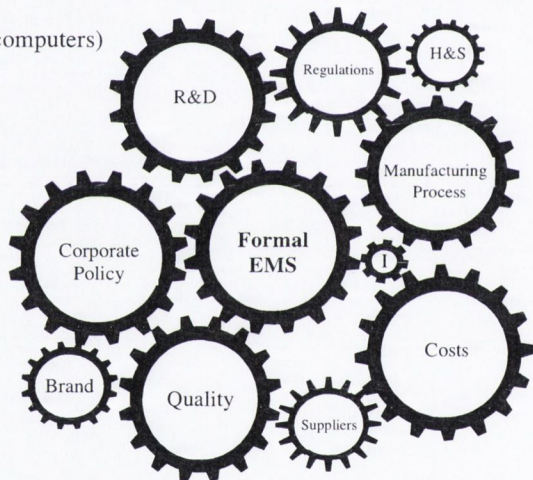


Figure 6.4.3: Systems of Activities and Influences - Firms A, B and C

Firm D (audio systems)



Firm X (mainframe computers)



Firm Y (car components)

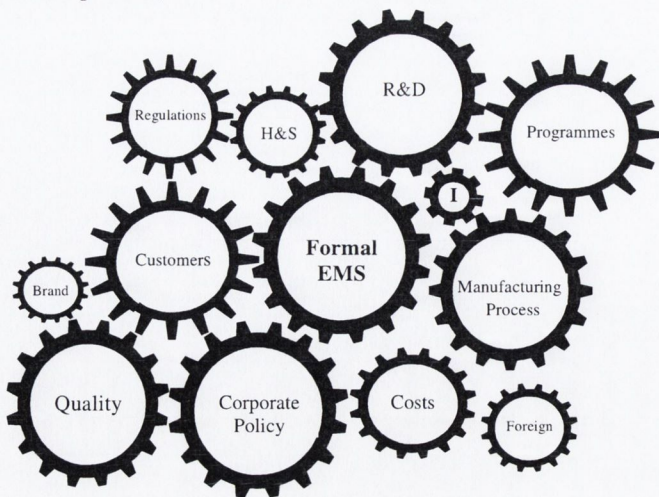


Figure 6.4.3 (contd.): Systems of Activities and Influences - Firms D, X and Y

DISCUSSION

7. DISCUSSION

7.1 Introduction

The aim of this research was to examine the relationship between strategic environmental management and firm innovation and performance in order to gain insights from innovative, entrepreneurial firms and to inform the progress towards sustainable development. Given the innovative nature of environmental management and the new paradigm linking it to performance with firm competencies and competitiveness, it was hypothesized that evidence would be found of relationships between indicators of innovation and performance in other areas of manufacturing and the emphasis placed by firms on environmental management. Innovative firms could provide insights into environmental management and indicate a path towards sustainable development.

Both survey and case data provide the basis for the empirical research. This work employs unique data which provide an international benchmarking facility for the identification of progressive/innovative firms. The data are from an economically and competitively important sector in Irish manufacturing. The opportunity presented by participation in the International Manufacturing Strategy Survey (IMSS) enabled the comparison of Irish based manufacturing firms with firms in sixteen other countries on the basis of manufacturing strategies and innovation and progressive performance measures. Irish based firms identified as progressive on the global scale could then be selected and further examined mainly through semi-structured interviews with experts in the field of environmental management and with firm managers.

This research contributes learning from innovative entrepreneurial firms and their engagement in the realm of environmental management. Firstly, it provides insights from their current environmental management and its interaction with innovation and other strategic processes. It describes how it functions within the organisation as an open system and identifies resources and capabilities which are factors in its successful implementation. Secondly, the research contributes learning about the drivers, activities and processes which motivate innovative entrepreneurial firms to implement successful environmental initiatives. This provides insights into how can we orientate innovative entrepreneurial firms towards better integration of innovation and environmental management which, given their increased likelihood of survival in the longer term, may contribute towards achieving sustainable development.

The use of mixed-methods provides comprehensive insights and learning on environmental management in organisations open systems. The first phase of this research, which employs data from the international manufacturing strategy survey, takes a resource-based view. It examines the relationship of innovation with environmental management and the strategic salience of the environment in manufacturing strategy. The opportunity to use international data enables the identification of innovative entrepreneurial firms in the global context. In the second phase, firms selected from the survey for case study analysis and others recommended by experts in the field of environmental management provide in-depth insights into the role of environmental management in organisations. Institutional and strategic perspectives complement each other to provide a comprehensive theoretical foundation for the analysis of environmental management in the context of sustainable development. The benefits of mixed-methods include the triangulation of data and results from different sources and methods to provide stronger evidence and reinforce findings.

7.2 Survey

The survey data provided some insights into environmental consideration in manufacturing strategy. However they remain inconclusive:

The IMSS survey comprised 558 respondents from 17 countries. Innovation and performance related variables were identified based on the literature. A measure of the salience of the environment in manufacturing strategy was determined - the environment in strategy (ES) index. This was developed using the relative position of the environmental item within four key manufacturing strategy questions. Negative, neutral and positive ES groups are identified.

There are some significant relationships between the ES index and the innovation and performance variables. However, results identify only three variables predicting the ES index: R&D, influence of manufacturing on business/marketing strategies and ISO14001 and these links remain inconclusive.

Several explanations are possible. For example in relation to ISO14001, while a firm may have certification, environmental management may not be a prominent feature of manufacturing strategy. For example, it may be equally considered with others as a priority or it may be an order qualifier rather than an order winner. Or a firm may have a well established environmental management system (EMS) and therefore did not need to invest significantly in action programmes over the previous three years or did not improve upon already superior performance. The IMSS questionnaire does not ask whether there is an EMS in place certified or not, it only asks about ISO14001. Also, there are no actual measures of environmental performance in the IMSS questionnaire against which to compare the ES index. Limitations of using the IMSS survey may also arise in regarding the innovation and performance related variables. These were selected for this analysis from the already existing questionnaire rather than being a part of its original design. An Irish environment (IE) index was created using the additional questions regarding environmental practices. These questions are also limited but they are more specific and yield stronger results in relation to links with the innovation and performance variables in the main IMSS questionnaire. For example, firms with a high IE score also have a higher innovation score. Therefore this part of the survey analysis provides some support for the hypotheses linking the prominence of environmental management with innovation and performance in other areas of manufacturing.

In order to further investigate these relationships and to illuminate these results a qualitative approach was adopted for the next phase of the research. Six firms were selected for case analysis. Four of these were selected based on the IMSS survey data and results and two other firms were selected through recommendation of experts in the field of environmental management.

7.3 Case analyses

The case studies provide extremely rich data and very insightful results. With regard to innovation and innovative capacity, all the six case firms are global leaders in their respective fields. However, differences emerge in relation to the links of innovation with environmental management. In some cases environmental management is very explicitly linked to innovation and in other cases environmental management is more subtle. And, in one case environmental management in the innovation processes is either inadvertent or compliance driven. These differences probably reflect corporate policy and formalisation as discussed below.

Formalisation of an environmental management system as a source of improved practice and performance is strongly supported by the evidence from the cases particularly as a source of innovation. Formalisation enables clarification, measurement and communication not only of environmental improvements and targets but also of the related business benefits such as costs and materials savings, process efficiencies and product enhancements. Additionally, the certification of an EMS through a third party further enhances the rewards of formalisation as opportunities for improvement and innovation are more likely to be identified and there is an incentive for continuous improvement. Although, the improvement may be minimal e.g. for ISO14001, some improvement must be shown on a regular basis. State supported programmes or projects also show how effective formalisation can be in achieving results and promoting environmental management as a source of innovation with clear business benefits. The formalisation process gives clear targets and measures of performance both in terms of environmental achievements and costs. They enable a focussed approach for the dedication of resources to specific outcomes and create organisational learning and capabilities.

Quality is one of the strongest themes throughout the case analyses. Each firm is uncompromising in its commitment to quality. However, the relationship with environmental management varies. The diverse approaches reflect the spectrum from complete independence to complete integration. Although the relationship between environmental and quality management differs across cases, the emphasis on superior quality management is notable in all firms. The ability to link environmental initiatives to costs/business requirements has been a key success factor in all firms. In particular, costs savings are distinct drivers for many initiatives. Reduced waste and increased recycling in all firms reflect the substantial inflation in the cost of waste disposal in recent years. Likewise, energy efficiencies lead to significant savings in all firms. In addition to waste and energy, savings in materials and packaging were particularly noted.

The relationship of each case site to the parent or corporate headquarters is also diverse. Some firms are directed by clear policies on environmental performance and corporate citizenship in general others are more linked to quality and compliance. The role of individuals is apparent in the cases. Apart from the environmental management knowledge and competency resources of individuals which may be assumed, individuals play important decision-making and social functions. The choice and direction of many environmental initiatives are steered by individuals even where a formal EMS is in place.

The cases show that the role of customers in influencing environmental management is mixed. Some firms experience very strong influences of customers and others none, while for others the influence is indirect and related to brand, quality or the image of being a leader in corporate citizenship. Suppliers have even less engagement with the environmental management. The choice and direction of many environmental initiatives are steered by regulations. In conjunction with costs, regulations particularly drive many initiatives in relation to emissions and waste. Recently, WEEE and RoHS have had particular impact. The influence of supported programmes is highlighted by the one indigenous firm whose experience shows how such programmes can be effective in achieving results and promoting environmental management as a source of innovation with clear business benefits.

7.4 Model

From the perspective of environmental management, the cases illustrate the manufacturing firm as a social system of activities and influences which differ in emphasis and in their relationships with each other. Environmental management operates via a system of resource sharing, and effective environmental

performance depends on fit with other activities. Elements or 'gears' in the System of Activities and influences which interact with environmental management were identified in the cases:

- * Corporate Policy: values, strategy, resources
- * Formal Environmental Management System (EMS)
- * Innovation: R&D, manufacturing processes, capabilities
- * Business Requirements: costs (e.g. waste, energy, materials, packaging), customers, suppliers
- * Quality, H&S
- * Regulations
- * Supported programmes
- * Where there is no formal EMS the environment (E) may interact independently with different areas
- * Individuals (I) – important in all relationships but highlighted in models if particularly noteworthy
- * Others: e.g. brand, foreign experience

The model provides a format for developing a comprehensive understanding of the complexities of environmental management in an open system. The environmental management system needs to be flexible to interact and communicate with all areas of the organisation and its social environment. If the Elements are compared against the different theoretical perspectives which have contributed to their understanding in this study, we see the most perspectives can contribute greatly to an understanding and, in combination, they provide a very comprehensive framework (Table 7.4.1).

Corporate and individuals' values, knowledge, and capabilities are influenced by institutional and stakeholders forces as well as the experience of individuals and contingency of each firm. Institutional and stakeholders influences create awareness, knowledge and motivation to as well as contributing to regulations and skills formation. Strategic choice will always play a role and the cases illustrate that there are many options which work well, for example, whether there should be integration with the quality system or not. Values, both individual and corporate, play a role, interpretations of regulations.

Capability to effectively communicate with all elements of the organisational system is essential. Understanding of business requirements and ability to relate these to environmental issues across the organisation are key success factors. For example, costs and efficiencies are major drivers for environmental initiatives and present environmental management with opportunities to work well with other functional areas in achieving dual goals and resource sharing. However, attention needs to be paid to overly focussing on cost reduction or gaining efficiencies using current materials and processes. Alternative eco-effective options may not have the same efficiency attractiveness but may have significant environmental impacts and longer-term sustainability benefits.

