The Dance on the Feet of Chance:

Handling Uncertainty and Managing Risk
in the Fuzzy Front-end of Innovation

A thesis submitted in fulfilment of the requirements for the award of the degree of

Doctor of Philosophy

from

Macquarie University

by

Hooman Attar

B.Sc. (Mech. Eng.), M.Sc. (Mech. Eng.), MBA

Macquarie Graduate School of Management

2009

TABLE OF CONTENTS

CHAPTER 1 MANAGING RISK AND HANDLING UNCERTAINTY IN INNOVATION – PROBLEM DEFINITION AND INTRODUCTION TO THE STUDY

CHAPTER 2 THE 'RIBBED BALLOON': A 'GENERATIVE METAPHOR' FOR INNOVATION-IN-PRACTICE

CHAPTER 3 RECONSTRUCTING RISK: FROM MANAGING RISK TO HANDLING UNCERTAINTY

CHAPTER 4 APPROACH AND METHODS: A NARRATIVE RECONSTRUCTION OF CRITICAL EVENTS

CHAPTER 5 COLONISATION AND CONVERSION: RISK SETTLEMENT AND RISK MANAGEMENT AT THE FUZZY FRONT-END OF INNOVATION

CHAPTER 6 CONCLUSION

Abstract

Corporations have problems dealing with the indeterminate aspects of innovation, particularly in the early 'fuzzy front-end' of the process. They have difficulty in reflecting upon and handling uncertainties of innovation; often exhibiting a 'dynamic conservatism' or a set of 'defensive routines' that inhibit inquiry about such contentious issues. They prefer, and are better equipped to operate within the 'language of investment' than the 'language of invention'. In the language of investment, corporations select an environmental niche, and attempt to program and fabricate its future according to rational, stable assumptions and formulations. This view is closely bound to a utopian image of risk management as a tool able to objectively map, measure, and monitor future uncertainties that govern the behaviour of the chosen niche. By seeking a close and clear fit between risk management solutions (means) and the dominant factors that determine future threats and opportunities to the niche environment (ends), corporations attempt to master risks and colonise the future through an orderly process.

It is the argument of this thesis that this approach is only good when targeting and 'solving' well-defined problems of risk management and innovation within an intellectual terrain that has already been intellectually 'set'. It fails to systematically recognise, reflect upon, and improve the effectiveness of the complex and creative task undertaken in the prior stage of 'problem setting' or 'risk settling'. In contrast to this approach, it is argued that in ill-defined, unique, and uncertain situations, 'problem setting' or 'risk settlement' are the key primary activities, and 'problem solving' or 'risk management' only secondary. This study, as its strategic objective, seeks to juxtapose these contrasting views and develop an integrated conceptual framework capable of supporting a reflective practice amongst practitioners grappling with the interplay between 'risk settlement' and 'risk management' at the 'fuzzy front-end' of innovation.

This framework, strongly influenced by Donald Schön's scholarly work, takes the form of a set of concepts designed to synthesise, mobilise, and focus a wide range of academic literature on managing risk and handling uncertainty in product innovation. It informs reflections on professional practice through pragmatist/existential explorations of the role of metaphor in basic thinking processes as well as sociopolitical and psychological insights into the factors influencing how practitioners intuitively transform and translate uncertain, unmanageable realities into packages of manageable problems, *converting* uncertainty into manageable risks and rewards.

In seeking to understand, reflect upon and improve the way in which such a conversion process within the practice of risk settlement works, it is argued that it is useful to view it has having four dimensions: 'undertaking spontaneous and reciprocal reflections', 'coping with anxiety', 'use of metaphors', and 'use of frames and framing'.

The study applies this framework and understanding to an empirical study of risk management and product innovation in the Australian Cooperative Research Centres (CRC) programme. A narrative reconstruction of critical events occurring in a series of R&D projects in the CRCs is used to elucidate, elaborate, and illustrate the conceptual framework that has been developed as both a contribution to risk management thought and, at least in prototype, as a guide for reflective practice. The framework, and its illustration, is designed to support practical reflection on the complexities of 'problem setting', 'risk settlement' and the 'non-rational' character of 'generative metaphors' and the practice of 'invention'.

Thesis Certification

I, Hooman Attar, declare that this thesis, submitted in fulfilment of the requirement for the award of Doctor of Philosophy, in the Graduate School of Management, Macquarie University, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted to any other academic institution for qualifications.

Hooman Attar
September, 2009

List of Tables and Figures

Acknowledgements

In September 2005, when I came to Macquarie Graduate School of Management for the chance to work with Richard Badham, I did not anticipate the kind of inquiry I was in for. This inquiry was in fact an enlightening journey within which my dogmas underwent metamorphosis, and which enabled me to reinvent myself and reshape my tacit interests into something that not only matters to the science of managing but the science of becoming. For this and more, 'thanks' hardly seems enough.

I am deeply indebted to Paul Couchman. The quality of this thesis would have suffered without Paul's assistance and encouragement. I wonder the study would exist at all had Paul not generously offered me the opportunity to build this research on his rich, comprehensive, and intriguing data.

There are many others to thank. At one time or another they have provided the support I needed to produce a doctoral thesis. Among these are: Mostafa Asadsangabi, Abdul-Mohammad Attar, Richard Cardew, Chris Carter, Richard Carter, Kaveh Chini, Richard Claydon, David Cray, Rahmat Darabi, Temi Darief, Bijan Jokar Deris, Mohammad Ali Dolatabadi, Qasem Emtiaz, Ali Esfandiari, Ahmad Farboud, Farhad Fattahi, Nigel Garrow, Saeed and Hamoun Ghorbani, Kourosh Heshmati, David Hollows, Mario Rouzbeh Jaberi, Jean-Etienne Joullie, Davoud Karimi, Amir Kashfi, Mohammad Reza Khalili, Akbar Khellat, Alireza Khorakian, Robin Kramar, Uma Kumar, Nasser Levy-Hayim, Azita and Kambiz Madanipour, Anne Markarian, Linda Julianna Matula, Ian McLoughlin, Amanda Mead, Abbas and Mehdi and Saeed Mirnezami, Shahla Mohayya, Babak Mojab, Michael Muetzelfeldt, Cyrus Nazari, Shibu Pal, Reza Radjai, Pedram Radmand, Hadi Saghir, Ali Sardarian, Nancy Schön, Steven Segal, Arash Selahi, Reza Soofi, Elizabeth Thomas, Ekaterina Todarello, Dzung Tran, Aref Vaezpour, Pooneh Vasseghi, Emma Wise, Sara Zaeemdaar, Michael Zanko, and Habib Zohouri.

Although I have noted in the text borrowings from the original thought of the late Donald Schön, my indebtedness to him is of a different order. There are no words to express my delight and good fortune at being able to incorporate many of his ideas and insights into both my research and my personal life.

Finally, my parents, my brother, and particularly my best friend, Pantea, have endured my preoccupation with this challenging work for much longer than I expected at the outset. For this and much more, thanks.

Hooman Attar
Macquarie Graduate School of Management (MGSM)
Sydney, Australia
March 2009

Glossary of abbreviations

AMMCOE   Australian Metals Manufacturing Centre for Excellence

ANT   Actor-Network Theory

CAD   Computer-Aided Design

CAM   Computer-Aided Manufacturing

CIT   Critical Incident Technique

CRC   Cooperative Research Centre

CSIRO   Australia's Commonwealth Scientific and Industrial Research Organisation

DFM   Design for Manufacturing

FFI   Fuzzy Front-end of Innovation

NPD   New Product Development

OPP   Obligatory Point of Passage

PDMA   Product Development and Management Association

PhD   Doctor of Philosophy

PMBOK   Project Management Body of Knowledge

PMI   Project Management Institute

QFD   Quality Function Deployment

R&D   Research and Development

ROP   Rite of Passage

Author's Publications Relating to This Thesis

Refereed Conference Papers:

Attar H., and Badham R., (2007), 'The risk of politics and politics of risk in Innovation' In Proceedings of the European Group for Organisation Studies, 23rd EGOS Colloquium, Vienna, Austria.

Attar H. Badham R., Couchman P.K., (2007), 'Opening up the Black Box of Unreflexive Modernization: Innovation, Risk Regulation and the Games of Uncertainty and Risk', In Proceedings of the Asia-Pacific Researchers in Organisation Studies, 12th APROS Colloquium, New Delhi, India.

Attar H., Badham R., Couchman P.K., (2008), 'Converting Uncertainty to Risk: A Critical Examination of Organisational Risk Management Practices During Innovation', In Proceedings of the European Group for Organisation Studies, 24th EGOS Colloquium, Amsterdam, Netherlands.

Attar H., Badham R., (2009), 'The Mapping is the Territory: Existential Artistry in Converting Uncertainty into Risk in the early Stages of Product Innovation', In Proceedings of the European Group for Organisation Studies, 25th EGOS Colloquium, Barcelona, Spain (the paper won the Bob Award for the best presentation).

Chapter 1 Managing Risk and Handling Uncertainty in Innovation – Problem Definition and Introduction to the Study

'By Chance' – that is the most ancient nobility of the world, and this I restored to all things: I delivered them from their bondage under their purpose. This freedom and heavenly cheer I have placed over all things like an azure bell when I taught that over them and through them no 'eternal will' wills. This prankish folly I have put in the place of that will when I taught: 'in everything one thing is impossible: rationality'. A little reason, to be sure, a seed of wisdom scattered from star to star – this heaven is mixed in with all things: for folly's sake, wisdom is mixed in with all things. A little wisdom is possible indeed; this blessed certainty I found in all things: that they would rather dance on the feet of Chance.

Friedrich Nietzsche: *Thus Spoke Zarathustra* in Kaufmann (1976: 278)

1.1 Preface: Radical Uncertainty and the Management of Risk

When I began my PhD some three years ago, I wanted to make sense of a radical shift in social and technological changes, their inherent complexities as well as the global risks and uncertainties. I moved from studying and working as an engineer and business consultant to working as a doctoral scholar. As a student I have been concerned, among other things, with theories of invention and innovation, theories of uncertainty and risk, and theories of social and technological change. As an engineer for many years I tried to develop new products and help client companies to make more effective use of risk management techniques in their own innovation projects.

My PhD began with studying the role of risk management methods in increasing the rate of success in product innovation models. But as I came across more academic discourses and disciplines, I noticed that in contemporary societies there is an increasing tendency to interpret events, facts, and artefacts in terms of risk and risk management. However, a moment's reflection on such interpretations as a whole is sufficient to produce a sense of confusion. As Michael Power (2004) argues, the term 'risk' is used in many different, inconsistent, and incongruent ways. As I proceeded, I gradually noticed that one of the decisive yet delusive issues in the contemporary conception of risk, concerns how people grapple with a particular kind of 'uncertainty', one which is radical in form and function yet

often inadequately addressed in most risk and risk management discussions. This is what Knight (2006) refers to as 'unmeasurable uncertainty', and which I will describe in this thesis as 'Knightian uncertainty' or what others have termed 'radical uncertainty' (Lester and Piore, 2004). It was my initial view, an opinion that has since been confirmed, that this type of uncertainty characterises many instances of problematic situations as they occur in organisations (such as product innovation), and yet it has remained poorly theorised. This uncertainty is probably best seen as a component dimension in a stage in the general process of handling uncertainty in problematic situations rather than a 'type' of uncertainty in its own right.

Traditionally, the concept of risk is a statistical one and risk management in its most general sense finds its place in the practice of probabilistic reasoning. It is based on an assumption that there is or can be a clear definition of the problems, future events, alternatives, or the objects at stake. It is seen as possible to identify the likely outcomes, estimate the likelihood of their occurrence, assign probabilities, and manage the selected risks.

Situations of radical uncertainty, however, although action is required, resist analysis in such risk management terms (Schön, 1967). In such conditions, the phenomenon or the situation faced – as Dewey (1938) observes – is inherently problematic. It does not easily lend itself to precise quantitative expression because possible outcomes or alternatives are unknown, vaguely defined, unmeasurable or only dimly apparent at the outset (Lester and Piore, 1999; Knight, 2006). Such situations can be both unique and pressing; at times something needs to be done quickly without having a clear definition of the problems because there is too much competing information or too little to make an informed decision (Schön, 1967). In such situations, one must invent and reinvent received wisdom about what to do given that the problems faced are multifaceted, means and ends are fuzzy, alternatives are ill-defined, outcomes are indeterminate, and the smallest impulse may generate flaws or happy accidents which alter one's experience of the situation and ultimately the whole course of action (Dewey, 1930; Schön, 1982). There are often mismatches between 'what one intends'

(intention), 'what one can put into practice' (implementation) and 'what emerges and how one perceives' (realisation) which block the flow of the kind of systematic and orderly activity and rational problem-solving recommended in standard risk management methodologies. In these situations one usually has to set and reset the problems as well as the likely relevant scenarios again and again, and only on occasion (or as an outcome) is one able to tentatively employ a calculus of probabilities.

The germ of this thesis is the notion that the practice of risk management often involves a primary yet overlooked process (what I call risk settlement) which in fact is very much like the early stages of innovation, in the sense that in both cases people strive to convert uncertain, ill-defined, and problematic situations, as described above, into packages of manageable problems – packages in which practitioners frame and formulate ambiguities with manageable risks and rewards. But 'manageable risks or problems' have to be created. They do not readily come in nice neat packages. Practitioners or organisations actively convert uncertainty in vague and unfamiliar situations, frame and reframe the phenomena so as to design a set of problems, packages, programs, and policies on the assumption that the settlement of this set eventually leads to organisational wellbeing. My argument here is that such activities are inevitable. The decision is not whether or not to perform them but whether they are recognised or not, or done well or badly. Practitioners convert uncertainty in problematic situations into a set of seemingly separate problems not because the phenomena deserve to be separated but in order to accommodate their limited understanding of them and because they cannot act unless they do so (Schön, 1975).

The general point about handling uncertainty and converting it into another configuration is far from original. In Hermann Hesse's words (1969: 168):

> Every science, is among other things, a method of ordering, simplifying, making indigestible digestible for the mind.

A recognition of this phenomenon has characterised modern thinking about uncertainty, from John Dewey's '*Quest for Certainty*' (1929) to the recent argument of Bruno Latour around the theme that 'that the world is not a solid continent of facts sprinkled by a few lakes of uncertainties but a vast ocean of uncertainties speckled by a few islands of manageable, digestible, calibrated and stabilised forms' (Latour, 2005: 242). However, its special importance here is that it helps me put this inquiry in its proper perspective: to ask about the process by which practitioners deal with uncertainty in the early stages of product innovation – contexts in which there are not just clear-cut problems to be solved but rather *problematic situations* characterised by ambiguity, anxiety, and indeterminacy (Dewey, 1938; Schön, 1983: 16).