Table 7.4.1 Contribution of various institutional and strategic theoretical perspectives to understanding of activities and influences in environmental management						
	Theoretical Perspectives					
Elements of the System	Institutional	Stakeholder	RBV	Contingency	Strategic Choice	Capability Triad
Corporate Policy: values, strategy, resources	✓	✓	✓	✓	✓	✓
Formal Environmental Management System	✓	✓	✓	✓	✓	✓
Innovation: R&D, manufacturing processes, capabilities	✓		✓	✓	✓	✓
Business Requirements: costs (e.g. waste, energy, materials, packaging), customers, suppliers		✓	✓	✓	✓	
Quality, H&S		✓	✓		✓	
Regulations	✓	✓	✓			✓
Supported programmes	✓	✓			✓	✓
Where there is no formal EMS the environment (E) may interact independently with different areas	✓	✓	✓		✓	
Individuals (I) – important in all relationships but highlighted in models if particularly noteworthy		✓	✓		✓	
Others: e.g. brand, foreign experience		✓	✓	✓	✓	

7.5 Formalisation

There is strong triangulated evidence for formalisation from the survey and case studies. It is possible that firms which are more formalised in general are more likely to have formal environmental strategies which in turn may lead to greater prominence in manufacturing strategies and perhaps they also more readily adopt formal certification systems such as ISO14001. Formalisation does not necessarily lead to better practice and this cannot be concluded directly from the data. However, formalisation would enable a firm to focus resources and capabilities for environmental management in all its operations and would facilitate a “shared vision of sustainability” throughout a firm as considered necessary by Hart (1995).

The results suggest that resources and capabilities applied in formalising manufacturing strategies, in finding strategic fit between manufacturing and business/marketing strategies and in formalising an environmental management system are also harnessed by some firms to achieve a positive and coherent environmental management strategy. Even if the strategies themselves are generic it is probable that the resources and capabilities of leading firms for their successful realization have more to teach other firms.

The results concur with the conclusions of other authors that environmental management systems which focus on processes and management enable firms to build upon the competencies learned in the previous implementation of quality management systems (such as ISO9000 and the diffusion of ISO14001) (Corbett and Kirsch, 2001; Darnall, 2002; King and Lenox, 2001). It does not imply that a firm’s competitive

advantage comes from their environmental management although this is possible. These are capabilities and resources which may confer unique competitive advantage on the firm as a whole and they are not necessarily confined or applied to environmental management. As adoption of environmental management systems becomes more widespread early innovators and adopters will have opportunity to exploit any possible advantage to full effect. The possibilities for competitive advantage are endless (such as design for the environment, cost effectiveness of waste prevention and management, products and processes which are energy efficient or use alternative energy to deal with global energy shortages and emissions regulations, entry into new unexploited markets of China and Africa with low cost alternative energy efficient and recyclable products, anticipation of and preparation for new regulations). Because environmental management can permeate all manufacturing and support operations, a firm which has a systematic approach to including environmental issues is more likely to be able to exploit some aspect to its competitive advantage (for example whether it be related to innovation, technology, product design, manufacturing process, costs, supply chain or support systems).

7.6 Strategic coherence

The development of an environmental index gives the overall importance of environmental management in a firm's manufacturing strategy. The index is compiled of four items which, although correlated, actually have different patterns of association with the indicators of innovation and performance. That the four strategic environmental issues addressed in the data have independent effects implies that, in general, they do not necessarily support each other to achieve or indicate coherence of environment management strategy in firms although it is evident that this is the case in a minority of firms who score positively on the environmental index. The index gives a combined result for these four items giving an overall position for environmental management. For example, a positive scoring firm may report higher use of action programmes and improved performance but not view environmentally improved products as a relatively important competitive priority – this is why an index is employed to give an overall effect of these four strategic areas. The index identifies firms giving an overall prominence to environmental management in a specific context of international research on manufacturing strategy. The resource-based perspective demands that these leading firms be examined more closely particularly in the areas of strategy development and implementation.

The case studies also illustrate the role of strategic coherence in environmental management. Where clear corporate policy is in place and where corporate values are more prominent, environmental management is more successfully integrated throughout the organisation.

7.7 Resource-based view research implications

While there are many firm resources and capabilities which may contribute to environmental management, it does not necessarily follow that these will be used explicitly to that end. There exists a complex interplay of variables such as decision making, attention, stakeholders, attitudes and behaviour which affect both salience of environmental management strategy and its operationalization (Buysse and Verbeke, 2003; Cordano and Frieze, 2000; Flannery and May, 2000; Lin *et al.*, 2001; Ocasio, 1997; Ramus and Steger, 2000). An implication for resource-based view of the firm (RBV) research is that the existence of resources and capabilities do not necessarily result in their deployment or transfer to all areas where possible. In this case, indicators of innovative manufacturing and performance do not necessarily indicate a prominence of environmental management (itself being considered innovative). Firms make strategic choices, perhaps they

remain ignorant of possible benefits, remain focussed on regulatory guidelines or differ on account of the role of individuals (Petts *et al.*, 1998; Porter and van der Linde, 1995; Sharma, 2000). Even in the progressive cases there is evidence that the full capability for innovation environmental management is not being applied.

By identifying and describing firms giving positive emphasis to environmental management this research contributes to RBV research and enables future focus on the systematic comparison of high performing firms against those following similar strategies with less success (Rouse and Dallenbach, 2002).

Further cases studies would facilitate greater understanding of the organisational processes and capabilities for environmental management. The combination of strategic perspectives such as the RBV with institutional perspectives to account for the role of factors such as regulations, market forces and stakeholders provides a richer understanding of environmental management in open system. Institutional perspectives are also critical to the broader Capability Triad model and these could be explored in greater depth. Linking environmental management to the innovation system rather than to quality or health and safety may be a solution which the Capability Triad can offer towards sustainable development.

7.8 Policy implications

These findings also have implications for policy makers. Resources and capabilities for strategy development and implementation may be a key area to focus on in policies promoting innovation and environmental management. While the resource based view focuses on scarce resources conferring competitive advantage on firms it is in the policy makers' interest that the capability to successfully transfer innovation and environmental management policies into practice be widespread. While it will be in the firms' interest to find their own uniqueness for competitive advantage, policy makers can enable and facilitate firms. Policy makers should take a competency and capability building based approach to complement technical, process or outcome based approaches. Environmental management permeates all areas of firms' activities and the ability to take a coherent systematic and strategic approach may be crucial to the success of any environmental policy.

Importance of regulations for sustainable development comes across strongly in the cases – not in the sense of the Porter hypothesis that this will stimulate innovation and competitive advantage but rather because it leads to a collective effort. While some competitive advantage may be seen in firms' ability to anticipate, prepare for and accommodate new regulations or in the type of solution a firm produces, the value of regulations such as Montreal Protocol, RoHS and WEEE is that they stimulate collective efforts of industry and institutions to find solutions such as the CFC and lead alternatives and the recycling of goods. Furthermore, the WEEE regulation engages the whole of society and initiated behavioural change at every level. And, the system is working. Although, it may not be the ultimate solution to use of resources, it is illustrative of how a system can work. Institutions, stakeholders and firms cooperated in preparation for the legislation in its development in a manner which could be applied to any innovation or initiative.

As noted above, viewing sustainable development as a framework based on the Capability Triad provides a means of promoting and implementing policy in a manner to stimulate collective effort and innovation.

7.9 Further research and limitations

Further research to explore the links with indicators of innovation and to refine the environmental index is possible using complementary data on environmental management practices which are available for a subset

of the respondents. The indicators of innovation identified in the data have been derived from the literature. The prominent roles of formalisation as well as quality systems and values suggest that further investigation into these linkages would lead to a greater understanding of the successful implementation of environmental management.

The IMSS data employed was from 17 countries giving rise to a further line of interesting comparative research. The resource-based perspective demands that leading firms be examined more closely particularly in the areas of strategy development and implementation in general as well as links with capabilities in other areas of innovation. The IMSS survey has few environmental questions which limits the available data for use as indicators of environmental management. Future IMSS surveys should incorporate some more specific questions relating to environmental management and certification. Also, there may be other influential firm resources and competencies which are not captured in the data. The environmental strategy questions are based on numerical scales. It is possible that high scores and some observed differences are due to a social desirability bias in self-reporting (Flannery and May, 2000; Podsakoff and Organ, 1996). Use of a mail survey with little particular emphasis on the environmental questions helps to reduce such bias. Use of relative position of the environmental items within strategy questions also helps to reduce possible bias. For example, if a respondent gave all high answers to a list of items including the environmental item, this item will have a neutral position. Also the IMSS survey enables the gathering of representative data and the creation of a longitudinal series of data (Levitas and Chi, 2002). This research helps address the issue of how elements of organisational structure and design affect environmental management and whether there is a link between 'green' management and 'good' management (Sharma, 2002). Further cases studies would facilitate greater understanding of the organisational processes and capabilities for environmental management particularly links to innovation and systems integration.

7.10 CONCLUSION

This research focuses on the relative positioning of environmental strategy and seeks to identify predictors of such in the context of innovative global manufacturing. While indicators of innovation and performance in manufacturing do not generally point towards prominence of environmental management in manufacturing strategy some individual indicators are significant. This research identifies and examines a minority of firms which positively emphasise environmental management in their competitive priorities, action programmes, improvement goals and performance improvement. These firms grasp the strategic opportunity presented by environmental management. There is evidence that these firms apply resources and capabilities for organisational strategy formalisation and implementation to environmental management. This suggests that policy makers should incorporate the development of such capabilities into environmental programmes. The case studies illustrate how formalisation facilitates measurement, monitoring, benchmarking and communication of an environmental management strategy. The communication of the environmental management strategy in terms of the language and business requirements of the different functional areas is a key factor in its success. Corporate values and linkages with other strategies such as quality also play significant roles. From the broader institutional perspective, regulations are important drivers for innovation. Emulating the innovation system and Capability Triad offers a possible solution to the collective societal approach to sustainable development and to leveraging the role of organisations and industry.

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Appendix

IMSS Questionnaires (III & IV)

Tables A4.1 & A4.2

INTERNATIONAL MANUFACTURING STRATEGY SURVEY (IMSS – III)

This survey has been designed to explore and identify the strategies and practices utilised by manufacturing firms around the world. The survey is carried out on the basis of information and performance through the end of 2000 and its results will be distributed in early 2002.

PLEASE REMEMBER that all responses will be treated with absolute confidentiality.

The survey questionnaire is divided in five sections:

SECTION A	Strategies, objectives and costs
SECTION B	Current manufacturing and integration practices
SECTION C	Past and planned manufacturing activities
SECTION D	Manufacturing Performance
SECTION E	Strategies and practices relating to environmental legislation

The answers must reflect the situation of a business unit, which can be a stand-alone firm or a plant belonging to a major enterprise.

The survey questions should be answered by the Director of Operations or Manufacturing, or, lacking this, by the person with an equivalent position in the company.

Should you find any question quite difficult to answer, just leave it blank and go to the next question.

Once the survey is finalised, please return it in the attached envelope.

MANY THANKS FOR YOUR CO-OPERATION.

This research (IMSS) is an initiative of:

The IMSS Research Network
(in 23 countries and with more than 700 companies around the world)

SECTION A

This section deals with the business unit's activities, strategies and costs.

A1. a. Please indicate what best describes your business unit.

☐ Company ☐ Division ☐ Plant ☐ Other

b. What are the name, origin and size of the corporation of which the business unit is a part?

Name _____ Country of headquarters _____

No. Employees: Local _____ Ireland _____ World _____

A2. Please identify the *primary* product/product family classification of the business unit (ISIC-code).

Tick one only.

☒ **ISIC Definition**

☐ 381 Manufacture of metal products, except machinery and equipment.

☐ 382 Manufacture of machinery, except electrical

☐ 383 Manufacture of electrical equipment apparatus, appliances and supplies.

☐ 384 Manufacture of transportation equipment.

☐ 385 Manufacture of professional and scientific and measuring and controlling equipment not elsewhere classified, and of photographic and optical goods.

A3. Does your company have other plants producing *similar products to your plant*?

(Please check as many boxes as needed):

☐ No, this plant is the *only plant* producing these products in our company.

Yes, the company has *more plants* producing the product:

☐ in this country

☐ in the EU

☐ in other economic regions (NAFTA, Pacific Rim, MERCOSUR, etc.)

A4. This question describes the location of your sourcing and sales activity. Please indicate the approximate split of sourcing and sales according to the following:

% of purchases from

100 %

This country
Outside this country but within the EU
Outside the EU

% of sales to

100%

A5. Please identify to what extent do you *sell* your *products* to:

components manufacturers _____ % of total sales

product assemblers _____ % of total sales

distributors _____ % of total sales

end-users _____ % of total sales

100%

A6 (a) Consider the degree of importance of the following goals to your major customers (please circle)

Has goal priority of your major customers changed in last 3 years?			
Goal	Change		
have lower selling prices	No	Lower	Higher
offer superior product design and quality	No	Lower	Higher
offer superior conformance quality	No	Lower	Higher
offer more dependable deliveries	No	Lower	Higher
offer faster deliveries	No	Lower	Higher
have superior customer service (after-sales and/or technical support)	No	Lower	Higher
provide a wider product range	No	Lower	Higher
offer newer products more frequently	No	Lower	Higher
provide greater order size flexibility	No	Lower	Higher
offer environmentally sound products	No	Lower	Higher
other (please specify) _____	No	Lower	Higher

A6 (b) Compared to your competitors, you *win orders* from your customers by aiming to:

	Not important			Very important		
have lower selling prices	1	2	3	4	5	
offer superior product design and quality	1	2	3	4	5	
offer superior conformance quality	1	2	3	4	5	
offer more dependable deliveries	1	2	3	4	5	
offer faster deliveries	1	2	3	4	5	
have superior customer service (after-sales and/or technical support)	1	2	3	4	5	
provide a wider product range	1	2	3	4	5	
offer newer products more frequently	1	2	3	4	5	
provide greater order size flexibility	1	2	3	4	5	
offer environmentally sound products	1	2	3	4	5	
other (please specify) _____	1	2	3	4	5	

A7. How would you describe the current *market aims* of your business unit in terms of customers, market segments, product attributes and geographical markets?

Please indicate each aim by circling on the appropriate scale

<u>Market coverage</u>	Few markets	1	2	3	4	5	Many markets
<u>Customer focus</u>	Few customers	1	2	3	4	5	Many customers
<u>Product focus</u>	Physical attributes	1	2	3	4	5	Service emphasis
<u>Geographical focus</u>	National	1	2	3	4	5	International

A8. How would you describe the development of the total market of the product line that you serve?

Declining rapidly	Declining	Stable	Growing	Growing rapidly
1	2	3	4	5

A9. Please estimate the present cost structure in manufacturing (your answer should add to 100 %).

Direct salaries/wages	_____
Manufacturing overheads (*)	_____
Outsourced/contract work (**)	_____
Direct material	_____
	100 %

(*) Note: Manufacturing overheads include salaries within design, planning and maintenance, and of indirect personnel in production, but exclude costs such as administration and sales.

(**) Note: Outsourced/contract work is all work performed outside the business unit's organisation, but necessary for and incorporated into the final products; it may range from a combination of materials, labour and overhead (i.e. subcontracted production) to just outsourced tasks (i.e. design, maintenance)

SECTION B

This section deals with the current manufacturing practice in seven different aspects: manufacturing process type (PT), planning and control systems (PC), quality (Q), technology (T), product development (PD), organisation (O), and supply chain integration (SC).

Manufacturing Process Type (PT)

PT1. What is the split between fabrication and assembly?

Fabrication	_____ % of value added
Assembly	_____ % of value added

100 %

PT2. Please indicate to what extent your activity is organised in the following layout

categories: (indicate percentage of total volume)

Process layout	
job shop	_____ %
cellular layout*	_____ %
dedicated lines	_____ %
	100 %

(*) Note: A "cell" is a *grouping* of equipment *dedicated* to support the production of *families* of parts sharing similar process operations.

PT3. Please indicate to what extent your activity uses one of the following process types:
(indicate percentage of total volume)

<u>Process type</u>	
one of a kind	_____ %
batches	_____ %
mass production	_____ %
	100 %

Planning and Control Systems (PC)

PC1. This question concerns the variability of market demand. We ask you to assume the average monthly demand equal to 100. Which is the *percentage variation* of this demand over a year?

Highest monthly demand + _____ % Lowest monthly demand - _____ %

PC2. How do you cope with *demand fluctuations*?

	<u>Cyclical demand</u> Degree of use					<u>Irregular demand</u> Degree of use				
	None				High	None				High
inventories	1	2	3	4	5	1	2	3	4	5
outsourcing	1	2	3	4	5	1	2	3	4	5
overtime	1	2	3	4	5	1	2	3	4	5
temporary workers	1	2	3	4	5	1	2	3	4	5
equipment overcapacity	1	2	3	4	5	1	2	3	4	5
other(s)	1	2	3	4	5	1	2	3	4	5

PC3. How many days of production (on average) do you carry in the following *inventories*:

Raw material/components _____ Work-in-process _____ Finished
goods _____

PC4. What proportion of your *customer orders* are:

Designed/engineered to order _____ %
Procured to order _____ %
Manufactured to order _____ %
Assembled to order _____ %
Produced to stock _____ %

PC5. How *far ahead* is your production *schedule frozen* (in work days)? _____ work days

PC6. Are your *production orders* planned through: (please select the most appropriate alternative)

push systems (e.g. MRP) ☐
pull systems (e.g. kanban) ☐
mixed pull and push systems ☐
flow bottleneck/constraints ☐

PC7. What proportion of your raw materials and components are *delivered to you Just-In-Time*?
_____ %

PC8. What proportion of your end products do you *deliver Just-In-Time*? _____ %

PC9. a. What percentage of your orders do you *deliver late* to your customers? _____ %

- b. What is the general reason for lateness (please select the most frequent reason)?
- lack of machine or labour capacity ☐
- late deliveries or poor quality of supplies ☐
- internal quality, bottlenecks, rush orders ☐

Quality (Q)

- Q1.** What is the business unit's *proportion* of money spent on *preventive and corrective maintenance*?

_____ % preventive maintenance
 _____ % corrective maintenance
100%

- Q2.** What is, approximately, the *proportion of quality costs* for the business unit (adds up to 100%)?

_____ % inspection/control costs (sampling, supervision, lab tests)

_____ % internal quality costs (e.g. scrap, losses)

_____ % preventive costs (training, documentation, preventive maintenance, etc.)

_____ % external quality costs (e.g. warranty costs, returns, etc.)

100%

- Q3.** Is your company certified?

	Certified	in process/planned	No
ISO 9000	☐	☐	☐
ISO 14000	☐	☐	☐

Technology (T)

- T1.** Please indicate to what extent the operational activity is performed using the following *technologies*:

	No use			High use	
	1	2	3	4	5
Stand-alone/NC machines	1	2	3	4	5
Machining centres	1	2	3	4	5
CNC-DNC	1	2	3	4	5
Automated tool change - parts loading/unloading	1	2	3	4	5
Robots	1	2	3	4	5
Automated guided vehicles (AGVs)	1	2	3	4	5
Automated storage-retrieval systems (AS/RS)	1	2	3	4	5
Flexible manufacturing/assembly systems – cells (FMS/FAS/FMC)	1	2	3	4	5
Computer-aided inspection/ testing/ tracking	1	2	3	4	5
Computer aided design/engineering (CAD; CAE)	1	2	3	4	5
Integrated design-processing systems (CAD-CAE-CAM-CAPP)	1	2	3	4	5
Engineering databases, Product Data Management systems	1	2	3	4	5
LAN-WAN/ Intranet / Shared databases/Internet	1	2	3	4	5

T2. To what extent are the following management areas software supported through the use of *Enterprise Resource Planning* systems?

	No use			High use	
Material management	1	2	3	4	5
Production planning and control	1	2	3	4	5
Purchasing and supply management	1	2	3	4	5
Sales and distribution management	1	2	3	4	5
Accounting and finance	1	2	3	4	5
Human Resources management	1	2	3	4	5
Project Management	1	2	3	4	5
Other (please specify _____)	1	2	3	4	5

T3. Please indicate to what extent you use the Internet to integrate the activities of the listed processes along the supply chain.

On the far left side, indicate the current degree of use of the Internet. On the second left-hand scale, indicate the relative payoff. On the right-hand scale, indicate the expected use within one year

Degree of Use of Internet					Relative payoff of Internet Use					Expected Use of Internet within 1 year										
None					High						None					High				
1	2	3	4	5	1	2	3	4	5	Procurement of <i>standard</i> parts/materials	1	2	3	4	5					
1	2	3	4	5	1	2	3	4	5	Procurement of <i>strategic</i> parts/materials	1	2	3	4	5					
1	2	3	4	5	1	2	3	4	5	Inventory management	1	2	3	4	5					
1	2	3	4	5	1	2	3	4	5	Production planning and scheduling	1	2	3	4	5					
1	2	3	4	5	1	2	3	4	5	Transportation planning	1	2	3	4	5					
1	2	3	4	5	1	2	3	4	5	Order processing and tracking	1	2	3	4	5					
1	2	3	4	5	1	2	3	4	5	Sales	1	2	3	4	5					
1	2	3	4	5	1	2	3	4	5	Customer service and support (CRM)	1	2	3	4	5					
1	2	3	4	5	1	2	3	4	5	Other (please specify _____)	1	2	3	4	5					

Product Development (PD)

PD1. How do you organisationally *co-ordinate* design and manufacturing?

	No use			High use	
Through rules and standards	1	2	3	4	5
Through meetings	1	2	3	4	5
Through cross-functional or multi-skilled teams	1	2	3	4	5
Job rotation between design and manufacturing	1	2	3	4	5
Other (specify _____)	1	2	3	4	5

PD2. To what extent do you use the following to manage your *product development cycle*?

	No use			High use	
Through early involvement of the manufacturing function	1	2	3	4	5
Through overlapping of product/process design (concurrent engineering)	1	2	3	4	5
Through tests and prototypes	1	2	3	4	5
Other (specify _____)	1	2	3	4	5

PD3. How often are your designs subject to Engineering and/or Customer *Change Orders*?

Never					All the time
1	2	3	4	5	

Organisation (O)

O1. At the end of the last fiscal year, in your business unit you had:

a. _____ employees in total, of which _____ were salaried employees.

b. _____ % of salaried employees belonging to a union or similar workers associations.

c. _____ % of employees in total who are temporary (i.e. not permanent) workers.

O2. How many organisational levels do you have (plant manager to first-line supervisors)? _____

O3. How many employees are under the responsibility of one of your line supervisors (on average)? _____

_____ in Fabrication

_____ in Assembly

O4. a. What proportion of your direct employees are paid by incentives? _____ %
employees

b. Among which (please select all relevant alternatives)

Work Group incentive ☐

Individual incentive ☐

Companywide incentive ☐

O5. To what extent do your employees give suggestions for product and process improvement?

No suggestions

1

2

3

High number of suggestions

4

5

O6. What proportion of your total work force work in teams*? in Fabrication _____ %
in Assembly _____ %

* A team is defined as a group of employees performing operative tasks, with a high degree of decentralised responsibility for task planning, execution and follow-up.

O7. How many *hours of training* are given to *new production workers*? _____ hours per new worker

O8. How many *hours of training* per year is typically given to *regular work-force*? _____ hours per employee

O9. How many of your *production workers* do you consider as being *multi-skilled**?