Aspects of 'converting uncertainty into manageable problems' have been discussed in a number of disciplinary areas, from the more traditional organisational areas of the 'problem of profit in economics' (Knight, 1921), 'managing new products' (PMBOK, 2004; Wheelwright and Clark, 1992), 'firefighting in innovation projects' (Bohn and Jaikumar, 2002), 'dealing with system accidents' (Perrow, 1999) 'sense making and managing the unexpected' (Weick and Sutcliffe, 2001), to broader social areas of 'maintaining governmental order and normalising the social' (Lupton, 1999), and 'using rituals to protect cultural integrity' (Douglas, 1966), to name but a few. All of these approaches outline variants of the same process, that of 'converting uncertainty into packages of manageable problems'.

Risk and uncertainty are all too often presumed to be similar in character with common properties (Wynne, 2002). However, the drawing of a sharp distinction between risk and radical uncertainty has figured prominently in the works of a number of scholars (Schön, 1967; Reddy, 1996; Lester and Piore, 2004; Knight, 2006). While this distinction has been raised in the work of these scholars, it has only been applied in sporadic, untheorised and inadequate forms in risk management literature. In this area the distinction remains far from developed, has not been analysed in depth, and the complex social psychological processes

involved in wrestling with uncertainty have received very little attention (Lupton, 1999). The purpose of this thesis is to help remedy this situation.

In this study, I shall argue, in contrast to the formal/traditional discourse of risk management, that the complex practice of handling uncertainty is not an 'applied science' but an 'artistic task'. Practitioners inevitably and iteratively transform a buzzing, incoherent, inconsistent, multifaceted and unmanageable reality into some settings and settlements with a relatively ordered character, with boundaries, trends and on occasion probabilities that allow management. In so doing, they are involved in an activity that is often implicit and intuitive, always uncertain and judgemental, and all too often unrecognised and unappreciated. This organisational phenomenon, however, is often either not explicitly acknowledged or its implications are not effectively explored.

In practice, uncertainty may be dealt with in different ways. According to the degree of fear and bewilderment, uncertainty may be screened through selective inattention; it may be repressed as undiscussable, as a taboo; it may be simplified through or by the making of myths (Malinowsky, 1954); or attempts may be made to convert it into an activity which can be carried out with minimal disrupting effects (Douglas, 1966). From a psychological perspective, in all such cases, one usually seeks to avoid a greater anxiety by selecting a lesser anxiety in concert with one's interests, tacit assumptions, value systems, and acceptable frames of discourse (Sullivan, 1965). In every case, however, this process involves a number of generic activities such as making sense of problematic situations, creatively recalling and reflecting on the ability of one's established theories to bear on the phenomena, metaphorically exploring the puzzling situation and establishing symbolic relations, and seeking to formulate and frame solvable problems while handling the anxiety this creates.

From a reflective practitioner's viewpoint, this thesis is interested in the difference between constructive and unconstructive, effective and ineffective, ways of handling this process and such activities. By providing an overview of unproductive forms of repression, selective

inattention (or interpretation) and the unconscious use of myth and taboo, I attempt in the thesis to draw attention to how a more productive and reflective approach may be established. I want to defend an alternative yet *overarching* and *all-encompassing* view, expressed in the works of few scholars, that the inevitably complex and social psychological process of converting the inherent uncertainties of innovation into manageability of risk (and reward) should be made explicit, and should be made a matter of ongoing systematic reflection, inquiry and experimentation.

The implications of this analysis clearly go far beyond managing risk in the innovation process. However, this thesis focuses on the role of risk management in the early 'fuzzy front-end' stage of innovation projects (Wheekwright and Clark, 1992). Despite this narrowing of 'content' focus, it is arguable that the method adopted in this thesis to explore it remains far too broad. The argument draws on a vast range of epistemological, psychological, and sociological literature, all of which can only be superficially covered in the course of a single PhD thesis. Despite this problem, however, I believe that the analysis is justifiable and indeed, essential if the risk management practice is to develop in an effective and reflective manner. The idea that risk management, as a more or less 'technical' discipline, dependent upon an often unacknowledged, or only superficially understood, prior process of 'uncertainty handling' or 'risk settlement' is, I believe, crucially important. Unless this is widely recognised, and addressed, what we take to be 'risk management' will only be the unwitting outcome of unacknowledged and potentially pernicious forms of prior social psychological activities.

In order to help address the broad range of literature that bears on this matter, and to reduce the dangers of eclecticism, the key arguments of the thesis will be developed by drawing on, developing, and extending the original (and, somewhat surprisingly, widely neglected) range of thought of Donald Schön. More recent ideas and concepts from different disciplines will be used to elaborate and extend Schön's original perspective, not replace it. In a sense,

Schön's theoretical corpus will be a selective guide to help navigate through the treacherous waters of uncertainty and how to handle it.

Why Donald Schön? There are three main reasons. Firstly, Schön is widely acknowledged to be one of the classic and still foremost thinkers on reflective practice (Yanow and Tsoukas, 2008), and the present thesis presents and illustrates a framework designed to support reflective practice in risk management. Secondly, Schön has been a significant contributor to the institutional analysis of corporate innovation, and raised to prominence the inherent 'dynamic conservatism' of organisations that creates an imbalance between the 'language of investment' and the 'language of invention' in handling the uncertainty of innovation (Freeman, 2006). Thirdly, Schön has also made a significant contribution to pragmatic thought, in particular in the use of metaphors and problem setting in situations of uncertainty, and links this to his analysis of innovation and reflective practice. For these reasons, Schön provides an accessible, integrative and highly suggestive basis for exploring the handling of uncertainty, and a coherent intellectual resource that can be drawn on to help guide and integrate subsequent investigations of aspects of socioeconomic and psychological processes that bear on this question.

1.2 Colonising a Utopian Future by Risk Management?

Since the Enlightenment, two contrasting yet complementary approaches to knowledge, the description of reality, and the organisation of the social and nature have been in good currency, and during the last hundred years the waves of new social, technological and scientific progress have pushed both traditions into prominence (Burrell and Morgan, 1979; Ashley and Orenstein, 2004; Hatab, 2005).

The first approach, exemplified by the work of Francis Bacon and Rene Descartes, prescribes a rational process of augmenting knowledge and world-making with the aim to establish progressive stages of certainty:

> For man is but the servant and interpreter of nature: what he does and what he knows is only what he has observed of nature's order in fact or in thought; beyond this he knows nothing and can do nothing. For the chain of causes cannot by any force be loosed or broken, nor can nature be commanded except by being obeyed. And so those twin objects, human knowledge and human power, do really meet in one; for where the cause is not known the effect cannot be produced; and it is from ignorance of causes that operation fails...Now my method, though hard to practice, is easy to explain; and it is this. *I propose to establish progressive stages of certainty...* [Emphasis added]

> Sir Francis Bacon: quoted in Burtt (1939: 23-28)

> The long chains of simple and easy reasonings by means of which geometers are accustomed to reach the conclusions of their most difficult demonstrations, had led me to imagine that all things, to the knowledge of which man is competent, are mutually connected in the same way, and that there is nothing so far removed from us as to be beyond our reach, or so hidden that we cannot discover it, provided only we abstain from accepting the false for the true, and always preserve in our thoughts the *order* necessary for the deduction of one truth from another [Emphasis added]

> Rene Descartes: *Discourse on the Method of Rightly Conducting the Reason and Seeking Truth in the Sciences,* (2004: 11) and *Principles of Philosophy* (2004: 3)

The opposite approach, exemplified by the work of Friedrich Nietzsche (see p. 14) and John Dewey, uncovers and describes the uncertainties in humanity's quest for certainty:

Man who lives in a world of hazards is compelled to seek for security. He has sought to attain it in two ways. One of them began with an attempt to propitiate the powers which environ him and determine his destiny...the other course is to invent arts and by their means turn the powers of nature to account... this is the method of changing the world through action...[But] the distinctive characteristic of practical activity, one which is so inherent that it cannot be eliminated, is the *uncertainty* which attends it. Of it we are compelled to say: Act, but act at your peril. Judgment and belief regarding actions to be performed can never attain more than a *precarious probability*...Fortune rather than our own intent and act determines eventual success and failure. [Emphasis added]

John Dewey: *The Quest for Certainty* (1929: 3-7)

The prototypes of these approaches go back to Greek philosophers who lived before Bacon, Descartes, Dewey and Nietzsche (Hatab, 2005).

In the first tradition, there has long been a quest for order, proceduralisation, stability and certainty, security, unity and control (Cooley, 1983). This quest seeks to eliminate uncertainty, disorder, contingency, chaos, insecurity, misery, and anxiety, through the systematic regulation of humankind, nature and society, with the hope of establishing a kingdom of order, justice, and beauty (Dewey, 1930; Hegel, 2001). Within this approach, reason and causality, as increasingly exemplified by science and technology, function as humankind's means in the rational march toward a kind of utopia, a steady march through which the mastery of humankind over nature and society is possible. For the advocates of this tradition, such as Bacon and Descartes among others, comprehensive rationality is the main reality; the order of nature is based on reason that must be explored by humankind; ignorance of causes is powerlessness and the only wisdom is the spread of knowledge about causality and the order necessary in the chain of events; hence the progressive establishment of certainty and methodical knowledge that promises to reduce humanity's practical activity to an ensemble of rationally-grounded tasks and techniques. This approach seeks to create comprehensive rational/law-like procedures for establishing causation between phenomena, and views practical reason as a matter of making rational decisions by subsuming decisions within a well-defined hierarchy of rules (Cassirer, 1968). Unexpected change in established

values is usually seen as abnormality, disorder, ignorance, impurity, flightiness and, in modern times, 'risks' that shall be mitigated and overcome.

Unlike such comprehensive and according to Popper (1971: 425) 'uncritical' rationalists, there is another tradition represented, at least in part by Nietzsche and Dewey, for whom flux, fortune, necessity, fate, non-rationality, indeterminacy, and uncertainty are the main realities. For proponents of this view, reasoning regarding actions to be performed can never attain more than a *precarious probability*; instead of reason things change and dance on the feet of chance; no 'eternal will' orders nature, hence humanity's full mastery over nature through systematic spread of knowledge about causality is illusory or impossible. This tradition recognises the centrality of a non-rational, prankish, and open-ended process of inquiry in each indeterminate piece of reality, on the assumption that there cannot be a comprehensive, final or ideal settlement, only a temporary and tenuous one (Dewey, 1938).

Throughout the development of modern societies and the development of professional activities there has been oscillation and conflict between these two world views ranging from positivism to anti-positivism, from scientism to existentialism, and from functionalism to phenomenology.

In essence, the former uncritical rationalist tradition sees humans' actions as occurring against a background of stability and rationality: rational humanity, rational institutions, and social progress occurring according to rational, stable values (Sztompka, 1994). It conceives of our practical activity, organisations, values and technological/scientific advancement as consistent, continuing, and to a great extent controllable, endurable, and predictable. It sees concepts of identity, profession, institution, and society not only as resting on the invention of technical and scientific means, but future changes occurring within a predictable, stable, and enduring framework of norms and values. Over and over again those operating according to this world view have sought to establish, once and for all, how the order of things really is; to form purposive, uniform, ideal, and orderly organisations which will endure and will be

predictable; to generate systematic regulations and values which will hold not only for a generation but for the progress of all people at all times (Fukuyama, 1992).

But, as Schön (1967: xii) argues, experience keeps imposing on us the fact that what usually appears to be continuous, rational, unshakable, and established is actually discontinuous, non-rational, distressing and fleeting. The drive for certainty and rationality forces us to ignore the uncertainties that are occurring and to selectively attend to unexpected irregular change in individuals, professions, institutions, and social norms and values.

Social Implications

In Giddens' (1999) terms, one of the most recent manifestations of uncritical rationalism is a preoccupation with risk and risk management as an attempt to 'colonise' the future. Risk management, as Giddens (2003) argues, is now in wide usage in societies that are future-oriented. It has become a mobilising dynamic of societies that want to determine their own future. In this form, the future is seen as a territory to be 'rationally' programmed or colonised by the instrumental application of risk and risk management techniques – calculating future profit and loss, future risks and rewards, future opportunities and hazards, mostly based on probabilistic and scientific reasoning (Giddens, 1999).

One major yet unspoken problem with this attempt to colonise the future (colonisation by uncritical rationalisation) is a propensity to undermine modernity's foundations (Giddens, 2003; Latour, 2005). While proclaiming eternal truths (doctrines, models, methods), such theorists succeed in doing little more than creating prescriptions, analyses and 'certainties' that only last as long as the first imprint of the theory in which they first appeared. At best, they achieve little more than a linear extension of the recent past into the future. In discussing the nature of the doctrine in the 'risk society' Ulrich Beck (2006: 330) comments:

> The irony of risk...is that rationality, that is, the experience of the past, encourages anticipation of the wrong kind of risk, the one we believe we can calculate and control, whereas the disaster arises from what we don't know and cannot calculate.

Over the last two decades it has become increasingly difficult to sustain this form of self-deception when old certainties are shattered or revealed as myths (Beck, 2006; Latour, 1993). As a result, an increasingly number of scholars view the utopian idea of 'mastery and control over nature and society' as a fiction (Latour, 2003: 36).

> [late modernity] does not signal an increase in mastery and consciousness, but only a heightened awareness that mastery is impossible and that control over actions is now seen as a complete modernist fiction. In [late] modernity, we become conscious that consciousness does not mean full control.

The uncritical rational attitude toward human action, social progress, and technological/scientific development suffers as the rate of uncertainty, irregularity, and anxiety increases; unexpected shifts (e.g. the soaring cost of food and lack of safe sources of energy), manufactured risks (e.g. the credit crunch and toxic assets) (Beck, 1992), and technological imbroglios (e.g. toxic toys and poisonous milk) (Latour, 1993). Too much is happening to individual identities, institutions, sociocultural values and global politics within the span of one person's life to relax on established certainties or to be confident about their projection into the future (Lash, 2003; Bauman, 2007). It appears, as if overnight, that the seemingly unthinkable becomes an idea in good currency and a generation of change is telescoped into a single year. Perhaps it is not an exaggeration to say that in recent times we rapidly exercised our seemingly well-established certainties for a while only to realise that they are in fact ephemeral.

In Drucker's (1992) terms, we are now experiencing an 'age of discontinuity' in management, traditions, and norms; and history provides little previous similarity and experience. We can no longer assume that there are clear rules and guidelines for making valid inferences from past experience. In many areas, it seems that that we cannot make predictions that will be valid for the next decade. There is less certainty about 'the line' of the future and, as options proliferate, we are faced with the dilemma of what Giddens (1999) calls a 'plurality of future scenarios'.