*A multi-skilled operator is skilled in several operational tasks.

_____ % of total number of production workers

O10. How *frequently* do your production workers *rotate* between jobs or tasks?

Never

1

2

3

4

Frequently

5

O11. a. What is the typical attitude of trade unions or similar worker organisations towards new work systems and technologies?

Very hostile

1

2

3

4

Very co-operative

5

b. What is the typical attitude of trade unions or similar worker organisations towards new compensation systems (i.e. pay-for-performance)?

Very hostile					Very co- operative
1	2	3	4	5	

Supply Chain Integration (SC)

This section refers to your customer and your suppliers of direct materials or parts, i.e. the materials, parts, components, or production services (e.g. subcontracted production) that are used in your production system to produce/assemble your final product.

SC1. Please indicate the following figures:

	Actual figure for 2000	% change over the last 3 years
Number of suppliers	_____	_____ %
Number of customers	_____	_____ %

SC2. What criteria do you use for selecting your principal parts/material suppliers?

	Level of Importance				
	None				High
Lowest price bid	1	2	3	4	5
Delivery performance (reliability, speed, flexibility)	1	2	3	4	5
Quality of products/services offered	1	2	3	4	5
Logistic costs (transportation, storage and handling)	1	2	3	4	5
Ability to provide innovation and co-design	1	2	3	4	5
Physical proximity/within region (local sourcing)	1	2	3	4	5
Willingness to disclose cost/other information	1	2	3	4	5
Legal/contractual terms	1	2	3	4	5
Evaluation of supplier potential (development programme / past performance record)	1	2	3	4	5
Other (specify _____)	1	2	3	4	5

N.B. When answering questions SC3 to SC5, please refer to the set of your key suppliers or customers. Please answer the questions about customers only in case your customers are other manufacturers and not final consumers or distributors.

SC3. Which are the reasons for outsourcing the following activities?

	Design activities Level of Importance					Production activities Level of Importance				
	Low				High	Low				High
Need for complementary capabilities	1	2	3	4	5	1	2	3	4	5
Lower costs	1	2	3	4	5	1	2	3	4	5
Lack of capacity	1	2	3	4	5	1	2	3	4	5

SC4. Who performs the following activities in your product development process?
(please select all the relevant alternatives)

	Supplier	Your firm	Customer	Other organisations
Your products' concept	☐	☐	☐	☐
Your products' functional specs	☐	☐	☐	☐
Your products' design	☐	☐	☐	☐
Your manufacturing process design	☐	☐	☐	☐
Component functional specs	☐	☐	☐	☐
Component Design	☐	☐	☐	☐
Component Process Design	☐	☐	☐	☐

SC5. How do you *co-ordinate* planning decisions and flow of goods?

	<u>With your suppliers</u>					<u>With your customers</u>				
	Level of Adoption					Level of Adoption				
	None			High		None			High	
Share information about the inventory levels	1	2	3	4	5	1	2	3	4	5
Share information about production planning decisions and demand forecast	1	2	3	4	5	1	2	3	4	5
Co-location of plants	1	2	3	4	5	1	2	3	4	5
Use of standard packages and containers	1	2	3	4	5	1	2	3	4	5
<i>Agreements on delivery frequency</i>	1	2	3	4	5	1	2	3	4	5
Use of Kanban systems to deliver your products						1	2	3	4	5
Supply your customer through consignment stock and/or Vendor Managed Inventories						1	2	3	4	5
Use of Kanban systems to acquire materials	1	2	3	4	5					
Require your supplier to manage or hold inventories of materials at your own site	1	2	3	4	5					

SC6. Which investments were made to co-ordinate with your suppliers?

	<u>By your suppliers</u>					<u>By your company</u>				
	Level of Investment					Level of Investment				
	Low			High		Low			High	
Extranet/EDI systems	1	2	3	4	5	1	2	3	4	5
Dedicated capacity, tools and equipment	1	2	3	4	5	1	2	3	4	5
Dedicated storage and transportation	1	2	3	4	5	1	2	3	4	5
Dedicated workforce	1	2	3	4	5	1	2	3	4	5

SC7. Which investments were made to co-ordinate with your customers?

	<u>By your customers</u>					<u>By your company</u>				
	Level of Investment					Level of Investment				
	Low			High		Low			High	
Extranet/EDI systems	1	2	3	4	5	1	2	3	4	5
Dedicated capacity, tools and equipment	1	2	3	4	5	1	2	3	4	5
Dedicated storage and transportation	1	2	3	4	5	1	2	3	4	5
Dedicated workforce	1	2	3	4	5	1	2	3	4	5

SC8. To what extent do you use the following co-ordination systems to manage your purchases of *strategic parts*?

	<u>For information acquisition</u>					<u>For managing the transaction</u>				
	No use			High use		No use			High use	
Face to face relationship	1	2	3	4	5	1	2	3	4	5
Dedicated EDI	1	2	3	4	5	1	2	3	4	5
Dedicated extranet	1	2	3	4	5	1	2	3	4	5
Internet catalogues	1	2	3	4	5	1	2	3	4	5
Internet auctions	1	2	3	4	5	1	2	3	4	5
Internet liquid exchanges	1	2	3	4	5	1	2	3	4	5
Your own virtual marketplace	1	2	3	4	5	1	2	3	4	5

SECTION C

This section deals with the goals, programmes and activities the business unit plans to emphasise over the next few years, and the relative payoff from activities undertaken within the last few years.

C1. Please indicate the importance of the following *improvement* goals for your manufacturing function for the next 3 years.

	Not important			Very important	
Improving manufacturing conformance	1	2	3	4	5
Improving product quality and reliability	1	2	3	4	5
Increasing product customisation ability	1	2	3	4	5
Increasing volume flexibility	1	2	3	4	5
Increasing mix flexibility	1	2	3	4	5
Reducing your time to market	1	2	3	4	5
Improving customer service and support	1	2	3	4	5
Increasing delivery speed	1	2	3	4	5
Increasing delivery reliability	1	2	3	4	5
Reducing manufacturing lead time	1	2	3	4	5
Reducing procurement lead time	1	2	3	4	5
Reducing procurement costs	1	2	3	4	5
Increasing labour productivity	1	2	3	4	5
Increasing inventory turnover	1	2	3	4	5
Increasing capacity utilisation	1	2	3	4	5
Reducing overhead costs	1	2	3	4	5
Improving your environmental performance	1	2	3	4	5

C2. To what extent does your organisation define a *written and formalised* manufacturing strategy?

Not at All					Very large extent
1	2	3	4	5	

C3. To what extent does your organisation *translate business or marketing goals* into a manufacturing strategy?

Not at All					Very large extent
1	2	3	4	5	

C4. To what extent does *manufacturing influence* the development of *business or marketing strategies* and goals?

Not at All					Very large extent
1	2	3	4	5	

C5. This question explores the action programmes (*major projects aimed at producing considerable changes in the company's management practices and organisation*) to which your company is now devoting high resource and innovation effort and on which is concentrated the management focus and commitment.

On the far left side, indicate whether the programme has been undertaken within the last three years. On the second left-hand scale, indicate the relative payoff from the activity. On the right-hand scale, indicate whether there are plans and budgeted activities to undertake the programme within the coming three years.

Degree of use last 3 years					Relative payoff					Action Programme	Expected Use within next 3 years				
None				High	None				High		None				High
1	2	3	4	5	1	2	3	4	5	Updating your <u>process equipment</u> to industry standard or better	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Expanding <u>manufacturing capacity</u> (e.g. buying new machines; hiring new people; building new facilities; etc.)	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Engaging in <u>process automation</u> programmes	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Implementing <u>Information and Communication Technologies</u> and/or Enterprise Resource Planning software	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Reorganising your company towards <u>e-commerce</u> and/or <u>e-business</u> configurations	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Rethinking and restructuring your <u>supply strategy</u> and the organisation and management of your suppliers portfolio	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Concentrating on your core activities and <u>outsourcing</u> support processes and activities (e.g. IS management, maintenance, material handling, etc.)	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Restructuring your manufacturing processes and layout to obtain <u>process focus</u> and streamlining (e.g. reorganise plant-within a-plant; cellular layout, etc.)	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Undertaking actions to implement <u>pull production</u> (e.g. reducing batches, setup time, using kanban systems, etc.),	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Undertaking programmes for <u>quality improvement</u> and control (e.g. TQM programmes, 6σ projects, quality circles, etc.)	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Undertaking programmes for the improvement of your <u>equipment productivity</u> (e.g. Total Productive Maintenance programmes)	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Implementing actions to increase the level of <u>delegation and knowledge of your workforce</u> (e.g. empowerment, training, improvement or autonomous teams, etc.)	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Implementing actions to improve or speed-up you process of <u>new product development</u> through e.g. platform design, products modularization, components standardisation, concurrent engineering, Quality Function Deployment, etc.	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Putting efforts & commitment on the improvement of <u>environmental compatibility</u> & workplace <u>safety & health</u>	1	2	3	4	5

SECTION D

This section deals with manufacturing and company performance.

D1. Please indicate the performance for your business in the following dimensions:

Figure for 2000			
Market share	domestic	_____	%
	global	_____	%
Sales		_____	\$ (_____ IRL)
Return on Sales ¹		_____	%
Return on Investment ²		_____	%
¹ ROS = Earnings before interests and taxes/Sales			
² ROI = Earnings before interests and taxes/Total Assets			

D2. Please indicate the amount of change of the following performance dimensions over the last 3 years:

	Strongly deteriorated		No change	Strongly improved	
Manufacturing conformance	1	2	3	4	5
Product quality and reliability	1	2	3	4	5
Product customisation ability	1	2	3	4	5
Volume flexibility	1	2	3	4	5
Mix flexibility	1	2	3	4	5
Time to market	1	2	3	4	5
Customer service and support (customer satisfaction)	1	2	3	4	5
Delivery speed	1	2	3	4	5
Delivery reliability	1	2	3	4	5
Manufacturing lead time	1	2	3	4	5
Procurement lead time	1	2	3	4	5
Procurement costs	1	2	3	4	5
Labour productivity	1	2	3	4	5
Inventory turnover	1	2	3	4	5
Capacity utilisation	1	2	3	4	5
Overhead costs	1	2	3	4	5
Environmental performance	1	2	3	4	5

D3. During the last 3 years, approximately what proportion of business unit revenues was spent on (average % of total revenues):

Research and development _____ % Process equipment _____ %
Training and education _____ %

D4. What is the Throughput Time Efficiency (defined as the time the products are worked on) as a % of the total manufacturing lead time (start of first operation to finish of last operation)? _____ %

D5. Please check which government-promoted and government-supported policies and/or programmes you consider as most appropriate for the competitiveness, profitability and growth of your industrial sector within the different time spans (check as many as you consider appropriate for either or both time spans).

Policy / Programme	Time Span	
	Short-Term	Long-Term
More investment in basic/public education	☐	☐
Greater investment in professional/technical education	☐	☐
Better general education programmes	☐	☐
Improvements in physical infrastructure	☐	☐
Fiscal incentives / tax credits for business investments	☐	☐
Fiscal incentives / tax credits for company-supported training	☐	☐
Fiscal incentives / tax credits for product/process R&D expenditures	☐	☐
"Soft" credit lines for R&D and training/development programmes	☐	☐
Promotion of scientific/technical grants and endowments	☐	☐
Greater flexibility of labour markets	☐	☐
Privatisation and antitrust programmes	☐	☐
Easier access to capital markets and/or sources	☐	☐
Export promotion programmes	☐	☐
Other (please indicate) _____	☐	☐

SECTION E

This section is exclusive to the Irish research network. The purpose of this section is to do a preliminary assessment of the impact of forthcoming legislation on the competitiveness of Irish manufacturing industry, to assess the preparedness of the industry and to identify sources of innovation in relation to environmental sustainability and associated legislation.