Many scholars agree that one principal and increasingly global source of uncertainty and difficulty is to be found in the process of technological innovation and in the many forms of social change which have accompanied and resulted from it (Schön, 1967; Wynne, 1988; Beck, 1999; Giddens, 1999; MacKenzie and Wajcman, 1999). As affirmed by researchers from many backgrounds, technological innovation as the cause and consequence of social change is no longer viewed simply as an exogenous factor (Bijker, 1995; McLoughlin and Dawson 2003; Badham, 2005; Latour, 2005; McLoughlin and Badham, 2005). Intertwined with ongoing technological change, new forms of globalisation also impose varied and shifting demands on our basic ideas of self, institutions, nature, societies, cultures, and national economies.

In this context, the grip of contemporary organisations on the levers of risk management throughout the process of product innovation has weakened decisively. Conflicts and uncertainties are accelerated, and organisations see and feel the global risks and uncertainties that leave them with minimal, organisationally-bounded means to decipher and resolve them. Corporations tend to develop profitable products and to avoid epochal events in which they see their business suddenly in deep trouble, their market undesirably displaced, jobs lost or their profits depressed by big shifts flowing from manufactured risks, organised irresponsibility, unintended consequences and even the very growth of human professional knowledge, innovation, and practical activity.

In the case of the 'credit crunch', for example, few corporations outside the United States were even vaguely aware of the degree and associated risk level to which their own products, business, economy and financial systems were held hostage to the subprime loans made to American homeowners – hostage to innovative complex instruments (including complicated risk management calculations) disguising mountains of debt. A system overwhelmed by innovative financial products without responsible and robust frames for setting and solving manageable risks was able to overthrow much of the conventional wisdom about corporate innovation, risk and uncertainty management, and above all social and technological

progress. Irresponsible, incompetent settlement of 'manageable risks' may result in contagious, disruptive 'manufactured risks', able to displace countless professions and to wreck giant corporations. Manufactured risks and tensions, of course, do not spring solely from organised irresponsibility in financial systems. They reflect an increasing technological path dependency across the globe.

With the global development of technology, individuals as well as public and private sector organisations have witnessed unprecedented ease of movement, mis/information and mutual trade across national economies that come with the diffusion of innovation and disruptive technologies (Christensen, 1999). With this has come a heightened awareness of the increasing rate of man-made disasters, 'unknown unknowns', and complex socio-technical entanglements. This has led critical commentators such as Beck (2005), Latour (2003) and Wynne (1996) to not only declare that 'full control is impossible' but also to draw our attention to the birth of 'risk societies' in which individuals seek to manage and control the 'self-manufactured risks and uncertainties' and 'non-rational problems' that three hundred years of overriding obedience to scientific-rationality has created.

It is difficult, if not irresponsible, to separate any formal discussion of 'risk management' from this context. In this late modernist context, it is plausible to argue that we can see a new kind of 'unexpected marriage' between 'technological innovation' and 'risk management' as the generation of uncontrollable risks becomes endemic within the innovation process in contemporary social institutions.

On the one hand, it is apparent that modern societies, besieged by the continual development and introduction of new products and processes into their lives, have been quick to adopt technological innovation as a permanent part of their culture and as a basis for social progress. Scientific/technological innovation has become a continuing task of institutions, developing nations, and modern developed societies as a whole, a perceived imperative should they wish to achieve power, prestige, order, justice, beauty, and happiness. Systematic

research and development (R&D) has been adopted as a way of competing, and an inseparable part of organisations as they seek to develop and exploit new paths of product development.

On the other hand there has been the alarming experience of practitioners, corporations and social systems that the world they are creating and encountering is moving toward uniqueness, ambiguity, uncontrollable anxiety, indeterminacy, discontinuity, value conflict, and surprises. *Radical uncertainty* increasingly appears to be central to their activities. Problems are interlocked and do not follow pre-existing, clear-cut rational techniques and theories. Means and ends are acknowledged to be fuzzy. The nonlinear, puzzling realities of professional practice appear to defy pre-defined tasks and tactics.

As a result, it is arguable that a rational approach to risk management as yet another 'technique' threatens to add fuel to the fire rather than 'solve' the risk problems. A rational view, with its origins in the uncritical Cartesian paradigm, appears mismatched with the changing and complex character of the contemporary situation. There is arguably a significant gap between contemporary risk management methods and the complex, uncertain demands of real-world practice (Flyvbjerg et al., 2003). Ironically the dominant models of risk management are themselves highly risky as they narrowly and naively project the past into a relatively infinite future (Taleb, 2007). Since September 2008 we have all witnessed how market conditions brought both risk management and innovation to the fore. The slavish devotion to formal models highlighted some of the root causes of problems inherent in the traditional settlement (or setting up) of manageable risks by professions, corporations and social systems involved in the development of innovative products[1]. These unexpected consequences, shocks, uncertainties, and discontinuities fed the notion that we are living beyond the canon of our established means for managing innovation, risk, and uncertainty and that something is badly wrong with the rational models, doctrines, and methods that are supposedly deployed to control and regulate our society.

---

[1] *Financial Times* 28th and 29th Oct. 2008 – 'The risk of slavish devotion to financial models'

It is arguable, therefore, that 'risk', 'risk management', and 'handling uncertainty and setting up manageable risks' can no longer be restricted and 'black boxed'. Modern innovating organisations need to strategically revisit not only how they navigate the uncharted waters of innovation but also how they cope with the treacherous task of setting and solving manageable risks in a manner that reclaims some of the credibility, competence and confidence lost to disastrous, destructive, and distressing manufactured risks.

It is argued in this thesis that those who hold the uncritical rationalist views of risk management and technological innovation are locked into a traditional asocial epistemology (Beck, 1999). There are nods, of course, to a need to improve institutional risk management and product innovation. Yet the overriding unspoken assumption is that these distressing surprises, discontinuities, and shocks will simply be accommodated within the existing system of coordination and control; more sensible regulations, more monitoring techniques, more transparency, a small adjustment here, a tweak there and everything will be fine again (Shiller, 2008; Summers[2], 2008; Taleb[3], 2009). In this form, the Descartesian and Baconian view is still what organisations embrace to restore order and recover the systems and specialisations under their sovereignty. Missing is a willingness to see that what we are witnessing is a metamorphosis, an epoch that demands an entirely fresh look at the world of technological innovation and risk management.

As stated at the outset, this study outlines how this doctoral thesis is attempting to make a contribution toward addressing such issues. It uses the idea of risk management in innovation as a lever and as a metaphor to raise awareness and discussion of nonlinear socio-technical changes, their inherent complexities and uncertainties, and how to effectively grapple with them. The thesis is principally about the need to look beyond restricted risk management as a 'technology of control' in situations of calculable threat and explore its character as a 'reflective practice' for handling situations of radical uncertainty. Its particular focus is on the

[2] *Financial Times* 26th Oct. 2008 – 'The pendulum swings towards regulation'

[3] *Financial Times* 25th Feb. 2009 – 'How bank bonuses let us all down'

handling of uncertainty at the fuzzy front-end of the innovation process. However, insofar as it is concerned with uncertain, problematic situations, the present study might also provide a practical and reflective framework for other individuals and social institutions whose professional activity has much in common with risk management and innovation.

In sum, the thesis illustrates how restricted, narrow approaches to risk management in innovation, what Wynne (2002) characterises as the 'cultural reification of risk', often reduce uncertainty to a sanitised, value-neutral discourse that ends up increasing rather than eliminating confusion, conflict, anxiety and ambiguity. This constitutes a systematic selective inattention, one that embodies and contributes to a dilemma at the heart of contemporary organisations. In this way, it is arguable that modernity is creating yet denying the non-rationality, disorder, and uncertainty that promotes, informs and designs its rationality (Bauman, 1991). This suffuses, and provides the background to, the more restricted study of risk management in product innovation. It is the argument of this thesis that in order to cope with uncertainty, indeterminacy, instability, anxiety, and ambiguity, we require a new Deweyian and Nietzscheian view which allows us to inquire, to explore, to experiment, to experience, to learn the reflective dance on the feet of chance.

The main thrust of the thesis is, however, most definitely *not* to replace rational tradition with nonlinear or non-rational views. I believe organisations and practitioners need both. As Nietzsche (Kaufmann, 1976) puts it:

> A little reason, to be sure, a seed of wisdom scattered from star to star – this heaven is mixed in with all things: for folly's sake, wisdom is mixed in with all things. A little wisdom is possible indeed; this blessed certainty I found in all things: *that they would rather dance on the feet of chance*.

The strategic objective, therefore, is to combine these two viewpoints such that both could be recognisable, constructive, and well understood for one another. This means abandoning uncritical rationalist epistemologies that sanitise epistemological discourse and do not acknowledge the ongoing existence of chance, uncertainty, complex artistic practice, and

critical reflection. However, it does not mean abandoning the partial insights and contributions that methodologies drawn from applied science and epistemologies can provide. In terms of this thesis, the exploration of handling uncertainty recognises the importance of applied 'risk management' as well as the prior artistic practice of 'risk settlement' that surrounds and enables such activity. In this way, the thesis attempts to provide more than a peaceful but a cooperative coexistence between applied and artistic science in the practice of risk management and product innovation. An all-encompassing schema or a new kind of *marriage*, this thesis proposes.

1.3 Schön's Schema

In working toward such an all-encompassing schema this thesis draws heavily on the works of Donald Alan Schön[4] (1930-1997). Schön is well known in organisational studies for his work with Chris Argyris on the concepts of reflective practitioner and pragmatic organisational learning. Less well known, however, is the depth of his published research on metaphor, problem-setting and solving under stressful situations of uncertainty and the implications for public policy, and the range of his work on innovation and change.

It is important to emphasise that this thesis is not a simple work of 'uncritical homage' to Schön but is, rather, a critical extraction from and development upon Schön's overall schema.

For this reason, it is necessary to provide a comprehensive introduction to his work. In some ways, this may appear to be a lengthy digression in an introductory chapter, and more appropriately located later in the thesis or in a supportive appendix. I request the indulgence of the reader here, however, because of the significance of Schön's enterprise for the thesis. It is important to clearly understand his (and the thesis') basic standpoint because it informs the more detailed critical analyses of innovation and risk management that follows. This includes Schön's championing of reflective professional knowledge in challenging societal conditions. It also extends to his committed advocacy for creative thought and professional artistry in the face of significant opposition from the restricted language of investment, dynamic conservatism, and images of the stable state that dominate institutional life and restrict the public imagination. Following the overview of these dimensions of Schön's work, the chapter will return to a more detailed outline of the specific contributions of this thesis and the chapters within it.

Schön was a student of Dewey's pragmatism and 'theory of inquiry', as well as an exponent of existentialism (Schmidt, 2000). He was a thinker trained as a philosopher turned inventor.

---

[4] Donald Schön's photograph has been used with the written permission of his wife, Nancy Schön.

Less well-known than his celebrated work on professional practice is his extensive and supportive writing on generative metaphors and their role in the formation and diffusion of new ideas, concepts, and setting problems in situations of uncertainty. Where this links directly into practice and innovation is his additional exploration of the hidden alternative conservative and radical usages of metaphors in everyday social and organisational life.

1.3.1 Conflicting Views of Professional Knowledge

As recently acknowledged by Yanow and Tsoukas (2008), Schön has been a major contributor to organisational studies, as the first organisational theorist to focus scholarly attention on the depth and details of reflective practice in the face of chaos, uniqueness, uncertainty, anxiety, and complexity. He explored in depth professional practice as a kind of intuitive artistry, as a non-rational engagement in making sense of problematic situations, selecting and naming 'things' of the phenomena, metaphorically exploring the new and unfamiliar in terms of its association with the old and familiar, framing the context and setting new problems.

For our present purposes, also, his work on problem setting and solving, innovation in organisations and the disruption of the 'stable state' in modern societies (Schön, 1971) provides a major and important linkage between such ideas and how individuals and organisations in late modernity do and should handle uncertainty in the innovation process.

I use Schön to orient this thesis because he is among the few who prominently address a central concern in the fields of policy making, organisations and management knowledge in practice – the one that essentially stems from the conflict and split between the two aforementioned competing philosophical viewpoints. In Schön's terms, this involves a growing split between the following two approaches to professional knowledge and the epistemology of practice:

- Systematic and methodical application and adaptation of pre-existing means (preferably science-based) to well-defined ends under the realm of technical rationality

- Artistic intuitive thinking and doing on one's feet through (usually non-rational) reflective practice under the assumption that in real-world situations of practice means and ends are by and large fuzzy, they evolve iteratively and determine one another over time according to one's reflective conversation with the situations

In Schön's words (1983: 240):

> It is no exaggeration to say that the field of management is split into two camps, each of which holds a different view of the nature of professional knowledge. At the same time that management science and technique have grown increasingly in power and prestige, there has been a persistent and growing awareness of the importance of an art of managing which reveals itself both in crucially important situations of uncertainty, instability and uniqueness, and in those dimensions of everyday practice which depend upon the spontaneous exercise of intuitive artistry. One sign of this split is that in some schools of management, representatives of the two tendencies – the professors of management science and the practitioners of case-method – no longer speak to one another...they go about their business as though the other school of thought did not exist.

Schön argues that a split of this kind which is barely tolerable in a professional school can create painful dilemmas for professions in organisational life, widening the rift between theory and practice, and above all resulting in serious consequences for society as a whole (Schön, 1982).

1.3.2 The Collapse of Technical Rationality and the Crisis of Confidence

The context of these reflections was Schön's experience with the growing crisis of confidence in professional practice that was part cause and part consequence of the American intellectual turmoil of the 1960s, including urban riots, the assassination of Kennedy and Luther King, Vietnam war, the Cold War, and most importantly, a steep rise in the US

economy after the World War II and its sudden sharp drop by early 1970 (Richmond, 1998). These challenges meant that by the 1970s American society had lapsed into an unstable and unsettling time with the fear of being in the Red Sea without any Promised Land or Stable State in sight. Schön identified different and contradictory responses to that disorienting and distressing time: *debacle and demise* (to reject and to revolt against failing systems in the form of reactionary radicalism), *delusion* (to return to the last stable state), *defiance* (to resist instability and change by dogmatism and defensiveness), *despair and denial* (to repress intolerable anxiety and uncertainty by selective inattention) (Schön, 1971).

Having refrained from espousing simple radical left or conservative right-wing solutions to this uncertainty, Schön joined a small group of intellectuals in the middle, acknowledging that the events of the 1960s and 1970s have significantly undermined the ideological and epistemological foundations of traditional thinking and triggered a widespread confusion and crisis of confidence.

Schön argued that much of the confusion was due to an inadequate examination of the alternatives available in formulating and dealing with these upheavals and uncertainties, whether for individuals, for organisations, or for society as a whole. He indicated that the crisis of confidence and professionals' inability in effectively handling problematic situations arose in large part from 'technical rationality', the dominant model of professional knowledge and practice at the time. Technical rationality influenced the definition of knowledge and practice of most practitioners and professional schools essentially aimed at applying reason (understood as science, scientific method, and technique) to resolve everyday problems of professional life and eventually the wellbeing of humankind (Schön, 1983). With the advancement of science and technology in the last three hundred years this prevailing tradition – as the heritage of positivism – had, Schön argued, given rise to a powerful and persuasive account of human progress, resting on a scientific world view that portrayed this as moving toward an ideal rational stable state. Throughout this science-based march toward

a kind of Promised Land, the professions had the role of mediators. The role of the professional was to apply a body of research-based knowledge, rules and techniques for resolving usually given, clear-cut problems of professional practice, organisational development, and social progress. It fostered a view of professionalism as the repetitive administration and application of techniques and theories to the same kinds of specialised problems and well-defined tasks. Professional work consisted of specialised task systems subject to instrumental measures of performance and control. Yet, Schön observed, this firmly established epistemology of practice had failed. It had left professionals unable to set and solve many of the problems that they routinely addressed, i.e. those that defy ordered solutions and technocratic approaches based on technical expertise alone.

In its failure to address such issues, Schön argued, 'technical rationality' carried its own 'epistemological nihilism'. When its fundamental canons are questioned, it still tends to function as an overriding norm that permits little or no freedom to change (Schön, 1967; Schön, 1971). In consequence, it fails to recognise and reflect on – and even openly rejects or represses discussion of – practitioners taking intuitive decision-making leaps in unique situations that escape the standard categories and classification most professionals are trained for and that do not lend themselves to the application of standards. These practical situations involve conflicting, complex, confusing, and contentious conditions in which problems are ill-defined, interlocked, intertwined, and puzzling. In such contexts, contending parties see, set, and frame, problems in different ways, employ Machiavellian stratagems of selective reasoning to disagree on what needs to be resolved and what must be done to resolve it.

1.3.3 Beyond the Stable State

In 1970, he delivered the prestigious Reith Lectures for the British Broadcasting Corporation (published subsequently as *Beyond the Stable State,* 1971) asserting that the belief in humanity's ability to attain any deterministic, utopian form of stable state is illusory; that change is inevitable and any form of belief in reaching a calm, constant afterlife-within-life

after a time of troubles is a myth. Humankind is alone and does not derive meaning from any *a priori* or transcendental essence, hence we are condemned to be free in our experience yet responsible for creating the meaning of our existence (Schön, 1971; Schmidt, 2000). Schön added that our modern life and social systems are likewise in permanent states of flux but we are afraid of change and tacitly resist it while often appearing to ourselves and others as not doing so (what he termed 'dynamic conservatism'). As a result, he argued, it is necessary to develop a new epistemology of practice for individuals, institutions, and social systems by which they become more open learning systems, capable of adapting and transforming while conducting a critical and self-reflective form of practice. This epistemology supports the development and use of heuristics that do not disregard the inherent uncertainty of experience, and demands a particular kind of ethic. This he called a Meta ethic for 'change and dealing with situations of uncertainty' and for the rest of his life Schön pursued this line of inquiry in varied yet congruent forms and fashions.

Schön knew that the loss of the myth of the stable state is frightening; that we suddenly confront ambiguity and anxiety beyond tolerable bounds; that our established concepts of individual, profession, organisation, and society decay or explode, and we are faced with more information than we can handle by rational means and the use of old established certainties. In an opening passage in *Beyond the Stable State* Schön (1971: 9) reveals his personal sense of his concept:

> I have believed for as long as I can remember in an afterlife in my own life – a calm, stable state to be reached after a time of troubles. When I was a child, that afterlife was Being Grown Up. As I have grown older, its content has become more nebulous, but the image of it stubbornly persists...The afterlife-within-my-life is a form of belief in what I would like to call the Stable State. Belief in the stable state is belief in the unchangeability, the constancy of central aspects of our lives, or belief that we can attain such constancy. Belief in the stable state is strong and deep in us. We institutionalise it in every social domain. We do this in spite of our approval of dynamism. Language about change is for the most part talk about very small change, trivial in relation to a massive unquestioned stability.

Reform by Reflection

The shocks of the 1960s and 1970s, uneasiness, mass terror, and turmoil had, Schön believed, unintentionally opened up the possibility of a new beginning – providing the momentum for reform and real change. His opinion was that the new beginning was not to be characterised by destructive formats of return, resistance, repression, or revolution. It could, and should, take the shape of 'reform by reflection'. Reform by reflection comes with learning about new ways of learning – ways that help us overcome a technical rationality that systematically undervalues and ignores key characteristics of open and creative practice, i.e. reciprocal, playful reflections by which we learn to surface our tacit inner voice, reinvent the self and learn to recreate a better life, a life where we have an important and influential role in shaping a meaningful becoming (Schön, 1967, 1992, 1994b).

However, Schön pointed that the very tradition of technical rationality that created a world in which there was a central need for such critical reflections, also makes it far from possible. Technical rationality has set powerful norms of behaviour and expectations not only for professionals but also for social institutions at all levels of modern societies. Under the yoke of technical rationality, problematic situations involving conflicts of means and ends, information overload, competing ideas, and incongruity are treated as merely technical problems. Problematic situations are also seen as being effectively addressed through the application of value-neutral means (mostly scientific-based) to well-defined ends. Success for such an approach depends on reinstating agreement about clear ends, and exploiting the best technical means for achieving them. The normative theories of choice that this implies marginalise the explicit treatment of uncertainty, value conflict, inconsistency, anxiety, artistry, intuition and emotion. While the inherent variability of the behavioural world imposes upon practitioners more complex and conflicting information than they can handle, technical rationality knows no strategy other than to rationally reduce this world to a stable, predictable, enduring form of technical/scientific control. In the face of flux and change, this

view fosters an interest in control, stability and the survival of systems (whether social and technical) through establishing or re-establishing the predictability of behaviour in its members, components, functions, and sub-systems. For technical rationality, instability, indeterminacy and inconsistency are, therefore, the sources of failure, a frightening 'Other' to be denied, repressed, or managed away.

1.3.4 Schön's Existential Orientation

Schön's stance is that many constants of our behavioural world are *artificial* (Simon, 1969) and *accidental* in the sense that they are created and intensified by human convention and continued by human choice – rather than inherent in the nature of the universe (Argyris and Schön, 1974: 17). We construct the reality of our behavioural worlds but we magically forget their origin, the laws and values, and mythical assumptions of stability and predictability that surround them (Schön, 1967: xiii). We tend to regard them as enduring and eternal. We easily forget that our artificial realities are always subject to revision, examination, doubt, collapse, or re-invention. Viewed as such, this perspective, as Schön points out, has strong parallels with Friedrich Nietzsche when Nietzsche argues that what is usually considered to be truth, reality, and conventional wisdom (Galbraith, 1969), is in fact (Nietzsche quoted in Kaufmann, 1976: 46-47):

> A mobile army of metaphors, metonymies, and anthropomorphisms – in short, a sum of human relations which have been enhanced, transposed, and embellished poetically and rhetorically, and which after long use seem firm, canonical, and obligatory to a people: truths are illusions about which one has forgotten that this is what they are; metaphors which are worn out and without sensuous power, coins which have lost their pictures and now matter only as metal, no longer as coins.

To avoid such illusions, Schön argues that we must treat the binding constants of our behavioural world as both 'psychological certainty' and 'intellectual hypothesis' (Argyris and Schön, 1974) – psychological certainty in the sense that such constants inevitably inform our assumptions and decisions during action yet must be regarded as intellectual hypothesis as

these governing norms are subject to error, scepticism and change. This apparent paradox is heightened in situations of greater unsteadiness, uncertainty, and chaos. The norms of behaviour advocated by technical rationality may provide a basis for action in such situations but there is little ground for the kind of critical inquiry, instant testability, and learning necessary for a more open, reflective and existential approach to knowledge and theory building.

As a result, in such conditions, norms of technical rationality misread situations as practitioners fail to reflect or precisely notice what is happening because much of the dynamics inherent in the situation fall beyond the frames, measures and logics of technical rationality. Put another way, technical rationality makes us overlook the experimental dimension inherent in the reciprocal interaction between the behavioural world and our tacit knowing, theories, values, and assumptions, and the existential orientation that is required for on-the-spot reflection and experimentation, and learning from 'what is going on right here, right now'.

Consequently, technical rationality does not permit us to access and examine the governing theories, assumptions and values that tacitly shape and influence our experience especially in unstable situations. We continue to treat both the constants of our behavioural world and the norms of technical rationality as psychological certainties, established and unquestionable, rather than as hypotheses, fallible, tentative, and subject to suspicion, change and disconfirmation. The failure to encourage a reflective existential stance usually results in reflex knee-jerk type responses to a lack of understanding and control in situations of instability, uncertainty, and chaos. It also means a failure to learn from exploring the way in which our theories, values, and assumptions have failed us.

The antidote is, as indicated above, to treat both our behavioural world as well as our governing theories, norms, values and assumptions as intellectual hypotheses. Schön argues that this crucially involves, firstly, exploring and experimenting, and then enhancing our

individual inner voice by reflecting on the personal as well as the interpersonal here-and-now (right here, right now). It involves an 'existential use of the self' (Schön, 1991: 356) in making sense of what is happening between us, between you and me, between us and them, between me and the matter at hand.

Drawing on Polanyi (1966), Schön believes that we tacitly know more than we can say and he considers the existential here-and-now as the test, the source, and the limit of our tacit theories, knowledge, assumptions, and values (Schön, 1971).

This existential use of the self begins with 'experience' and a crucial starting point – that theories drawn from the past cannot be assumed to be literally applicable to the here-and-now. Like metaphors, they may suggest analogy, exemplar, family resemblance, projective models, or symbolic relations. Our theories may help us to develop a feel for something and make sense of situations, and act in the here-and-now but this is provisional, because such metaphorical explorations are inevitably subject to test, doubt, and error. This type of what Schön (1971: 231) calls 'existential theory building' therefore grows out of existence – the present here-and-now – and involves re-examination against the next here-and-now, which may turn out to be different (Schön, 1971; Schmidt, 2000).

To further enhance personal competence in surfacing a precise inner voice as we focus on the here-and-now, Schön explicitly took up the existential notion of 'existence precedes essence', extended it as a projective model, and argued that the experience (or phenomenon) precedes concepts about the experience (or phenomenon). In other words, Schön considers one's experience in the here-and-now to be both prior to and more fundamental than one's conceptualisation or theory about situations prior to the fact (Hainer, 1968; Schön, 1974: 28). Put simply, we shall get some experience before we conceptualise or theorise about the next piece of reality we encounter. Since we know more than we can put into words we must act in order to learn from our experience and from our tacit knowing in action.

In the face of complex and turbulent situations, Schön recommends that we assume and build on this existential stance. This tenuous, provisional stance involves re-examining and reflecting on the personal as well as the interpersonal here-and-now, seeking and screening the hidden metaphors behind our ideas in good currency, renouncing authoritative unquestioned myths, and trusting ourselves (our inner own voice) as we self-reflectively make sense and experience what is happening in the 'ever-present present'.

1.3.5 'Theories-in-use' and 'Espoused Theory'

In *Theories in Practice* (Argyris and Schön, 1974, 1992) Schön along with Argyris, formulated the concepts of 'theories-in-use' and 'espoused theory' to help translate this existential approach into *a basis for a meaningful personal style* useful for practitioners in testing and learning from their experience in the here-and-now. Schön distinguished 'theories-in-use' (what we actually do in our actions, or in our practice) from 'espoused theory' (what we say, conceptualise, and verbalise). He proposed that 'theories-in-use' are usually tacit, non-verbal, not-articulated world views, values, insights, strategies, and assumptions that shape intentional behaviour and guide our action. Theories-in-use are the means for achieving what we want or would like to achieve. 'Espoused theories' are explanations, justifications and somewhat sanitised stories we offer about our action and behaviour. Espoused theories, therefore, are expressed images of the self in which we believe or declare ideas and thoughts as if they are our true beliefs. The transition from the complex, comprehensive, and confusing 'theories-in-use' to simplified, selective, specific 'espoused theories' involves a very large reduction in content, wealth and depth of experience. It involves the loss of much original differentiation or possibilities when we use simplified symbols, codes, concepts, and patterns to stand for our complex theories-in-use (Hainer, 1968; Argyris and Schön, 1974).

Schön's schema is designed to support practitioners in transforming their hardly communicable experience into evolving concepts that would imbue their life with meaningful

becoming through finding their inner voice and providing a valid basis for their tacit personal style and for educating others to do likewise.

1.3.6 The Reflective Practitioner

Within the information gap between theories-in-use and espoused theory, Schön identifies a critically important role for 'reflection-in-action' most clearly delineated in his seminal book *The Reflective Practitioner* (Schön, 1983). Reflection-in-action, says Schön, is the process of on-the-spot reflection and experimentation through which theories-in-use can be instantiated, developed, and on occasion modified and adequately verbalised (Schön, 1992).

The commitment to focus on events (here-and-now) in a reflective existential stance offers us a great competency to encounter uncertainty, instability, and uniqueness. It lets us cope with the pieces of reality once we encounter, then modifying and improving our theories-in-use as events require without being restricted by bias, stress or defensiveness (Schön, 1974: 28). The recognition of instability, novelty, happy accidents, or unintended consequences, with their resulting ambiguity and anxiety, can become a source of reflection, experimentation and appreciation, rather than despair, dogmatism, or denial. In short, this commitment calls for what I shall call 'the dance on the feet of chance'.

The ability to take such a reflective existential stance and to be conscious of taking it is Schön's model of reflective behaviour in threatening situations of uniqueness, indeterminacy, and uncertainty. Thus, any behavioural world, espoused theory, and theory-in-use could be regarded as conditional, tentative, subject to doubt and change, and likely to be refuted. Such a reflective stance reduces our need for stability, determinacy, certainty, or constancy, allowing us to be freer to test and improve our theories-in-use without intolerable disruption or being saddled with anxiety, dogmatism and bewilderment. The ability to take such a tentative yet creative stance implies that we are able to envisage and crystallise, even to a

small extent, behavioural worlds, theories-in-use, and espoused theories different and more effectively than the ones we have created and jealously guarded.