IE. 1 Can you please identify the *primary* product group of your unit according to the ISIC (rev3) code below:

✓ Tick one box only

ISIC Code & Definition

28 Fabricated metal products, except machinery & equipment

- ☐ structural metal prods, tanks, reservoirs, steam generators
- ☐ other fabricated metal prods; metal working service activities

29 Machinery and equipment n.e.c.

- ☐ engines and turbines, except aircraft, vehicle/cycle engines
- ☐ pumps, compressors, taps and valves
- ☐ bearings, gears, gearing and driving elements
- ☐ ovens, furnaces and furnace burners

- ☐ lifting and handling equipment

- ☐ other general purpose machinery

292 Special purpose machinery

- ☐ agricultural and forestry machinery
- ☐ machinery for metallurgy
- ☐ machinery for food, beverage and tobacco processing
- ☐ machinery for textile, apparel and leather production
- ☐ machine-tools

- ☐ machinery for mining, quarrying and construction
- ☐ weapons and ammunition
- ☐ other special purpose machinery

31 Electrical machinery and apparatus n.e.c.

- ☐ electric motors, generators and transformers
- ☐ electricity distribution and control apparatus
- ☐ insulated wire and cable
- ☐ accumulators, primary cells and primary batteries
- ☐ electric lamps and lighting equipment
- ☐ other electrical equipment n.e.c.

☐ **293 Domestic appliances n.e.c.**

☐ **30 Office, accounting and computing machinery**

☐ **32 Radio, television & communication equipment / apparatus**

☐ **33 Medical, precision and optical instruments, watches & clocks**

- ☐ medical and surgical equipment and orthopaedic appliances
- ☐ instruments and appliances for measuring, checking, testing, navi-

-gating & other purposes, except industrial process control equip.

- ☐ industrial process control equipment
- ☐ optical instruments and photographic equipment
- ☐ watches and clocks

☐ **34 Motor vehicles, trailers and semi-trailers**

- ☐ motor vehicles
- ☐ parts and accessories for motor vehicles and their engines
- ☐ bodies (coachwork) for motor vehicles; trailers / semi-trailers

☐ **35 Other transport equipment**

☐ **361 Furniture**

☐ **369 Manufacturing n.e.c.**

- ☐ jewellery and related articles
- ☐ musical instruments
- ☐ sports goods
- ☐ games and toys
- ☐ Other manufacturing n.e.c.

Note: n.e.c = not elsewhere classified

IF NOT found please specify your *primary* product: _____

IE. 2 Will your company be affected by the European Directive on Waste Electrical and Electronic Equipment (WEEE)?

Yes ☐ No ☐ Don't know ☐

IE. 3 Has your company prepared an action plan/strategy for recovery of waste from end-users of your products?

Yes ☐ No ☐ In process ☐ Intend to do so ☐ Don't know ☐

IE. 4 Does your company *currently* have any system in operation to recover waste *product* from end-users?

Yes, by own company ☐ No ☐ Don't know ☐
Yes, by contractors ☐
Yes, by distributor ☐
Yes, by group scheme ☐

If yes, what is done with recovered *product*? (please tick all applicable answers)

Re-used ☐ Re-cycled ☐ Disassembled ☐ Sold ☐ Disposed ☐
Other (please specify) _____

IE. 5 Does your company recover waste packaging from end-users?

- Yes, by own company ☐
- No ☐
- Don't know ☐
- Yes, by contractors ☐
- Yes, by distributor ☐
- Yes, by group scheme ☐

IE. 6 Does your company operate a waste management system?

- Yes (please specify below) ☐
- No ☐
- Don't know ☐
- Manufacturing by-products ☐
- Packaging ☐
- Paper ☐
- Other, please specify _____

IE. 7 Has your company ever conducted an environmental audit, eco-audit or similar?

- Yes ☐
- No ☐
- Don't know ☐

If yes, when was the last audit conducted? _____

how often are environmental audits conducted? _____

please specify if & where the results of such audits are published _____

IE. 8 To what extent does your company consider environmental impacts in planning for the following:
(please circle answer or indicate conditions)

Product design	never	sometimes	regularly	depends on: _____	always
Manufacturing process	never	sometimes	regularly	depends on: _____	always
Energy Use	never	sometimes	regularly	depends on: _____	always
Emissions	never	sometimes	regularly	depends on: _____	always
Packaging	never	sometimes	regularly	depends on: _____	always
Distribution	never	sometimes	regularly	depends on: _____	always
Transport	never	sometimes	regularly	depends on: _____	always
Recovery	never	sometimes	regularly	depends on: _____	always
Other (please specify)	_____				

IE. 9 Can you give details of any specific initiative or innovation your company has implemented in relation to the environmental impact of the following:

- Product design _____
- Manufacturing process _____
- Energy Use _____
- Emissions _____
- Packaging _____
- Distribution _____
- Transport _____
- Recovery _____
- Other (please specify) _____

IE.10 Is your company a member of or certified by any of the following?

Repak ☐ Green Dot ☐ EMAS ☐ Eco-label ☐ ISO 14000 *please specify* ISO no(s). ____

Other (please specify) _____

IE.11 In the context of the implementation of EU regulations relating to environmental sustainability, recycling, recovery from end-user etc., how do you view your company's situation compared to your European competitors?

Unfavourably ☐

Similarly ☐

Favourably ☐

Please specify any issues _____

Open Comments

Please state here whatever opinions you may deem pertinent, either on aspects not covered in this questionnaire, or on the questionnaire itself, and/or issues of importance for your own industrial sector.

As mentioned earlier, the results of this study will be distributed to the participating companies at the end of the project and a seminar will be held, which is estimated to be early 2002. Finally, we kindly ask you to supply the following information:

Your name: _____ Contact Number: _____

Your position within the company: _____

The name of the business unit: _____

Country: _____

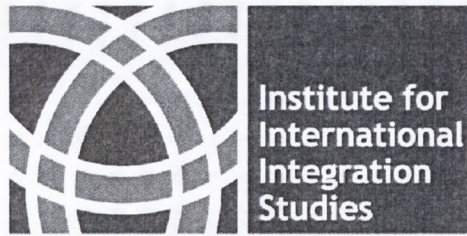
Thank you for your co-operation.

Please once again note that your answers will be treated with full confidentiality and the names of companies, business units, products or individuals will not be released.

If you have any queries or require any assistance please do not hesitate to contact us.

Please return this questionnaire to:

Déirdre Crowe,
IMSS,
School of Business Studies,
Trinity College,
Dublin 2.



INTERNATIONAL MANUFACTURING STRATEGY STUDY (IMSS – IV) 2005 SURVEY

This survey is part of the IMSS which entails:

- an international survey;
- a customised benchmarking report (with international sectoral comparisons) for each participant;
- a country report (with international and sectoral breakdown); and
- a seminar for participants.

The survey is designed to explore and identify strategies, practices and performance of manufacturing firms around the world during 2005. Previous surveys have taken place in 1992, 1998 and 2001.

The survey is divided into four sections:

- SECTION A** Description, strategy and performance of the business unit
- SECTION B** Description, strategy and performance of the dominant activities of the plant
- SECTION C** Current manufacturing and supply chain practices, and past and planned improvement programmes
- SECTION D** Outsourcing from Ireland and environmental management

Questions should be answered by the Director of Operations/ Manufacturing (or equivalent).

If you cannot answer a question, please leave it blank and go to the next.

Please return the completed survey (in the enclosed envelope).

Results will be distributed in 2006.

All responses will be treated with ABSOLUTE CONFIDENTIALITY

MANY THANKS FOR YOUR CO-OPERATION

This research is an initiative of the *IMSS Research Network*
c/o Institute for International Integration Studies, Trinity College Dublin

Section A

Description, strategy and performance of the business unit

Description of the Business Unit

A1. a. What best describes your business unit? Tick one.

☐ Company ☐ Division ☐ Plant ☐ Other

b. What are the name, origin and size of the corporation of which your business unit is a part?

Name _____ Origin (country of headquarters) _____

Size (no. of employees): Local plant _____ Ireland _____ World _____

A2. Indicate the form of ownership of your company, or its parent company. Tick one.

☐ Public ownership ☐ Institutional ownership ☐ Private ownership
☐ Co-operative

A3. Which best describes your business unit's situation relating to manufacturing?

	At one site in this country	At more than one site in this country	At sites in a few countries in Western Europe	Globally, at sites in various continents
Where are the business unit's products produced?	☐	☐	☐	☐

A4. How would you describe the external environment?

Market dynamics	Declining rapidly	1	2	3	4	5	Growing rapidly
Market span	Few segments	1	2	3	4	5	Many segments
Product focus	Physical attributes	1	2	3	4	5	Service emphasis
Geographical focus	National	1	2	3	4	5	International
Competition intensity	Low intensity	1	2	3	4	5	High intensity
Market concentration	Few competitors	1	2	3	4	5	Many competitors
Market entry	Closed to new players	1	2	3	4	5	Open to new players

The Business Unit's Competitive Strategy

A5. Consider the importance of the following attributes to win orders from your major customers.

	Current importance					Over the last 3 years the goal has				
	Not important		Very important			become less important	stayed the same		become more important	
lower selling prices	1	2	3	4	5	1	2	3	4	5
superior product design and quality	1	2	3	4	5	1	2	3	4	5
superior conformance quality	1	2	3	4	5	1	2	3	4	5
more dependable deliveries	1	2	3	4	5	1	2	3	4	5
faster deliveries	1	2	3	4	5	1	2	3	4	5
superior customer service (after-sales and/or technical support)	1	2	3	4	5	1	2	3	4	5
wider product range	1	2	3	4	5	1	2	3	4	5
offer new products more frequently	1	2	3	4	5	1	2	3	4	5
offer more innovative products	1	2	3	4	5	1	2	3	4	5
greater order size flexibility	1	2	3	4	5	1	2	3	4	5
environmentally sound products	1	2	3	4	5	1	2	3	4	5

Business Unit Performance

A6. What is the current business unit performance? For market share indicate average in market(s) served by business unit products. How do you perform relative to three years ago and to main competitor(s)*?

	Current figure (2004)	Compared to three years ago the indicator has					Relative to our main competitor(s), our performance is			
		deteriorated more than 10%	stayed about the same	improved 10%-30%	improved 30%-50%	improved more than 50%	much worse	equal	n.b.	
Sales	€	1	2	3	4	5	1	2	3	4
Market share	%	1	2	3	4	5	1	2	3	4
Return on sales (ROS)	%	1	2	3	4	5	1	2	3	4
Return on investment (ROI)	%	1	2	3	4	5	1	2	3	4

1 ROS = Earnings before interests and taxes/Sales

2 ROI = Earnings before interests and taxes/Total Assets

*consider the average performance of the group of competitors that are the direct benchmark for the business unit

A7. During the last three years, approximately what proportion of business unit sales was invested on (average % of total sales):

_____ % Research & development _____ % Process equipment _____ % Training & education

=====

Section B

Description, strategy and performance of manufacturing for the dominant activity of the plant

Dominant activity refers to the most diffused and relevant activity and way of operating, which is considered to best represent the plant itself. From now on, please refer always to the dominant activity of your plant.