Schön went beyond Dewey's pragmatist theories of learning suited to times of relative stability, arguing that the only way to learn and cope with the complex, rapidly changing world, is to take an existential stance in the form of reciprocal, reflective conversation with the materials of the situation (Richmond, 1998). The term conversation, in Schön's usage, is metaphorical and does not refer to a literal conversation about the situation but to a practitioner's conversation – like transaction with the matters and materials at hand. In transaction with the materials of a situation, a practitioner encounters surprises in the form of 'back-talk' that momentarily interrupts action, evoking uncertainty. Triggered by shock, by surprise, by excitement, by the unexpected, or by the happy accident, reflective practitioners *think on their feet* in the midst of action to frame and reframe the puzzling situation. Reflective practitioners iteratively go on to transform such situations in a way that resolves uncertainty, at least for the moment. They are in a unique process of reciprocal transaction with the situation. Influenced by their appreciation of it at the same time that they shape it by their thinking and doing, reflective practitioners set new conditions that occasion new problems and constructive interventions they have confidence in undertaking.

1.3.7 The Process of Metaphor

What sparks off and stimulates reflection, the source of the 'surprises' that make this happen, for Schön has very much to do with the process of metaphor. Drawing on the German philosopher, Ernst Cassirer (1953) and his notion of 'radical metaphor', Schön (1963, 1979) argued that metaphors, apart from being ornaments of the language, are 'generative' in the sense that they intuitively come to mind and construe uncertain, unfamiliar situations in terms of our familiar and old images, theories, and concepts. Metaphors tacitly invade our feeling, thinking and doing to formulate and frame our understandings and perceptions. Conceived in this way, 'generative metaphors' can nevertheless function as both stimulators and inhibitors

for 'reflective practice'. Generative metaphors, however, create 'new ways of seeing', yet if treated as rigid will restrict critical reflection on 'ways of not-seeing'. Treating 'generative metaphors' as hypothetical, flexible 'projective models' or as factual, solid, 'protective means', this is the core dilemma rooted in language, says Schön. We may treat metaphors uncritically and unreflectively when we use them as somewhat rigid 'protective means' – when an old concept A comes to conservatively reduce and restrict our experience and conception of B without itself being questioned, reflected upon or modified. This is the case when we use A to stimulate new ways of seeing B yet do not reflect on the ways of not-seeing which our rigid treatment of A has created. This conservative tendency may inhibit us from effectively inquiring about the limits and strength of our metaphorical insight and inference. Metaphors can provide momentum for change, reform, reflection, creativity, and critical inquiry when we use them as flexible 'projective models', when we make sense, interpret, and frame situations of uncertainty, confusion, uniqueness, and indeterminacy, casting and recasting them in new perspectives while inquiring about new possibilities. In more radical use of metaphors we treat B in the manner of A (or in terms of A), see B in A-like ways which might in turn enable us to question and see A in a way quite unknown before. This involves an ongoing and reciprocal reflection to see and inquire about both A and B in fresh lights (an implication of such critical inquiry is explained at length in the next chapter).

1.3.8 A Schema Based on Schön

Schön did, however, finish his work a number of years ago, and there are multiple insights into the issues and areas that he raised as being of central significance. However, Schön's remarkable eruditions – his apparently limitless grasp of subjects as diverse as psychotherapy, music, planning and urban studies, social and organization theory, invention and technological innovation – very nearly masks the fact that his seemingly prescient work is very much about a few basic and heartfelt, but decisive questions: What has happened and

continue to happen to professional practice? How in their encounter with surprise or situations of uncertainty, competent practitioners handle indeterminate zones of practice? Why their common yet obscured pattern of action should become a vivid basis for educating others to do likewise?

Schön was intensely aware that thoughtful practice, grounded often in uncertainty and uncertainty's affective complement, anxiety, can become a generator of new knowledge whose validity and utility is, however, a function of practitioners' quality of reflection in and on their action (Schön, 1994). Consequently, Schön's schema was to reveal, reframe, and reform the confusing and complex world of practice (such as the process of product innovation) by the existential notion of self-reflection.

However, as a recent study by Raphaël Fischler (2009: 24), one of Schön's students, shows 'most authors only pay lip service to his ideas'. Fischler rigorously examined 253 journal articles found in planning-related fields (urban studies, city and regional planning, planning theory, urban design, architecture, and landscape architecture) published between 1983 and 2008 citing Schön's (1983) *The Reflective Practitioner*. Surprisingly his study shows that very few have used the notion of 'reflective practice' in novel ways, let alone integrated much of Schön's work and extended it into other academic disciplines such as risk management. Yanow and Tsoukas (2008) support this in their recent analysis of Schönian element of 'surprise' in professional practice.

What I shall be doing in this thesis is using Schön's schema as a form of intellectual map in the early stage of innovation (i.e. the fuzzy front-end), and in the analysis of risk. In this sense, this research goes beyond the limited partial and psychological dimensions of Schön's work (Yanow and Tsoukas, 2008), to integrate his ideas and insights within the broader corpus of a life's work that extends from existentialism, through metaphor, framing and creative thought, to social and psychological reflections on handling uncertainty and managing innovation in organisations.

In this process, I shall argue that corporate organisations have problems dealing with the complex and uncertain nature of innovation, particularly in the early 'fuzzy front-end' of the process. In Schön's terms, they prefer, and are better able to handle an already established 'language of investment' than the creative and tentative 'language of invention' (Schön, 1967).

In fuzzy, uncertain situations, 'problem setting' is the key primary activity, and 'problem solving' only secondary (Schön, 1978, 1983, 1988), but organisations have difficulty in handling, discussing and reflecting upon the primary problem setting process. They exhibit a 'dynamic conservatism' (Schön, 1971) or a set of 'defensive routines' (Argyris, 1999) as they evolve in terms of the manner in which they inhibit reflective discussion on such issues.

This thesis seeks to provide a framework capable of supporting practical reflection on such issues, and to assist in opening up discussion and debate on the complexities of 'problem setting' and the uncertainties that characterise the 'language of invention'. While it can be argued that handling such 'fuzzy' situations is inherent in all areas of management (Grint, 1997), the particular focus of this thesis is on one of the primary and most clearly recognised areas of such fuzziness – the early stages of product innovation. How the practice of risk management is and should be handled in this area is the main area of inquiry, although the approach that I take and the framework that is developed have broader relevance.

The framework that has been developed builds on Schön's insights in conceptualising the initial handling of uncertainty as a 'conversion practice', i.e. translating and reducing unmanageable uncertainty into packages of manageable problems (Schön, 1995). One particular focus of the present study is about how this 'conversion' occurs in the case of 'risk management', with particular attention to the early stages of product innovation.

As I have argued above, the traditional approach to managing risk is based on a 'technical/rational' view of knowledge in action and description of reality. In Schön's terms, this is based on models of 'applied science' (Schön, 1958, 1983, 1988). Risk management is

viewed as a technocratic process for generating ideas, making decisions and solving problems. This has to do with the proper selection and application of clear-cut methods to achieve unambiguous targets within a well-defined strategy. Risk managers are those who clearly identify and 'objectively' assess whatever risks exist, successfully identify the various possible means available for confronting them, comprehensively map the relevant chain of consequences likely to result from any choice, and select the course of action likely to achieve the best possible goals at minimum cost and time, all prior to the fact (Wynne, 2002; Lester and Piore, 2004).

I shall argue that this traditional model of risk management is an approach to 'solving' well-formed problems that works within an intellectual terrain that has already been intellectually 'set up'. Yet, the traditional model fails to systematically recognise, reflect upon and improve the effectiveness of the artistic work undertaken in the prior stage of problem setting or 'risk settling' (Beck, 1999; Lupton, 1999a). In contrast to traditional approaches to risk management, therefore, it is the argument of this thesis that in situations of uncertainty, 'problem setting' or 'risk settlement' are the primary activities for practitioners, and 'problem solving' or 'risk management' are secondary.

The conceptual framework, outlining the nature of the 'conversion' process, works within Schön's basic schema, grounded as it is in a pragmatic/existential philosophy, an institutional view of economics, and an understanding of knowing-in-practice that recognises complexity, paradox, uncertainty, playfulness and politics, and yet attempts to produce 'actionable knowledge' that contributes to both theory and practice.

1.4 Thesis Structure: Themes and Topics

At one level, I intend to extend Schön's schema in order to provide an intellectual map and a projective model for exploring a specific topic. Drawing on Schön's work, the thesis develops and illustrates a conceptual framework for handling uncertainty in the practice of

risk management in the early stages of product innovation. At another level, it is my belief that this conceptual framework has broader relevance as a generative metaphor, not only for other stages of product development, but for organisational risk management as a whole, and how practitioners and organisations grapple with risk as a social issue in late modern societies.

Chapter 2 initiates the discussion of the nature and dynamics of innovation, opening up the 'black box' of generative metaphors in academic disciplines that attempt to conceptualise the phenomenon of technological innovation. In so doing, it provides a necessarily schematic overview of the broad modernist intellectual tradition that has become so embedded that academic models of innovation (metaphorical accounts such as funnel, trajectory, paradigm, dominant design, etc.) fulfil a conservative role, institutionalising a way of not-seeing rather than creatively exploring such metaphors as a way of seeing.

In situations of radical uncertainty (often marked by too much competing information, i.e. more than can be handled) one needs a theory for pattern recognition, a 'template', or a 'model for intervention' that is flexible in use, as is a truly generative metaphor. Such creative thought-aids are essential as 'guiding tools' to helping scan, screen, and channel the abundance of information, determining what to focus on, what to ignore, and how to do this. Yet organisations frequently have problems admitting, or utilising, this insight, often having great difficulty in handling the non-linear language of innovation appropriately, particularly in its early stages. They tacitly accept the need for putting a normative template on the complex reality of innovation yet intuitively treat such templates as a recipe or an instruction manual, and as an unchanging and undiscussable tool. There is a tendency to see the model in all its concreteness rather than as illustration of an elastic concept. An example of this is the 'funnel stage-gate' metaphor which has been adopted by a majority of organisations.

This chapter explores this popular metaphor as well as contrasting metaphors, innovation as 'fireworks', as 'spaghetti', as 'rolling a snowball', and as 'an emergent network of

heterogeneous actors', most of which are seen by practitioners as non-actionable and unsatisfactory.

This chapter seeks to draw on, rather than dismiss, both 'funnel' and 'fireworks' metaphors of innovation, emphasising the generative nature of such metaphors (if shorn of their historical and institutional embeddedness), and the need to combine and 'play' with them if innovation is to be creatively and constructively explored. The chapter seeks to expound a metaphor that combines the utility of the linear 'funnel' model with the realism of the 'fireworks' metaphor. This is a metaphor of the innovation process as a ribbed balloon. Developing on Schön's idea of the creative use of metaphors, and the difficulty that organisations have with openly discussing and employing a 'language of invention', this chapter attempts to support a more open and creative exploration of risk management in innovation through this metaphorical approach.

Chapter 3 approaches risk management from a different direction. It provides a brief history of risk analysis and the traditional view of risk management, followed by a review of the broader academic social/cultural/political approaches to risk. These broader approaches identify significant deficiencies in the commonsense views of risk. In line with the classic 'Knightian' definition of uncertainty, these broader perspectives implicitly refer to a need for handling uncertainty in modern social institutions in a *reflective* rather than reflexive knee-jerk manner. Despite the importance of their observations in this regard, these broader approaches do not provide a coherent risk management framework useful for practitioners. Yet they set the stage for such an attempt. In order to provide the foundations for such an attempt, the chapter returns to a more detailed examination and elaboration of the nature of radical uncertainty and its importance as a decisive factor for formulating a reflective practice approach for the practice of risk management. With this end in view, I build on the insights offered by classical and contemporary approaches to handling radical uncertainty so as to create a foundation for drawing on the critical insights of the broader views of risk without

losing the practical focus that has, in the past, tended to be monopolised by the narrower more rational views of risk management.

Chapter 4 provides a discussion and approach to an empirical study of product innovation in Cooperative Research Centres (CRC) in Australia. Little research is available on how practitioners during product innovation actually handle stressful situations of uncertainty and set up manageable problems, namely manageable risks and rewards. In order to elucidate, elaborate and illustrate a conceptual framework that captures four dimensions of this orgnisational phenomenon, I therefore, present a prototypical case study; a study of a how managers in a government-funded R&D programme (CRC) tackle problematic situations of ambiguity and anxiety in the early stages of three CRCs. I show how these managers (as reflective practitioners) actually engage in 'undertaking spontaneous and reciprocal reflections', 'coping with anxiety', 'using metaphors', and 'framing and reframing'.

The data used to examining, elucidating, and enhancing this framework, was previously collected during an inquiry about the critical events in the CRC programme by two Australian researchers who arranged a series of in-depth interviews with managers and practitioners to address issues of mistrust, organisational conflicts, fear of uncertainty and anxiety, defensiveness, and resistance to change; and to discover how these managers nurtured the sense of companionship and commitment necessary for creativity under such conditions. They had encouraged managers to discuss the meanings and stories they assigned to problematic and critical events encountered in everyday practice and their actual response to such situations.

At the time of interviewing (conducted by chief investigators), about two or three years after beginning of each CRC, managers were faced simultaneously with unexpected failures and unintended consequences as well as happy accidents. Minor changes in the early stages produced major organizational conflicts among contending groups in each CRC. While in

annual reports top management and government were proud of the CRCs' accomplishment, they were also vexed by the conflicts, which had become a feature of everyday practice. The interviewers had also participated in a series of direct observations (e.g. meetings where CRC managers made plans to deal with organizational conflict).

Using Flanagan's (1954) critical incident technique (CIT), Badham and Garretty's (2003) idea of 'critical events' and Schön's (1991) distinction between 'manifest and underlying story' as a way of uncovering and discriminating between practitioners' 'espoused theories' and 'theories-in-use', the chapter outlines an appropriate strategy for elucidating, elaborating, and illustrating the conceptual framework.

In chapter 5, I use the CRC stories to help illustrate a conceptual framework that views risk management (broadly defined) as a process of colonisation and conversion. Drawing on a broader notion of colonisation the chapter outlines the first, and primary, stage of the handling of uncertainty as a process of 'risk settlement' that establishes the basic conceptual territory, its conditions and boundaries – in short the terrain that subsequent discussions of risk management will occupy. Rational risk management, more narrowly defined is then considered as a 'secondary' set of practices that is only made possible by this prior 'primary' practice – that converts the complexity and anxiety of 'uncertainty' into packages of 'manageable risks and rewards'. I then single out, integrate, and explain four practices in such colonisation and conversion practice in a conceptual framework: 'coping with anxiety', 'framing and reframing', 'the process of metaphor', and 'reflection'.

Finally, in chapter 6 I elaborate the main contributions of the thesis, the implications and limitations of the idea of 'colonisation as process' for organisations and professions, and the place of reflective responsibility in handling uncertainty in the larger society. I then outline recommendations for future research.

Chapter 2 The Ribbed Balloon: A Generative Metaphor for Innovation-in-Practice[5]

Invention is full of unanticipated twists and turns. It is a juggling of variables in response to problems and opportunities discovered along the way (Schön, 1967: 18). *A great deal in the process of invention defies definition in advance. Invention, often pictured as a race, is more like exploring an unfamiliar coastline in a fog. The rational myth of invention makes these features seem surprising* (Schön, 1967: 37). *To protect itself from uncertainty, the corporation has constructed a family of myths of innovation, of which, the most important is the myth of rationality* (Schön, 1967: 110).

2.1 Introduction

Drawing on Schön's idea of generative metaphors, in this chapter I seek to introduce a reflective practice approach to innovation models by developing a new 'generative metaphor' – the ribbed balloon – one that, it is argued, provides more useful support for professional practice than either 'funnel' or 'fireworks' metaphors. In providing the background to this task, the intellectual origins and depth of embeddedness of the linear 'funnel' metaphor are

---

[5] This picture has been modified from its original version : http://www.ft.com/cms/s/0/0dfe3f44-1798-11dd-b98a-0000779fd2ac.html?nclick_check=1

reviewed as a basis for showing how generative metaphors can become 'conservative', thereby hindering their creative 'radical' potential. This chapter challenges conservative and restrictive *uses* of metaphor – whether economic, managerial or sociological – in guiding and explaining technological innovation.

Despite their value, many of these metaphorical accounts are somewhat inattentive to their self-created 'ways of seeing' and 'ways of not-seeing' and when examined can be seen to misrepresent the world of innovation-in-practice. Critical a-rational approaches to innovation, for example, view innovation as a nonlinear, messy, and indeterminate process. These views are less concerned with prescription, and for the most part are fatalistic about innovation; using imagery such as 'fireworks', 'spaghetti', and 'snowball rolling' as descriptive yet, ultimately, restrictive and non-actionable metaphors.

Using the notion of generative metaphor, I build on both 'funnel' and 'fireworks' metaphors. I seek to introduce, illustrate, and elaborate a new 'generative metaphor' that is multifaceted, and more realistic, than current managerial lenses, broader than economic ways of seeing, more actionable than critical approaches, and incorporates the often unacknowledged role of anxiety in the handling of uncertainty in human and organisational affairs.

Towards a new metaphor

For some thinkers, technological innovation is understood through the lens of 'tool' metaphor, and humans are understood as tool-wielding and tool adapted creatures. Marshall McLuhan, for example, argued that like the bees in the plant world we have always been the sex organs of the technological world (McLuhan, 1964: 239, 1967). But, he says, we have taken this so far that we have become the genitals [sic] and exist only to improve next years' models. McLuhan expresses his view when he claims that, first the human made the hammer, and thereafter the hammer made the human, that new technologies inherit the past yet broker the future. Others like Bruno Latour (1993, 2002: 250), however, question the 'tool'

metaphor, arguing that technologies and humans are intertwined in 'collectives', that humans are not for themselves or by themselves, but always by other things and for other things. Latour also uses the example of the hammer. As he puts it: 'thanks to the hammer I become literally another man, a man who has become 'other'', but for Latour this is not because the hammer determines us, or we develop the hammer, but the human-hammer couplet is a new generative reality.

Despite increasing recognition of this intertwining of the technical and the social, and the complexities and problems it gives rise to, researchers still write stories and develop theories and academic models that deploy the metaphor of the 'heroic' individual inventor or entrepreneur as the source of innovation. Such images are often accompanied by other metaphorical descriptions, such as the portrayal of technological innovation as a linear (Rothwell, 1985), funnel-like (Hayes, 1988), risk-reducing (Smith and Reinertsen, 1997; Tidd and Bessant, 2009), paradigmatic (Nelson, 1981; Christensen, 1997) or proceduralised process (Cooper, 2002), many of which assume the technology in question acted as though it had a life of its own. As a background ethos, such assumptions frequently recur in the latest business school 'pro-innovation' speculations on new images of organisational change (Abrahamson, 1991). While such images proliferate within, and even dominate, much of our corporate culture, they have not been effective enough to address the frequently identified high failure rates in product innovation (Crawford, 1987; Booz Allen Hamilton, 2007). Moreover, this domination continues despite evidence of widespread social and economic disruptions consequent on the introduction of new technologies, and recurring data on the economic and technical problems of both process and product innovation (Wynne, 1996, 2002).

In this thesis I shall argue that many of these variants of the linear metaphor, as a means of apprising practitioners, wittingly or unwittingly foster selective inattention to the chaos of uncertainty and the psychological anxiety that permeates innovation practice.

The particular focus of this chapter, however, is on two particular models/metaphors: the 'innovation as funnel variants of the linear metaphor' and 'the nonlinear innovation as fireworks metaphor'. As we shall see, these two metaphors have come to dominate much of the discussion and debate over the nature of innovation, the former providing a practical managerial methodology, the latter a critical and realistic awareness of process and complexity. After outlining the nature and function of these metaphors (and the background assumptions about social progress, technological innovation, economic development, etc. that influence the conservative use of the funnel), the chapter presents an alternative metaphor of a 'ribbed balloon' to help provide a more interesting and creative, critical yet practical, approach to innovation – an elastic ribbed balloon in which flows of people, materials, money and ideas merge, converge, diverge, interact, and evolve over time so as to construct an artefact. This metaphorical approach also sets the innovation context for the subsequent discussions of risk management in the early stages of product innovation.

In a sense, the combination of the two metaphors of 'funnel' and 'fireworks', in a 'ribbed balloon' metaphor, could be seen as a radical treatment of the funnel metaphor, with some aspects modified and changed in a way that helps shake off some of the conservative dogma and inaccuracies that hinder its creative use (Wheelwright and Clark, 1992).

The ribbed balloon metaphor is intended to provide a three-dimensional view of innovation as a socio-technical practice (Badham, 2005) that draws on and integrates the work of authors such as Schön (1967, 1971), Van de Ven et al. (1999), Bucciarelli (1994), Law et al. (1988, 1992), and Wotherspoon (2001). These authors all converge when they assemble their argument to talk about the sociopolitical, messy and unpredictable nature of technological innovation. Bucciarelli and Schön, in particular, provide a detailed argument on the indeterminate zones of practice; Law et al. and Van de Ven et al. integrate this with a broad socio-political processual view of the unpredictability and messy (fireworks) nature of the innovation process.

Hence, according to the ribbed balloon metaphor, the corporate product innovation is a messy and uncertain process that proceeds iteratively through a series of 'ideal type' phases, from a pre-project fuzzy front-end, through the 'rite of passage' of 'project approval', before branching out into the project development phase. The process, then, provisionally concludes with the second rite of passage – 'the decision to adopt or commercialise'. At this point, if the innovation is approved and 'launched' it enters the third phase of 'implementation and/or diffusion', which itself can be seen as culminating in a final decision point of 'evaluation of success', before proceeding further. The central theme of the chapter is the notion that innovation is shaped by technical, economic, and sociopolitical constructs in an iterative phased process characterised by ongoing uncertainty, anxiety, and discontinuity.

2.2 The Nature of Generative Metaphors

It is easy to dismiss metaphors as a kind of 'anomaly of language' or as 'language games' (Searle, 1979). But behind such discussions sits a major debate not only about the way we see the world through the use of metaphors as generative tools, but also about what sort of metaphors work better for colonising our future, programming humanity, and for the purpose of this study, modelling innovation in age of discontinuity and uncertainty (Cassirer, 1953; Schön, 1963; Lakoff and Johnson, 1980). It is necessary, therefore, to provide a brief outline and justification of generative metaphors to support the argument of this chapter.

As I argued in the previous chapter, there are scholars who believe that many of the orthodoxies and realities of our behavioral world are in fact based on metaphors created and intensified by human convention and choice. Yet the origin of these metaphors, the self-created ways of seeing, and the consequent ways of 'not-seeing' are usually forgotten or taken for granted (Morgan, 1980). The consequence of this selective inattention to the use of metaphors has made thinkers such as Schön (1963), Fromm (1951), Ricoeur (2004), and McLuhan et al. (1997), argue that we must carefully focus on the role of metaphors in the

development of our language as well as the way in which our thought and practical activity has progressed over time.

This study argues that the inattentive use of metaphor is an often invisible problem that afflicts the practice of technological innovation. The restrictive 'conservative' and creative 'radical' uses of metaphor are central elements in our use of language and approaches to reality. Metaphors are, consequently, a central component of all thought, and are far from being only an ornament to language (Cassirer, 1953; Schön, 1963; Koestler, 1967; McLuhan et al., 1997; Morgan, 1997).

Metaphors as a primitive form of language, or as the 'forgotten language' (Fromm, 1951) are sources of creativity in human beings. The use of metaphor has also been central to many technological and scientific inventions and innovations (Farber, 1958, Nash, 1963). Metaphors are essentially 'generative' in the sense that they give us our views of the world, tell us how to compare and think about things, make sense of situations, and shape the stories we tell (Schön, 1979; Schmidt, 2000). Metaphors function to eliminate the anxiety of confusion, to structure the unknown, to describe the unfamiliar, to reframe problematic situations by setting solvable problems, to interpret our obscure areas of experience and organise the chaos (Edge, 1974; Schön, 1979). The process of using metaphor is, especially in situations of confusion, one that enables a transition from helplessness and anxiety to power, or excitement or, at the very least, less anxiety (Schön, 1963). We usually think and inform our action through the use of metaphors. As Schön (1963) remarks, however, metaphors can be used in either a 'conservative' or a 'radical' manner when tackling novelty, ambiguity, doubt and uncertainty.

2.2.1 Conservative and Radical Functions of Metaphor

Schön (1979) observes that the use of metaphor plays a central role in sparking off reflection and stimulating exploration in the innovation process, the source of the 'surprises', 'shocks',

or 'excitement' that make inquiry and invention happen. His view of metaphor has affinities with Kuhn's (1970) use of exemplars and Wittgenstein's (1953) seeing A as B through family resemblance.

Schön argues, however, that while metaphors are inherently generative – in the sense that they suggest relationships, similarities, differences, etc. – they can be used as either a stimulator or inhibitor of creative thought; metaphors as flexible 'projective models' (acknowledging uniqueness, uncertainty, and ambiguity) or as fixed 'protective means'. Metaphors are used in the latter sense as a form of 'defensive mechanism', when a concept A operates to shape our experience and scope of thinking about B yet A's nature remains unchanged and unexamined in one's mind-set, A's limits and the ensuing restrictions and problems during this metaphorical process remains unexplored and unquestioned.

Such rigid and restrictive usage deploys metaphors as an instrument for conservatism, security, or techniques of control, keeping (often unconsciously) as much as possible of one's old settings, certainties, and orthodoxies (embedded in the metaphor) when treating either familiar or unfamiliar situations. Such uses often fail to acknowledge or actively deny their nature and role as metaphor, such that the metaphor at times goes underground. Schön argues that an example of such a metaphor is that of the 'balance scale', a central component of much of the language of decision making theories and logic. We 'weigh alternatives' in pairs (mind/matter, subject/object, 'mechanistic vs. organic', 'to be or not to be', 'innovate or die', 'carrots or sticks', 'capitalism or communism', 'you are with us or against us', and recently 'publish or perish'), usually without examining the basis of the dualism. The balance scale metaphor is *literally* applied to frame and interpret situations in a conservative manner – rather than reflectively deployed in a projective manner.

In general, as Morgan (1980, 1993, 1997) illustrates, we often remain uncritically unaware of the role and function of metaphor in our everyday thought and speech, their strengths and limitations, and to the fact that metaphors can be used in a creative, flexible and elastic

manner. As Wittgenstein (1953) argued, any thing and every expectation involved in the concept of a thing or an instrument may be conceptually grasped and structured in an indefinite number of ways. One can never be sure of having grasped all potential interpretations or meanings.

Schön (1963, 1979) extends this insight into a prescriptive model of how one should understand and use metaphors in a radical projective manner. When one confronts a new situation, he argues, an interpretation of this situation in terms of an established concept or theory should be seen as a projective exploring of the old A in the new B but not restricting our understanding of B within such confines.

For Schön, therefore, the use of metaphors in a radical form can be a momentum for inquiry, critical reflection, change, and exploration – when used as flexible 'projective models', i.e. when we make sense, interpret and frame situations of uncertainty, confusion, uniqueness, and indeterminacy *tentatively and as hypotheses*. In this radical use of metaphor we may treat B in the manner of A (or in terms of A), see B in A-like ways, yet not restrict our understanding of B to these terms and also use this analysis to see A in a new light.

Schön illustrates this use of metaphor with the example of the Cold War. As Schön (1963) shows, the Cold War metaphor is not simply the notion of 'cold' added to 'war' but through this characterisation of a problematic situation some aspects of the 'cold' as well as 'war' have been changed, transposed, and mutually adapted in favor of the formation of a new concept to not only deal with difficulties in a diplomatic conflict but seeing both 'cold' and 'war' in new lights. Both concepts were made to cover more than they did before. As Schön puts it (1963: 31):

> These concepts have been displaced to situations outside of their ordinary patterns of use and they have been transformed in the process. Through their displacement they have been extended. They have been made to include a new kind of instance.

One could extend examples of such uses of metaphor to further examples like the 'Cola War' between Pepsi and Coca Cola in the 1980s and 1990s (Morris, 1987).

Another example is the predominance of 'balance scale' metaphor in international relations. It was influenced in the 'balance of terror' mindset dominant in the Cold War nuclear stand-off (Wohlstetter, 1959), which in fact provided security and certainty for four decades. With the collapse of the twin towers this metaphor was revived as a new terror balance: you're either with us, or against us. In such cases, the metaphorical couplets opened up new understandings but also imposed blinkers. If identified and discussed as projective metaphorical models, they are capable of playing a reflective radical function. However, when used conservatively, as a rigidly imposed view of history, then new sets of ideological blinkers are imposed.

Now one may ask the question: is it possible to so clearly differentiate between the conservative and radical functions of metaphor?