Description of the Plant's Dominant Activity

B1. Which of the following (ISIC code Rev 3.1) best describes your dominant activity (tick one):

- ☐ 28 - Manufacture of fabricated metal products, except machinery and equipment
- ☐ 29 - Manufacture of machinery and equipment not elsewhere classified
- ☐ 30 - Manufacture of office, accounting and computing machinery
- ☐ 31 - Manufacture of electrical machinery and apparatus not elsewhere classified
- ☐ 32 - Manufacture of radio, television and communication equipment and apparatus
- ☐ 33 - Manufacture of medical, precision and optical instruments, watches and clocks
- ☐ 34 - Manufacture of motor vehicles, trailers and semi-trailers
- ☐ 35 - Manufacture of other transport equipment

B2. Indicate the percentage of sales represented by the dominant activity: _____ %

B3. Estimate the present cost structure in manufacturing (NB: percentages should add up to 100 %).

Direct salaries/wages _____ %
Manufacturing overheads * _____ %
Outsourced/contract work ** _____ %
Direct materials/parts/components _____ %
100 %

* Note: Manufacturing overheads include salaries within design, planning and maintenance, and of indirect personnel in production, but exclude costs such as administration and sales.

** Note: Outsourced/contract work is all work performed outside the company, but necessary for and incorporated into the final products.

Manufacturing Strategy

B4. How important are the following improvement goals for your manufacturing function for the next 3 years?

	Not important			Very important	
	1	2	3	4	5
Improving manufacturing conformance	1	2	3	4	5
Improving product quality and reliability	1	2	3	4	5
Increasing product customization ability	1	2	3	4	5
Increasing volume flexibility	1	2	3	4	5
Increasing mix flexibility	1	2	3	4	5
Reducing time to market	1	2	3	4	5
Increasing product innovativeness	1	2	3	4	5
Improving customer service and support	1	2	3	4	5
Increasing delivery speed	1	2	3	4	5
Increasing delivery reliability	1	2	3	4	5
Reducing unit manufacturing cost	1	2	3	4	5
Reducing manufacturing lead time	1	2	3	4	5
Reducing procurement lead time	1	2	3	4	5
Reducing procurement costs	1	2	3	4	5
Increasing labour productivity	1	2	3	4	5
Increasing inventory turnover	1	2	3	4	5
Increasing capacity utilization	1	2	3	4	5
Reducing overhead costs	1	2	3	4	5
Improving employee satisfaction	1	2	3	4	5
Improving your environmental performance	1	2	3	4	5

B5. To what extent does your organization define a written and formalized manufacturing strategy?

Not at all	To a very large extent			
1	2	3	4	5

Manufacturing Process Design (NB: percentages should add up to 100 %)

B6. To what extent do you use the following process types (% of total volume)?

Process type	
One of a kind production	_____ %
Batch production	_____ %
Mass production	_____ %
	100 %

B7. What proportion of your customer orders are (NB: the percentages should add up to 100 %):

Customer orders	
Designed/engineered to order	_____ %
Manufactured to order	_____ %
Assembled to order	_____ %
Produced to stock	_____ %
	100 %

B8. To what extent are your manufacturing activities organized in the following layout categories (% of total volume):

Process layout	
Job shop	_____ %
Cellular layout*	_____ %
Dedicated lines	_____ %
	100 %

* **Note:** A “cell” is a grouping of equipment dedicated to support the production of families of parts sharing similar process operations.

Manufacturing Performance

B9. How has your operational performance changed over the last three years? How does your current performance compare with main competitor(s)*?

	Compared to three years ago the indicator has					Relative to our main competitor(s), our performance is				
	deteriorated more than 10%	stayed about the same	improved 10%-30%	improved 30%-50%	improved more than 50%	much worse	equal	much better		
Manufacturing conformance	1	2	3	4	5	1	2	3	4	5
Product quality and reliability	1	2	3	4	5	1	2	3	4	5
Product customization ability	1	2	3	4	5	1	2	3	4	5
Volume flexibility	1	2	3	4	5	1	2	3	4	5
Mix flexibility	1	2	3	4	5	1	2	3	4	5
Time to market	1	2	3	4	5	1	2	3	4	5
Product innovativeness	1	2	3	4	5	1	2	3	4	5
Customer service and support	1	2	3	4	5	1	2	3	4	5
Delivery speed	1	2	3	4	5	1	2	3	4	5
Delivery dependability	1	2	3	4	5	1	2	3	4	5
Unit manufacturing cost	1	2	3	4	5	1	2	3	4	5
Manufacturing lead time	1	2	3	4	5	1	2	3	4	5
Procurement lead time	1	2	3	4	5	1	2	3	4	5
Procurement costs	1	2	3	4	5	1	2	3	4	5
Labour productivity	1	2	3	4	5	1	2	3	4	5
Inventory turnover	1	2	3	4	5	1	2	3	4	5
Capacity utilization	1	2	3	4	5	1	2	3	4	5
Overhead costs	1	2	3	4	5	1	2	3	4	5
Employee satisfaction	1	2	3	4	5	1	2	3	4	5
Environmental performance	1	2	3	4	5	1	2	3	4	5

*consider the average performance of the group of competitors that are the direct benchmark for the plant

B10. What is the current performance level on the following dimensions?

Throughput Time Efficiency (defined as the time the products are worked on as a % of the total manufacturing lead time – i.e. start of first operation to finish of last operation)?

%

Late deliveries to customers (as percentage of orders delivered)? _____%

Scrap and rework costs (as percentage of sales)	_____ %
---	---------

Customer complaints (as percentage of orders delivered)	%
---	---

SECTION C

*Current manufacturing and supply chain practices, and past and planned action programmes**
Remember to answer considering the plant's dominant activity identified in the previous section.

* By action programme we mean a major project involving considerable effort and changes in the company's management practices and organization

Planning and Control of the Plant's Dominant Activity

PC1. What is the variation of market demand over a year? Assume that your total monthly demand equals to 100, indicate:

demand for highest month _____ demand for lowest month _____

PC2. How do you cope with demand fluctuations?

	Degree of use				
	None				High
Inventories	1	2	3	4	5
Outsourcing	1	2	3	4	5
Equipment overcapacity	1	2	3	4	5
Overtime	1	2	3	4	5
Flexible working hours	1	2	3	4	5
Temporary workers	1	2	3	4	5
Temporary lay off	1	2	3	4	5
Levelling production plan	1	2	3	4	5

PC3. How many days of production (on average) do you carry in the following inventories:

_____ Raw material/components _____ Work-in-process _____
 Finished goods

PC4. How far ahead is your production schedule frozen? _____ work days

PC5. Are your production orders planned through: (select all the appropriate alternatives)

push systems (e.g. MRP) ☐

pull systems (e.g. kanban, replenishment) ☐

PC6. Indicate degree of the following action programmes undertaken over the last three years and planned efforts for the coming three years.

Degree of use last 3 years						Planned effort within next 3 years				
None				High		None				High
1	2	3	4	5	Expanding <u>manufacturing capacity</u> (e.g. buying new machines; hiring new people; building new facilities; etc.)	1	2	3	4	5
1	2	3	4	5	Restructuring manufacturing processes and layout to obtain <u>process focus</u> and streamlining (e.g. reorganize plant-within-a-plant; cellular layout etc.)	1	2	3	4	5
1	2	3	4	5	Undertaking actions to implement <u>pull production</u> (e.g. reducing batches, setup time, using kanban systems, etc.),	1	2	3	4	5

Quality of the plant's dominant activity

Q1. What is the proportion of the maintenance budget spent on the following activities?
(adding up to 100%)

<u>Maintenance</u>	
Preventive maintenance	_____ %
Corrective maintenance	_____ %
	100 %

Q2. What is the approximate proportion of quality costs (adding up to 100%)?

<u>Quality cost</u>	
Inspection/control costs (sampling, supervision, lab tests)	_____ %
Internal quality costs (e.g. scrap, losses)	_____ %
Preventive costs (training, documentation, preventive maintenance, etc.)	_____ %
External quality costs (e.g. warranty costs, returns, etc.)	_____ %
	100 %

Q3. Indicate degree of the following action programmes undertaken over the last three years and planned efforts for the coming three years.

Degree of use last 3 years						Planned effort within next 3 years					
None						High					
1	2	3	4	5		1	2	3	4	5	
1	2	3	4	5	Undertaking programs for <u>quality improvement</u> and control (e.g. TQM programs, 6σ projects, quality circles, etc.)	1	2	3	4	5	
1	2	3	4	5	Undertaking programs for the improvement of your <u>equipment productivity</u> (e.g. Total Productive Maintenance programs)	1	2	3	4	5	
1	2	3	4	5	Undertaking programmes to improve <u>environmental performance</u> of processes and products (e.g. environmental management system, Life-Cycle Analysis, Design for Environment, Environmental certification)	1	2	3	4	5	

Product Development of the Plant's Dominant Activity

PD1. Which best describes your business unit's situation relating to product development?

	At one site in this country	At more than one site in this country	At sites in a few countries in Western Europe	Globally, at sites in various continents
Where are the business unit's products developed?	☐	☐	☐	☐

PD2. How do you organizationally coordinate design and manufacturing?

	No use			High use		
Rules and standards	1	2	3	4	5	
Formal meetings	1	2	3	4	5	
Informal discussions and communication	1	2	3	4	5	
Cross-functional or multi-skilled teams	1	2	3	4	5	
Job rotation between design and manufacturing	1	2	3	4	5	
Co-location of design engineers and manufacturing managers	1	2	3	4	5	
Liaison roles	1	2	3	4	5	

PD3. To what extent do you use the following methods to coordinate product design and process design and engineering?

	No use			High use		
Early involvement of the manufacturing function in product design	1	2	3	4	5	
Overlapping of product and process design	1	2	3	4	5	
Prototyping and testing at early stages of product design	1	2	3	4	5	

PD4. To what extent do the following stakeholders collaborate with the R&D function in your product development process?

	No collaboration			High collaboration	
Suppliers	1	2	3	4	5
Manufacturing	1	2	3	4	5
Marketing	1	2	3	4	5
Customers	1	2	3	4	5

PD5. Which of the following best describes the level of customisation of your dominant activity? (Tick one)

- ☐ Standard products that come in only one version
- ☐ Products that are modularised, based upon a number of standard components and assembled to customer order or sales forecast
- ☐ Products that are based upon a product platform, which they share with a number of other products, but they also contain a significant number of product-specific parts
- ☐ Products that are to some extent customised and have unique characteristics depending on the customer's order
- ☐ Products that are made entirely to the customer's specification

PD6. Indicate degree of the following action programmes undertaken over the last three years and planned efforts for the coming three years.

Degree of use last 3 years						Planned effort within next 3 years				
None				High		None				High
1	2	3	4	5	Increasing <u>performance</u> of product development and manufacturing through e.g. platform design, standardization and modularisation	1	2	3	4	5
1	2	3	4	5	Increasing the <u>organizational integration</u> between product development and manufacturing through e.g. Quality Function Deployment, Design for manufacturing, Design for assembly, teamwork, job rotation and co-location, etc.	1	2	3	4	5
1	2	3	4	5	Increasing the <u>technological integration</u> between product development and manufacturing through e.g. CAD-CAM	1	2	3	4	5

Technology of the Plant's Dominant Activity

T1. To what extent is the operational activity in your plant performed using the following technologies:

	No use		High use		
Stand-alone/NC machines	1	2	3	4	5
Machining centres	1	2	3	4	5
Automated parts loading/unloading	1	2	3	4	5
Automated guided vehicles (AGVs)	1	2	3	4	5
Automated storage-retrieval systems (AS/RS)	1	2	3	4	5
Flexible manufacturing/assembly systems – cells (FMS/FAS/FMC)	1	2	3	4	5
Computer-aided inspection/testing	1	2	3	4	5
Product/part tracking and tracing (bar codes, RFID)	1	2	3	4	5
Integrated design-processing systems (CAD-CAE-CAM-CAPP)	1	2	3	4	5
Engineering databases, Product Data Management systems	1	2	3	4	5

T2. To what extent are the following management areas supported through the use of Enterprise Resource Planning systems?

	No use			High use	
Material management	1	2	3	4	5
Production planning and control	1	2	3	4	5
Purchasing and supply management	1	2	3	4	5
Sales management	1	2	3	4	5
Distribution management	1	2	3	4	5
Accounting and finance	1	2	3	4	5
Human Resources management	1	2	3	4	5
Project Management	1	2	3	4	5
Product Life-Cycle Management	1	2	3	4	5

T3. Indicate degree of the following action programmes undertaken over the last 3 years & planned efforts for the coming 3 years.

Degree of use last 3 years						Planned effort within next 3 years				
None	High					None	High			
1	2	3	4	5	Engaging in <u>process automation</u> programs	1	2	3	4	5
1	2	3	4	5	Implementing <u>Information and Communication Technologies</u> and/or Enterprise Resource Planning software	1	2	3	4	5

Organization of the Plant's Dominant Activity

O1. At the end of the last fiscal year, you had: **a.** _____ % production employees, **of which:**

b1. _____ % production employees belonging to a union or similar workers' associations

b2. _____ % temporary (i.e. not permanent) workers

O2. How many organizational levels do you have (from plant manager to first-line supervisors included)? _____

O3. How many employees are under the responsibility of one of your line supervisors (on average)?

_____ in Fabrication _____ in Assembly

O4. a. On average, what proportion of your direct employees' compensation is based on incentives? _____ % of compensation

b. Indicate the usage of incentives (select all relevant alternatives)

Incentives	For production activities (based on production performance)					For improvement activities (based on participation or results)				
	Never	Very frequentl y				Never	Very frequentl y			
Individual incentive	1	2	3	4	5	1	2	3	4	5
Work Group incentive	1	2	3	4	5	1	2	3	4	5
Companywide incentive	1	2	3	4	5	1	2	3	4	5

O5. To what extent do employees give suggestions for product & process improvement (no. suggestions per employee per year)?

	No suggestions		A few (about 5)		Many (more than 10)
Individual suggestions	1	2	3	4	5

O6. What proportion of your total work force work in teams? *:

In functional teams _____ %

In cross-functional teams _____ %

* Note: By team is meant a group of employees performing operational tasks with high degree of decentralized responsibility for task planning, execution and follow-up.

O7. How many hours of training per year are given to regular work-force? _____ hours per employee

O8. How many of your production workers do you consider as being multi-skilled? _____ % of total number of production workers. * Note: A multi-skilled operator is skilled in several operational tasks.

O9. How frequently do your production workers rotate between jobs or tasks?

Never					Frequently
1	2	3	4	5	

O10. To what extent is your workforce autonomous in performing tasks?

No autonomy (only execute their tasks)					High autonomy (plan, execute and control their tasks)
1	2	3	4	5	

O11. Indicate degree of the following action programmes undertaken over the last 3 years & planned efforts for the coming 3 years.

Degree of use last 3 years						Planned effort within next 3 years				
None				High		None				High
1	2	3	4	5	Implementing actions to increase the level of <u>delegation and knowledge of your workforce</u> (e.g. empowerment, training, autonomous teams, etc.)	1	2	3	4	5
1	2	3	4	5	Implementing the <u>Lean Organisation Model</u> by e.g. reducing the number of levels and broadening the span of control.	1	2	3	4	5
1	2	3	4	5	Implementing <u>Continuous Improvement Programs</u> through systematic initiatives (e.g. kaizen, improvement teams, etc.)	1	2	3	4	5
1	2	3	4	5	Increasing the level of <u>workforce flexibility</u> following your business unit's competitive strategy (e.g. temporary workers, part time, job sharing, variable working hours, etc.)	1	2	3	4	5

Supply Chain of the Plant's Dominant Activity

This section refers to your suppliers of direct materials or parts, i.e. the materials, parts, or components that are used in your dominant activity production system to produce/assemble your final product.

SC1. For what reasons have you outsourced some production activities?

	Level of Importance				
	None				High
Access to complementary competencies	1	2	3	4	5
Access to production capacity	1	2	3	4	5
Reduce costs	1	2	3	4	5

SC2. What is the percentage of purchases in the following categories of suppliers? (your answers should add up to 100%)

<u>Suppliers</u>	
Materials suppliers	_____ %
Parts suppliers	_____ %
Systems suppliers	_____ %
	100 %

SC3. Regarding location of your sourcing activity indicate the approximate split of purchasing according to the following (your answers should add up to 100%):

<u>Sourcing activity</u>	
This country	_____ %
Within Western Europe	_____ %
Outside Western Europe	_____ %
	100 %

SC4. What proportion of your raw materials and components are delivered to you Just-In-Time? _____ %

SC5. Indicate the following supplier figures:

Total number of suppliers (figure for 2004)	_____
Average number of suppliers per item	_____
Proportion of suppliers considered as key/strategic suppliers	_____ %

SC6- SC8: Please refer to the set of your Key/Strategic Suppliers.

SC6. What criteria do you use for selecting your key/strategic suppliers?

	Level of Importance				
	None				High
Lowest price bid	1	2	3	4	5
Delivery performance (reliability, speed, flexibility)	1	2	3	4	5
Quality of products/services offered	1	2	3	4	5
Logistic costs (transportation, storage and handling)	1	2	3	4	5
Ability to provide innovation and co-design	1	2	3	4	5
Physical proximity/within region (local sourcing)	1	2	3	4	5
Willingness to disclose cost/other information	1	2	3	4	5
Evaluation of supplier potential (development programs or past performance record)	1	2	3	4	5

SC7. How do you coordinate planning decisions and flow of goods with your key/strategic suppliers?

	Level of Adoption				
	None				High
Share inventory level knowledge	1	2	3	4	5
Share production planning decisions and demand forecast knowledge	1	2	3	4	5
Order tracking/tracing	1	2	3	4	5
Agreements on delivery frequency	1	2	3	4	5
Dedicated capacity	1	2	3	4	5

Require supplier(s) to manage or hold inventories of materials at your site (e.g. Vendor Managed Inventory, Consignment Stock)	1	2	3	4	5
Collaborative Planning, Forecasting and Replenishment	1	2	3	4	5
Physical integration of the supplier into the plant	1	2	3	4	5

SC8. Indicate to what extent you use electronic tools (Internet or EDI based) with your key/strategic suppliers for the following.

	Level of Adoption				
	None				High
Scouting/ pre-qualify	1	2	3	4	5
Auctions	1	2	3	4	5
RFx (request for quotation, proposal, information)	1	2	3	4	5
Data analysis (audit and reporting)	1	2	3	4	5
Access to catalogues	1	2	3	4	5
Order management and tracking	1	2	3	4	5
Content and knowledge management	1	2	3	4	5
Collaboration support services	1	2	3	4	5

This Section Refers to Your Direct Customers

SC9. Indicate the percentage of sales in the following categories of customers (your answers should add up to 100%):

Customers	
System integrators	_____ %
Finished products manufacturers	_____ %
Wholesalers / distributors	_____ %
End users	_____ %
	100 %

SC10. Regarding location of your sales activity, indicate the approximate split of sales according to the following (your answers should add up to 100%):

<u>Sales activity</u>	
This country	_____ %
Within Western Europe	_____ %
Outside Western Europe	_____ %
	100 %

SC11. What proportion of your end products do you deliver Just-In-Time? _____ %

SC12. Indicate the following figures:

Total number of customers (figure for 2004) _____

Proportion of customers considered as key/strategic customers
 _____ %

SC13 & SC14: Please refer to the set of your Key/Strategic Customers.

SC13. How do you coordinate planning decisions and flow of goods with your key/strategic customers?

	Level of Adoption				
	None				High
Share inventory level knowledge	1	2	3	4	5
Share production planning decisions and demand forecast knowledge	1	2	3	4	5
Order tracking/tracing	1	2	3	4	5
Agreements on delivery frequency	1	2	3	4	5
Dedicated capacity	1	2	3	4	5
You manage or hold inventories of materials at your customers' site(s) (e.g. Vendor Managed Inventory, Consignment Stock)	1	2	3	4	5
Collaborative Planning, Forecasting and Replenishment	1	2	3	4	5
Physical integration with the partner (e.g. cross-docking, co-location)	1	2	3	4	5

SC14. Indicate to what extent your key/strategic customers use electronic tools (Internet or EDI based) with you for the following.

	Level of Adoption				
	None				High
Scouting/ pre-qualify	1	2	3	4	5
Auctions	1	2	3	4	5
RFx (request for quotation, proposal, information)	1	2	3	4	5
Data analysis (audit and reporting)	1	2	3	4	5
Access to catalogues	1	2	3	4	5
Order management and tracking	1	2	3	4	5
Content and knowledge management	1	2	3	4	5
Collaboration support services	1	2	3	4	5

In question SC15 please refer to the set of your Key/Strategic Suppliers and Customers

SC15. Indicate use of the following action programmes undertaken over the last 3 years & planned efforts for the coming 3 years.

Degree of use last 3 years						Planned effort within next 3 years				
None				High		None				High
1	2	3	4	5	Rethinking and restructuring <u>supply strategy</u> and the organization and management of suppliers' portfolio through e.g. tiered networks, bundled outsourcing, and supply base reduction.	1	2	3	4	5
1	2	3	4	5	Implementing <u>supplier development and vendor rating</u> programs	1	2	3	4	5
1	2	3	4	5	Increasing the level of <u>coordination</u> of planning decisions and flow of goods <u>with suppliers</u> including dedicated investments (in e.g. Extranet/ EDI systems, dedicated capacity/tools/equipment, dedicated workforce, etc.)	1	2	3	4	5
1	2	3	4	5	Rethinking and restructuring <u>distribution strategy</u> in order to change the level of intermediation (e.g. using direct selling, demand aggregators, multi-echelon chains, etc.)	1	2	3	4	5
1	2	3	4	5	Increasing the level of <u>coordination</u> of planning decisions and flow of goods <u>with customers</u> including dedicated investments (in e.g. Extranet/ EDI systems, dedicated capacity/tools/equipment, dedicated workforce, etc.)	1	2	3	4	5

=====

SECTION D

Outsourcing from Ireland and Environmental Management

Questions D1-D3 refer to outsourcing or transfer of any of your plant's production activities

D1. If you have outsourced or transferred production activities in the past 3 years please specify the country, to whom, activity and main advantages or difficulties encountered?

Country	To 3 rd Party or Own Facility please specify	Activity Outsourced	% previous output (approx.)	Main Advantage	Main Difficulty
Ireland					
Eastern Europe please specify					
Asia please specify					
Other please specify					

D2. Do you intend to outsource or transfer any production activity? If yes, please specify below.

Country/Region	To 3 rd Party or Own Facility please specify	Activity to be Outsourced	Approx. % Output to be outsourced	Expected Advantage	Difficulty expected or encountered	Expected Timeframe

D3. Have you *reversed* a decision to outsource in the past 3 years? If yes, please explain _____

Questions E1-E14 refer to Environmental Management

E1. Do you operate an environmental management system (EMS) at your plant? Yes ☐ No ☐

IF Yes, is this formal ☐ informal ☐ certified ☐ please specify _____

Are the expected benefits of adopting EMS as great as expected?
Yes ☐ No ☐

Certification

E2. Is your plant or product certified/licensed by or a member of any of the following?

Quality ISO9000 ☐ ISO9000:2002 ☐ Other
please specify _____

Environmental ISO 14001 ☐ Year _____ is this a site
certificate ☐ or a company-wide certificate ☐

EMAS ☐ Year _____

Integrated Pollution Control Licence ☐ Year _____

Repak ☐ Green Dot ☐ Eco-label ☐ EU
Flower ☐

Other, please specify _____

E3. Have you participated in any environmental improvement programmes?