In a sense, making such a sharp distinction is itself subject to the potential errors one finds in the balance scale metaphor. If, however, the clear differentiation is seen as a projective insight, allowing other multiple and more graduated interpretations, then such a contrast has its uses. It is of particular value in the way in which it is used by Schön, in bolstering and supporting arguments for an open, creative and flexible approach to understanding and action in practice, avoiding the danger of 'reading off' what is occurring or should occur in terms of a pre-existing template and being open to the influence of context, circumstance and changing requirements.

In the conservative use of metaphors we see the metaphor as a rigid tool or an indisputable 'shortcut for thinking', as a kind of 'reasoning' or 'logical proof' to shape and interpret the reality, to set and solve problems. We use the tool-like metaphor to change other things but

the tool remains usually unaffected, unquestioned, and unchanged in our thought (Schön, 1963: 126). But as Dewey (1938: 141) reminds us:

> While the direct use of objects, factual and conceptual, which have been determined in the course of resolving prior problematic situations, is of indispensable practical value in the conduct of further inquiries, *such objects are not exempt in new inquiries from the need for reexamination and reconstitution*. The fact that they have fulfilled the demands imposed upon them in previous inquiries is not a logical proof that, in the form in which they have emerged, they are organs and *instrumentalities* which will satisfy the demands of a new problematic situation. On the contrary, one of the commonest sources of error is the *premature assumption that a new situation so closely resembles former ones that conclusions reached in these earlier cases can be directly carried over*. Even the history of scientific inquiry shows how often this error has been made and for what long periods it has gone undetected. One indispensable condition of controlled inquiry is readiness and alertness to submit the conclusions of even the best grounded conclusions to re-inquiry with reference to their applicability in new problems [emphasis added].

When metaphors, concepts, thought, or instruments in general are deployed without being changed or adapted and present themselves as literal, unchanging or undiscussable mechanisms, means, methods for framing and solving problematic situations – this is, according to Schön and other metaphor theorists (in particular Cassirer, 1945; Morgan, 1997), an unjustifiable and conservative way to deal with uncertainty or new situations.

In the more radical use of metaphor, by contrast, our old tools are treated as flexible or elastic instruments, as projective models to bear on the new situation. In this use of metaphor it is somewhat unclear what expectations are to be carried over and how they are to be met or not. The metaphor is subject to an indefinite number of interpretations and reexaminations (Schön, 1963: 62) and the inquirer first *notices or feels* a possible symbolic relation between A (metaphor, concepts, old situational understandings) and B (the new situations), finding and modifying aspects of A in the light of B and vice versa, with unpredictable and creative consequences.

2.3 Defining Innovation

Innovation is one of a family of terms already well established in the vocabularies of those concerned with invention, new product development and socio-technical change (Clark and Wheelwright, 1992; Bijker, 1995; Christensen 1999; Van de Ven, 1999). Product innovation has been studied in a wide variety of contexts, including in relation to social change, economic development, and organisation theories. Before examining the theme in more depth, it is useful to look at a number of definitions of innovation that have been proposed:

- the introduction of a new idea, method or device (Merriam Webster on-line)

- change that creates a new dimension of performance (Peter Drucker, 1992)

- the process of developing and implementing a new idea (Van de Ven et al., 1999)

- an invention that has been put into practice and commercial use (Schumpeter, 1912; Schön, 1967)

Schumpeter (1912, 1942) also makes a clear distinction between 'invention' (new theory or a new idea) and 'innovation' (new idea in practice or a new theory in commercial use). Recent research on the socioeconomic construction and dynamics of science and technology (Nelson, 1962; Latour, 1979, 1987, 1996; Bijker, 1987, 1995; MacKenzie, 1996; MacKenzie and Wajcman, 1999) has shown that scientific and technological invention and innovation overlap and it is extremely difficult to specify the point at which a new technology, product or process begins to be put into use given that products' aspects change throughout their evolving process of use (Rogers, 1995). Invention and innovation are best understood as features of a single, continuous and intertwined process rather than as stages in a linear progression. In this thesis, 'product innovation' refers generally to the process of bringing either a 'new product' or a 'new idea regarding an existing product' into use.

2.3.1 Technological Innovation as a Prototype for Social Progress

To explain how certain metaphors have informed the notion of 'progress' and how the idea of 'progress' has been concerned with the fulfilment of social and economic ends by the means of science and later technological innovation, a brief historical account of the ideology of progress is important. An excellent account of this story exists in the works of Bury (1932) and Nisbet (1994).

The idea of progress has diverse origins in classical Greek and Christian schools of thought as well as in the Enlightenment of the eighteenth century. The eighteenth century was remarkable for the belief in the *possibility* of systematic progress and a concern with the achievement of a 'social order'. The eighteenth century contained two influential, yet contrasting, images of progress: 'dichotomous' and 'evolutionary process' (Badham, 1986).

In the dichotomous model, progress was identified with 'one great transition from societies based on ignorance, prejudice and vested interest to societies organised with the use of human reason and in conformity with the natural laws of human conduct' (Badham 1986: 16). Inspired by the Newtonian view of nature as a mechanical system, advocates of the dichotomous model believed that the new natural form of organisation based on reason inevitably and automatically seeks equilibrium, reaches a stable state and finally takes the shape of a 'balanced mechanism' (Badham, 1986; Gellner, 1972).

In contrast to this dichotomous view, the second model was identified as a 'gradual and evolutionary process in which societies were regarded as passing through a number of passages, stages, a series of transition from one relatively stable type of society to another'. The natural state of mankind, therefore, was regarded as one of change and development from infancy to maturity rather than as the attainment of a once-and-for-all self-stabilising mechanism of natural laws. In this model, progress is imagined as an organic process instead of a mechanistic procedure (Badham, 1986; Gellner, 1972).

Drawing on both a dichotomous and an evolutionary process, developed by Comte, Saint-Simon, and Spencer, theorists contributed to a view of social progress as a continuous and unitary process passing through a *fixed series of stages*. They emphasised, or re-emphasised the key role of the advancement of scientific and technological knowledge and the passage of humankind through different stages of human subsistence – agriculture, pasturage, economy and commerce (Meek, 1973). The emerging industrial society was understood as an organic social form in which humankind steadily marched toward its *ideal finality* by means of science and technology.

Before the eighteenth century, theorists began to see industry, understood as scientific and technological advancement, as the unquestioned means of social progress and to conceive what we may now call 'social-technological change'. However, before the Enlightenment of the eighteenth century two earlier strands had laid the foundation for technological change with their view of reason and its role in progress. For Bacon and other thinkers who believe in an empiricist conception of reason, science acted as means of comprehending the natural order. For Descartes and other rationalists, reason was seen as embodying a form of self-analysis capable of providing rational insights into principles of human conduct. The latter school of thought also took the form of an appeal to natural order. For both schools of thought, it was natural science and its application stood as the foundations of modern industrial society (Badham, 1986).

Bacon, among others, believed that the idea of human progress would be achieved only by harnessing the natural sciences to create technique and technology for the achievement of human ends (Burtt, 1939: 123).

Bacon, in fact, viewed science and technology as means to control the order of nature (Burtt, 1939: 56). Science and technology, from this point of view, can establish the reign of humankind over nature and in this way humanity can achieve happiness and make steady progress toward knowledge and power. Bury (1932) in his classic inquiry into the origin of

the idea of progress, argues that Bacon's quest for the happiness and progress of humankind was directly concerned with new scientific inventions (Bury, 1932: 38).

Now one may ask, is there any goal or finality for this kind of human progress? Bacon (2000: 27) himself asserts, 'It is not possible to run a course aright when the goal itself has not been rightly placed. Now the true and lawful goal of the sciences is none other than this: that human life be endowed with new discoveries and powers'. However, as Bury documents, Bacon was only one among many whose concern with human happiness resulted in faith in the 'light of natural reason' as a basis for new faith in humanity's progress. Eighteenth century philosophers also developed their ideas in terms of 'progress to an ideal' in the light of science and later technological invention (Voltaire quoted in Bury, 1932: 99):

> [We] may believe, Voltaire says, that reason and industry will always progress more and more; that the useful arts will be improved.

Carl Becker (1932) addresses the same point – progress toward a kind of ideal – when he argues about the convergence between dichotomous and evolutionary processes in the writings of Comte, Saint-Simon and Spencer (Becker, 1932: 66)

> Rationally considered the idea of progress is always at war with premises. It rests upon the notion of universe in perpetual motion; yet the idea of progress has always carried the implication of finality, for it seems to be meaningless unless there is movement towards some fundamental objectives. The formal theories of progress are vitiated by this radical inconsistency.

While Bacon and Descartes laid the foundation of 'scientific and technological change' it was not until the eighteenth century that people began to expound the idea of social progress, through science and technology, to a kind of Promised Land. It was in the nineteenth century that more expressions in terms of technological progress and the growing power of humanity over nature were publicly recognised; as a landmark in the great Exhibition of London in 1851 (Bury, 1932: 218).

However, while Bacon, Saint-Simon, Comte, Spencer and Voltaire laid the foundation for social progress by the light of reason (later exemplified as science and technology) a fuller account needs to include the religious roots of the values of technological innovation (Tawney, 1926; Becker, 1932). Carl Becker , for example, in his *Heavenly City of the 18th Century Philosophers* (1932), points out that the eighteenth century belief in 'progress', regarded as a theory for the salvation of humanity and humanity's future, was in fact a transposition of the Christian belief against which these same-century philosophers thought they were rebelling. Faith in the light of natural reason was a version of faith in the divine light in humankind and consequently 'progress' was a version of salvation interpreted in terms of society and social order rather than the individual soul. David Noble (1997) reiterates a more recent interpretation of this idea in his examination of Christian theology regarding the divinity of humankind and the effect of this on the technological innovation.

2.4 Metaphors of Innovation

The idea that human progress would be achieved by harnessing natural science to create technology had another profound effect. It was in the light of such doctrines that the professions in the late nineteenth and early twentieth century achieved dramatic success in reliably adjusting scientific means to human ends (Bernstein, 1979; Schön, 1983). Engineering design and methods as well as scientific analysis became the prototypes of the successful use of technical rationality and positivism. Perhaps it was in this spirit that, in the early decades of the twentieth century the ideas of 'scientific management' and 'instrumental rationalism' – (the development of law-like methods, rule-following models, and tool-like metaphors for the good of social ends) – came into good currency (McLuhan, 1964).

In fact, the set of ideas and objectives underlying the notion that there is merit in social progress in the light of science and technology generated a trend in using tool-like metaphors as guides to modelling and programming human's practical activities. First, 'progress' that rests on faith in reason, according to which there is a kind of Promised Land or ideal state

which humanity is colonising and marching toward. Whether progress takes the shape of dichotomous or evolutionary, there is a belief that scientific and technological developments are mechanisms of progress and means of transition to a final ideal one. Under this view of progress, if nations are to seek knowledge, beauty, social order, power, prestige, and happiness they must have methods, models, techniques, instruments, mechanisms, and organic structures for harnessing science and technology to human ends; hence a new trend in the use of tool-like metaphors in a variety of disciplines (economics, sociology, management and organisation studies, psychology, and even nonlinear dynamics) as models for a sustainable social market economy, as mechanisms to direct and describe the phenomenon of technological innovation as the key principle of progress.

2.4.1 Economic Metaphors: An Evolutionary Way of Seeing Innovation

As this image of progress by technological movement became institutionalised and dominant in industrial societies, it also gave an enormous impetus to the science of economics, thanks to the birth of 'economic man', and focused attention on the relation between technological change and economic development. However, technological progress was essentially peripheral to social change until the seventeenth century, and the integrative role that it now plays in industrialised societies has imparted a new dynamism to national economies and social order in a number of important ways.

Economic Equilibrium and 'Firm as Profit-maximiser'

The implications of these new and evolving dynamisms have been a matter of concern for economic thought. From Adam Smith's natural economy and his *The Wealth of Nations* and Karl Marx and his critique of capitalism to classic and neo-classical economics, there has been an endeavour to understand the role of science and technology and their relationships with the development of a 'stable mechanism' for maximising wealth, economic development, and social order. Some authors like Smith have put the role of science and

technology into some coherent kind of economic and political context to approve free market economy while others like Marx have done likewise to disapprove it (Clark, 1985). Regardless of the difference in their attempts, theories converge when these writers inquire about the scientific and technical activities that contribute to modes of production and consequently economic growth. Whether it is Smith's 'men of science', Ricardo's 'corn model', or Marx's 'means of production' what is distinctive is how exploitation of science and technology has become increasingly significant and systematic in developing economic models for capital accumulation since the nineteenth century (Freeman, 1991).

In spite of the merit of their economic theories, one central problem has not been given much consideration – recognition of the increasing instability, disequilibrium, and dynamism brought about by change in technological infrastructures. In other words, previous economic theorists (along with their models) failed to realise that technological changes in a dynamic economic system become both cause and consequence of increasing economic disequilibrium. In their investigations, technology became the icon or symbol of economic growth rather than being treated as a critical destabilising component (Mathias, 1972). However, for writers like Smith and Marx, understanding technology and technological change was an essential plank in their complex chain of reasoning, but not the most important one (Clark, 1985). The central problem of classical and ultimately neo-classical economic theories and models has been their emphasis on reaching *equilibrium* and the attempt to legitimatise this by mathematical formulation (Nelson and Winter, 2002).

Hence, little attention was paid to the process by which technological innovations affect new productions and destabilise an economic system. According to Cooper (1971), once technological change becomes a critical ingredient of an economic system it begins to create 'disproportionalities' and 'discontinuities' within and between industrial sectors. In fact, in an increasingly integrated economic system, systematic and specialised centres of productive activities not only become a possible source of technological change but have to adapt to

changes that arise from others' changes (Clark, 1985). As Murray (1972) and Freeman (1974) demonstrate, twentieth century forms of economic organisation not only have been enmeshed with technological changes but also have produced settings within which technological change becomes an important cause for continuous instability and dynamism.

Economic Disequilibrium and 'Firm as Profit-seeker'

While Smith, Ricardo and Marx laid the foundation of modern economics it was not until the late twentieth century that the only major contribution to the role of technological change in economic growth was rediscovered in the writings of Joseph Schumpeter. Keynes had earlier decried the neo-classical system for its usefulness only in the special case and advocated a general theory for state intervention, but it was in the early part of the 20th century that Schumpeter developed a theory for economic growth by asserting that the *central problem of economics is structural change not equilibrium*. Therefore, for Schumpeter, technological change played an essential role to develop a theory not only for profit but also for economic development.