Cleaner Greener Production Programme ☐

Environmentally Superior Products Scheme ☐

Other, please specify _____

Environmental Integration

E4. To what extent are environmental concerns/management integrated with the following activities & processes at your plant?

	Not at all		Partially		Fully
Manufacturing Design & Process Development	1	2	3	4	5
Manufacturing Strategy	1	2	3	4	5
R&D Strategy	1	2	3	4	5
New Product Design & Development	1	2	3	4	5
Adoption of new technology	1	2	3	4	5
Quality management systems	1	2	3	4	5
Health & safety systems	1	2	3	4	5
Updating of process equipment	1	2	3	4	5
Equipment maintenance	1	2	3	4	5
Updating of IT equipment	1	2	3	4	5
Materials management	1	2	3	4	5
Purchasing	1	2	3	4	5
Supplier Evaluation	1	2	3	4	5
Procurement Costs	1	2	3	4	5
Training of buyers	1	2	3	4	5
Packaging	1	2	3	4	5
Transport & Distribution	1	2	3	4	5

Waste Management	1	2	3	4	5
Business Strategy	1	2	3	4	5
Marketing Strategy	1	2	3	4	5
Customer requirements	1	2	3	4	5
Induction training	1	2	3	4	5
General training	1	2	3	4	5
Employee evaluation	1	2	3	4	5
Employee compensation	1	2	3	4	5

Organisation

E5. Is there a person at your plant with **explicit** responsibility for environmental management/issues? Yes ☐ No ☐

IF Yes, what their title and background/functional area eg.
Sr.mgmt/technical/operations/HR/legal/multi-disciplinary?

Do they operate in a dedicateenvironmental unit or team? Yes ☐ No ☐

IF No, how are environmental management/issues dealt with at your plant? *please tick as applies*

by individuals ☐ by each functional area ☐
as they arise ☐ as directed by parent company ☐

Other, *please specify* _____

Environmental Practices

E6. *please tick if applies to your plant and/or parent company*

	Plant	Parent
Written Environmental Policy	☐	☐
Written Corporate Social Responsibility Policy	☐	☐
Dedicated environmental unit/department	☐	☐
Environmental performance indicators/goals	☐	☐
Environmental training programme for employees	☐	☐
Internal environmental audits	☐	☐
External environmental audits	☐	☐
Environmental accounting	☐	☐
Benchmark environmental performance	☐	☐
Public Environmental Reports	☐	☐
Public Corporate Social Responsibility Reports	☐	☐
Evaluation of supplier's environmental performance	☐	☐
Require specific environmental practices by suppliers	☐	☐
Environmental information for customers/consumers	☐	☐
Track cost of waste throughout supply chain	☐	☐
Life-cycle analysis (LCA) of your products	☐	☐
Design-for-Environment	☐	☐
Triple Bottom Line	☐	☐
Other practice, <i>please specify</i> _____		

Research & Development

E7. Does your plant have a budget for Research & Development? Yes ☐ No ☐

IF No, does your parent company dedicate a proportion of R&D budget to environmental issues? Yes ☐ _____% No ☐

IF Yes, please estimate approximate expenditure on R&D over past 3 years _____

was any proportion of R&D *specifically dedicated* to environmental issues in past 3 years? Yes ☐ _____ % No ☐

Products & Processes

E8. Please describe any environmentally differentiated products?

Are these produced at your plant ☐ and/or another plant by your parent company ☐

IF None, have you researched environmentally improved products? Yes ☐
No ☐

Please describe any *plans* you may have to introduce environmentally superior products

E9. Please describe any environmentally differentiated processes?

Are these processes at your plant ☐ and/or another plant by your parent company ☐

IF None, have you researched environmentally improved processes? Yes ☐
No ☐

Please describe any *plans* you may have to introduce environmentally superior processes

New Legislation

E10. WEEE (EU Directive on Waste Electrical and Electronic Equipment)

Are your products affected by WEEE? Yes ☐ No ☐ Don't know ☐

Does your firm recover WEEE waste from end-users of your *products*?

Yes ☐ No ☐ In process of implementation ☐ Intend to do so ☐ By parent co

E11. RoHS (EU Directive on Hazardous Substances also known as the 'Lead-Free' Directive)

Are your operations affected by RoHS? Yes ☐ No ☐ Don't know ☐

Does your firm manufacture lead-free or other RoHS compliant products?

Yes ☐ No ☐ In process of implementation ☐ Intend to do so ☐ By parent co

E12. Energy Use & Emissions (Kyoto)

Do you purchase from renewable energy source? Yes ☐ No ☐

Do you monitor your energy use? Yes ☐ No ☐

IF Yes, how? hourly ☐ daily ☐ weekly ☐ by production line/cell ☐

other _____

Do you monitor your emissions? Yes ☐ No ☐ Intend to ☐

Does your plant have a Greenhouse Gas Emissions Permit from the EPA? Yes ☐ No ☐

Intend to ☐ Not app

Is your plant engaged in the Emissions Trading Scheme? Yes ☐ No ☐

Intend to ☐ Not app

E13. How has new environmental legislation (please specify) influenced any of the following?

manufacturing strategy/process _____

product development _____

competitiveness _____

other / comment _____

Drivers & Stakeholders

E.14. Please rate the influence of the following in determining environmental practices at your plant?

	No Influence		Some Influence		Considerable Influence
Regulatory authorities	1	2	3	4	5
Parent/corporate headquarters	1	2	3	4	5
Industry trade associations	1	2	3	4	5
Shareholders/investment funds	1	2	3	4	5
Management employees	1	2	3	4	5
Non-management employees	1	2	3	4	5
Unions	1	2	3	4	5
Banks and other lenders	1	2	3	4	5
Insurance companies					
Household consumers	1	2	3	4	5
Suppliers of goods & services	1	2	3	4	5
Environmental groups/organisations	1	2	3	4	5
Local/community groups/organisations	1	2	3	4	5
Others groups/organisations <i>please specify</i>	1	2	3	4	5

Thank you for your time and co-operation

The international results of this study will be distributed to participating companies once results have been collated (estimated mid-2006). If you would like to receive a copy of these results as well as your individual customised benchmarking report please provide your contact details below:

Name: _____

Email: _____ Telephone: _____

Your position within the company: _____

Name of the business unit: _____

Please remember your answers will be treated with complete confidentiality and the names of companies, business units, products or individuals will not be released.

Table A4.1
Positioning of each Environmental Item in Relation to List Mean (N=558)

Environmental Item Response	Position of Environmental Item				Difference
	Negative	Neutral	Positive	Total	
Competitive Priorities					
Not important - 1	92	8	0	100	
2	74	26	0	100	
3	41.9	57.5	0.6	100	
4	2	97	1	100	
Very Important - 5	0	86	14	100	
Total (n=502)	43	55	2	100	
Action Programmes					
Degree of Use – None - 1	41	59	0	100	
2	15	84	1	100	
3	4	83	13	100	
4	0	60	40	100	
Degree of Use – High - 5	0	37	63	100	
Total (n=505)	7	69	24	100	
Changes in Performance					
Strongly Deteriorated - 1	100	0	0	100	
2	71	29	0	100	
No Change - 3	24.1	75.5	0.4	100	
4	0	84	16	100	
Strongly Improved - 5	0	23	77	100	
Total (n=518)	16	72	12	100	
Improvement Goals					
Not important - 1	100	0	0	100	
2	84	16	0	100	
3	45	55	0	100	
4	8	89	3	100	
Very Important - 5	0	68	32	100	
Total (n=537)	34	59	7	100	

Table A4.2
Comparison of Actual Responses with Final Environmental Index Groups –Percent (N=497)

Response	Environmental Index Group				Difference
	Negative	Neutral	Positive	Total	
Competitive Priority					***
Not important - 1	83	12	5	100	
2	76	18	6	100	
3	55	34	11	100	
4	27	28	46	100	
Very Important - 5	15	23	62	100	
Action Programme					***
Degree of Use – None - 1	86	11	4	100	
2	72	23	6	100	
3	64	26	11	100	
4	35	30	35	100	
Degree of Use – High - 5	14	27	59	100	
Change in Performance					x
Strongly Deteriorated - 1	75	0	25	100	
2	82	19	0	100	
No Change - 3	75	20	5	100	
4	29	38	33	100	
Strongly Improved - 5	3	15	82	100	
Improvement Goal					x
Not important - 1	89	11	0	100	
2	89	9	2	100	
3	66	27	7	100	
4	35	38	27	100	
Very Important - 5	15	24	61	100	

*** = $p < .001$, x = could not be tested due to empty cells however similar pattern to first two exhibited

Glossary & Abbreviations

GLOSSARY & ABBREVIATIONS

<i>BITC – Business in the community</i>
<i>CGPP – Cleaner Greener Production Programme – run by the EPA</i>
<i>CSR – corporate Social Responsibility</i>
<i>DfE Design for Environment – system of incorporating environmental criteria into design processes</i>
<i>EI – Enterprise Ireland – to support indigenous industrial development</i>
<i>EMAS – Eco-Management Audit System – EU environmental management system</i>
<i>Emissions Trading Scheme: users of large amounts of greenhouse gases can offset their emissions by buying credits from others who do not use their full quota</i>
<i>EMS Environmental Management System</i>
<i>EMT – Ecological modernization theory</i>
<i>EPA – Environmental Protection Agency</i>
<i>ESP Environmentally Superior Products - programme run by Enterprise Ireland</i>
<i>EU – European Union</i>
<i>Green dot – international symbol for firms which contribute to recycling schemes such as Repak</i>
<i>Greenhouse Gas Emission Permit permission to have high levels of emissions from EPA</i>
<i>H&S Health and Safety</i>
<i>ICT Information and communication technology</i>
<i>IE – Industrial Ecology</i>
<i>IMSS – International Manufacturing Strategy Survey (survey data for this research)</i>
<i>ISIC – International Standard industrial classification system</i>
<i>ISO – International Standards Organisation</i>
<i>ISO 9000 – Quality management system certification</i>
<i>ISO14000/14001 – environmental management system certification</i>
<i>Kyoto Agreement – 1997 - International global agreement to reduce global greenhouse gas emissions by at least 5% from 1990 levels by 2012</i>
<i>LCA Life-Cycle Analysis – complete assessment of products and material at all stages of supply, production, use and disposal</i>
<i>Montreal Protocol – 1987 - International agreement to phase out the use of ozone-depleting e.g CFC Carbofluorocarbons</i>
<i>NGOs – non-governmental organisations</i>
<i>PCB Printed circuit boards – component of electrical equipment</i>
<i>PVC – polyvinyl chloride – although this can be easily recycled it releases toxins</i>
<i>R&D Research and development</i>
<i>Repak – industrial paper and cardboard recycling scheme in Ireland</i>
<i>RoHS: Legislation linked to the WEEE (see below) on the use of hazardous substances such as lead in equipment. This legislation is not yet fully implemented. It is commonly referred to as the ‘lead-free’ directive.</i>
<i>TNS – The Natural Step – environmental management programme</i>
<i>TS16949: A successful partnership between International Standards Organisation (ISO) and the international automotive industry has resulted in the publication of a new edition of ISO/TS 16949, which specifies quality system requirements for suppliers in this sector. It is expected that the technical specification (TS) will become the common and unique basis for the automotive industry's quality management system requirements worldwide, gradually replacing the multiple national specifications now used by</i>

the sector
<i>WBCSD – World Business council for Sustainable Development</i>
<i>WEEE:</i> Waste Electrical and Electronic Equipment Legislation introduced by the European Union in 2003 on the return of used consumers goods to the responsibility of the manufacturer. This legislation has been fully implemented in Ireland since July 2005.