Schumpeter's *Theory of Economic Development* achieved what none of the other classical economists, Marx and Keynes, were able to do: his model made profit fulfil an economic function. While for Marx and others 'capital accumulation' was the primary force in economic development, for Schumpeter the central autonomous cause for growth was 'entrepreneurial innovation'. Schumpeter, in fact, developed a theory for the surplus of profit which in neo-classical economics was considered a sign of market imperfection. Schumpeter argued that profit has another role, i.e. to lure the entrepreneur to innovate, without which growth and progress would not take place. In addition, 'entrepreneur' in Schumpeter's argument (1912) is regarded as a heroic figure, not necessarily an individual but more a quality – entrepreneurship.

This Schumpeterian energising role for profit is regarded as a complete departure from the neo-classical belief in 'firm as profit-maximiser' to the one as 'firm as profit-seeker', and profit as a cost for survival in the long term.

Innovation as Creative Destruction

One important phrase or metaphor in Schumpeter's argument is that innovation is also creative destruction for it undermines or destabilises older ways of doing business. Schumpeter believed that neo-classical economics cannot deal adequately with 'economy structural change' or 'disequilibrium dynamics' as a consequence of technological advance (Nelson and Winter, 2002). However Schumpeter used the notion of creative destruction to describe the process of change that accompanies radical innovation, later neo-Schumpeterian researchers revealed that destruction could also spring from a combination of incremental sub-innovations (Nelson and Winter, 1982; Tushman and Nadler, 1986). Hence destruction may be incremental or radical and its magnitude remains usually unclear prior to the fact. Small increments of change in product or process may be significant in the aggregate and generate a substantial increase in productivity. This could be even a creative combination of existing techniques, ideas, or methods (Tushman and Nadler, 1986). Aggregates of IT ideas, food engineering techniques, as well as the new machinery associated with the fast-food chain restaurants, for example, have made great difference in economic performance and output per worker during the past decade or so. A modern fast-food restaurant appears to be quite a different yet aggregated set of incremental changes in its functions compared to those of the 1980s and early 1990s. Here a family of sub-innovations which are collectively important have dramatically increased the productivity of a traditional business.

Innovation as Invasion

Destruction may appear in a more abrupt, disruptive and radical form (Christensen, 1999). As Christensen (1999) argues, these disruptive technologies usually come from outside of the sustained patterns in an industry. They may come from a foreign new technology, from small

ventures, or from another industry. When disruptive innovation enters a traditional industry it can spread rapidly in clusters and couple with other sub-innovations, providing new products and processes which aggressively displace the pre-existing patterns and norms. The new technology or the cluster of them fulfils the older functions in a new form. Such disruptive innovations, in fact, invade traditional ways of doing business. The cassette deck as a type of tape recorder for playing or recording audio compact cassettes, for example, was invaded by compact disks (CD). Laserdisc first came as a disruptive technology and later coupled with other sub-innovations such that CD has grown to even encompass other applications, a departure from its origins as a music format. Hence the scope and range of change of creative destruction *often remains uncertain and unforeseen prior to the event*.

In both incremental and radical cases there is the occasion for destruction; radical innovations or a bundle of sub-innovations can move unpredictably from one field to another and create discontinuous change in an industry. Once innovation has been made, Schumpeter says, a group of entrepreneurs emerge and eventually a whole business cycle is set in motion. The equilibrium in the economic system, therefore, is upset by innovation, and movement like a wave of change is set off through the economy. The economic system reaches a new equilibrium and then the whole process starts over again (Schumpeter, 1912).

Innovation as Evolution

As a corollary, economists as well as organisation and management theorists have endeavoured to incorporate in an economic growth model a characterisation of technological change and its effect on two areas – economic and technical change at an industrial and organisational level as well as growth at a national level. They have tried to understand how technologies in different industrial sectors are interrelated and what the implications are when creative destruction takes place in an economic system. They have been concerned with achieving an aggregated level of analysis in which both micro/macroeconomic units as well as the internal efficiency of firms could be determined. Hence, the focus has been on

searching and formulating the nature of the routines and patterns that might develop over time and guide action and policy both in organisations and national economy. Amid the unpredictable, unstable, and uncertain character of creative destruction, neo-Schumpeterians were looking for regularities or certain patterns of technological change in a national economy as well as the norms and routines that could serve to improve product innovation across organisations.

For major neo-Schumpeterian economists like Nelson, Winter, Freeman and Dosi, who have grappled with the process of creative destruction in search of a useful theory or model that can guide national policies, the process is *evolutionary* as well as inherently uncertain. Innovation involves uncertainty in the sense that it is misleading to treat organisations in an economic system as if they exist in a world of perfect knowledge and rational foresight.

Evolution by Natural Selection

These theorists bring 'bounded rationality' into their investigations in the sense that actors are not assumed to have accurate foresight even probabilistically (Nelson and Winter, 2002). They believe that new technological alternatives compete with each other and with prevailing practice, with *ex post* selection determining the winners and losers, usually with considerable *ex ante* uncertainty regarding who the winner will be (Nelson, 1994). More specifically, Nelson and Winter (1977) argue that innovation cannot be patched up by developing the theory in terms of rational expectations, and introducing considerations of risk aversion. They emphasise that a useful theoretical structure must allow for essential diversities, nonlinearity and disequilibrium in innovation alternatives as well as bounded rationality in people. Because of the uncertainties involved, different people, and different organisations, will disagree as to where to spend their resources such as R&D budgets, and when to make their bets. Some will be proved to have been right and some wrong. Explicit recognition of uncertainty, therefore, is important in thinking about policy.

Nelson and Winter (1977: 48), nevertheless, indicate that the economic development due to new technologies takes place in an evolutionary fashion given that innovation involves:

> A continuing disequilibrium. At any time there is coexistence of ideas that will evolve into successful innovations and those that will not, and actual use of misjudged or obsolete technologies along with profitable ones. Over time selection operates on the existing set of technologies, but new ones continually are introduced to upset the movement toward equilibrium

Although Nelson and Winter put emphasis on the role of uncertainty in innovation, they argue that in most modern fields of technology there is a considerable body of technological and market understanding and routines that provide guidance as to what kinds of product innovations are likely to be technologically as well as commercially successful. Hence, the process is far from strictly random. Their studies for finding regularities and directions of innovative activity suggest that in many fields progress in technologies and product innovations tends to proceed from technological patterns and routines previously built, and improving them in various directions. In addition to this, evolution, in Nelson and Winter's argument, allows for trial-and-error cumulative learning in all individuals, organisations and social levels. Clearly, they have adopted the metaphor of Darwinian evolution – that technology in question makes natural selection.

Patterns of Natural Selection: Technological Trajectories, Regimes, and Paradigms

A corollary of this belief has concluded in the 'natural trajectories' which tend to appear, as the progress and improvements proceed along particular directions. This reflects that technologists understand what they are likely to achieve, and entrepreneurs recognise what customers will buy (Rosenberg, 1976; Nelson and Winter, 1977; Nelson, 1994)

However, these accounts are not purely technical. Nelson and Winter also studied *cognitive* aspects of such technical dynamism among social actors (technologists as well as entrepreneurs) and termed such aspects as 'technological regimes' (Nelson and Winter, 1982). Technological regimes or regimes for technological progress in their argument refer to

the cognitive structure within which the group of actors (within and across organisations) work and interact (Nelson, 1981). Later, Dosi (1982) called this cognitive structure a 'technological paradigm'. Dosi too investigated the dynamics and discontinuities of varied technological infrastructures and introduced the term 'technological trajectories' to refer to the direction of progress within a technological paradigm. Principles of technological regimes, trajectories and paradigms which are somewhat analogous to Thomas Kuhn's 'scientific paradigms' (Kuhn, 1970), rest on actors' problem-solving activities and their trade-offs among technological variables. As Dosi notes (1982: 148):

> We shall define a 'technological paradigm' broadly in accordance with the epistemological definition as an 'outlook', as set of procedures, a definition of the 'relevant' problems and of the specific knowledge related to their solution. We shall argue also that each 'technological paradigm' defines its own concept of 'progress' based on its specific technological and economic trade-offs. Then, we will call a 'technological trajectory' the direction of advance within a technological paradigm...thus, a technological trajectory is a cluster of possible technological directions whose outer boundaries are defined by the nature of the paradigm itself...On the other hand, once a path has been selected and established, it shows a momentum of its own...which contributes to define the directions toward which the 'problem solving activity' moves: those are what Nelson and Winter define as natural trajectories of technical progress

In some ways these economists have developed social/psychologically informed metaphors (i.e. 'technological regime' and 'paradigms') to improve neo-classical economic models, suggesting that despite uncertainties and bounded rationalities actors may be expected to behave (in the future) according to the routines developed in the past (Nelson and Winter, 1982: 134). Nevertheless, they argue that there is a challenge to develop a comprehensive metaphor or theoretical structure that is capable of exploiting this aspect of behavioural continuity for the purposes of explanations and prediction; hence most of the actual work has remained to improve these metaphors (Nelson and Winter, 2002).

Dominant Design

For neo-Schumpeterian organisation and management theorists, on the other hand, the unit of analysis is somewhat smaller (i.e. the behaviour of firms across industries). Their discourse revolves around managing through cycles of technological change as well as exploring patterns that can help the survival of the firms in an industry as the new products and innovations come into being (Utterback, 1971; Abernathy and Utterback, 1978). In other words, they were concerned with the relation of technological change in product and process innovation and that of management, competition and industry structure. They attempted to develop management and organisation theories for the effectiveness of firms in originating, developing, and implementing product innovations across industries.

The search for finding regularities and directions of innovative activities resulted for a number of researchers suggesting that the emergence of a 'dominant design' (Suarez and Utterback, 1995: 16) or 'technological guidepost' (Sahal, 1985: 61) in an industry has a strong and significant effect on firms' survival (Suarez and Utterback, 1993). A dominant design is defined by Suarez and Utterback (1995: 16):

> specific path along a design hierarchy, which establishes primacy among competing design paths. The dominant design which emerges in each industry is not necessarily the result solely of technical potentials, but also of timing, collateral assets, and other circumstances. In several cases dominant designs have or have not yet occurred. Once a degree of standardisation is accepted, major innovations in an industry seem less and less likely to occur short of a wave of new entrants and increasing competition...for a design to be dominant or a standard requires a degree of experimentation and a rich collaboration between producers and users, not simply a synthesis of parts and functions in a product.

Utterback and Abernathy (1978) also argue that when a new technology comes into being, there is considerable uncertainty regarding which one of a variety of possible designs will succeed. Different ones are tried out by different players. After a period of time and competition one or a few of these designs come to dominate the others. As a consequence,

the attention and resources of organisations over time become concentrated on a few dominant designs at the expense of the alternatives (Nelson, 1994).

S-curves

Some neo-Schumpeterian scholars strongly concurred with their predecessors and depicted technological progress as a series of *S-curves*, argued that technological change follows a cyclical pattern (Foster, 1986; Anderson and Tushman, 2004). They suggested that any industry evolves through a succession of technology cycles in which each cycle begins with a technological discontinuity. As is shown in figure 2.1 below technology B inaugurates discontinuity in A as its performance declines in time, hence a new technology cycle comes into being.
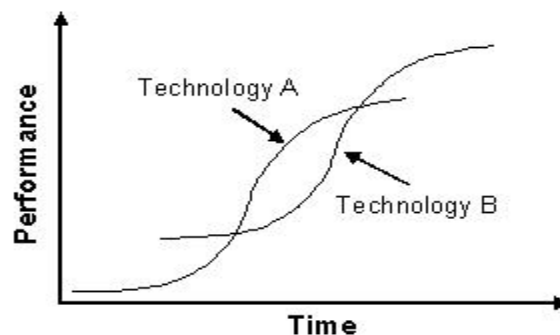
Fig 2.1 S-curve

A number of critics argue that the domain of dominant design, in spite of the insights it provides, is narrow and limited (Pavitt, 1987). They consider that these studies make little attempt to integrate major political and sociological treatments of technological innovation into their investigations. These critics emphasise that the evolution of technology is a very complex process that might involve many social groups such as universities, governments, courts and legislatures rather than merely private firms or a collaboration of users and producers (Nelson, 1994). They also point out that a dominant design can only be settled after broad orientations have become clear, and not during the time that the new technology is still in flux (Nelson, 1994).

A Comment on the Economic Metaphors: Self-fulfilling Prophecy

Whether it is natural paradigms or trajectories or dominant designs that affect and shape the dynamics of technological innovations, both groups come to be decried by theorists of social the construction of technology for being technological determinist (MacKenzie, 1996). More specifically, natural trajectories and paradigms have been questioned by sociologists of technology such as MacKenzie (1996: 55) who argue:

> Natural is a dangerously ambiguous term here. One meaning of 'natural' is what is taken to follow as a matter of course – what people unselfconsciously set out to do, without external prompting…natural has quite another meaning connoting what is produced by, or according to nature…the notion of technological trajectory can thus very easily be taken to mean that once *technological change* is initially set on a given path its development is then determined by technical forces…if Nelson and Winter incline to the first meaning of natural (what people unselfconsciously set out to do) Giovani Dosi can sometimes be read as embracing the second.

MacKenzie believes that economic relations are never wholly self-sustaining and self-explaining. They exist only to the extent that certain kinds of relations between people exist. Instead, technological trajectory can be seen as one instance of the pervasive phenomenon of the self-fulfilling prophecy. Self-fulfilling prophecy points to the fact that persistent patterns of technological change are persistent in part because technologists, and others, *believe* they will be persistent (Mackenzie, 1996).

2.4.2 Managerial Metaphors: A Rational Way of Seeing Innovation

As a heritage of social progress in the light of scientific reason there is a rational view of product innovation which draws on scientific reasoning, fostering a type of proceduralised innovation process guided mostly by applied science-based methods and measures. According to the rational view, innovation thrives by scientific deduction and applied

science. Corporate growth can be achieved by harnessing technology to create new products for the fulfilment of organisational ends (Bernstein, 1979; Schön, 1983) and proper application of scientific theories and techniques leads to corporate creativity (Hainer, 1967). Questions such as 'how to make innovation work' or 'how to drive new products into market' are dealt with economic/business/applied approaches, benchmarking technical proposals and the best means to be selected by the use of science-based tools within a well-defined strategy.

Phrases in common use such as 'innovation as a stage-gate system' and 'a roadmap for creativity', for example, suggest a rational approach in corporate creativity and innovation. Under these views, innovation is usually pictured as a straightforward and sequential process that should lend itself to procedural control, methodological analysis, and scientific management. According to this view, innovation in organisations should thrive by establishing a close fit between the following prescriptions, heuristics, or metaphors and the firm's pattern of action:

The process of product innovation should be orderly

There are a number of accounts outlining stages and controls using systematic project management methodologies and models (Cooper, 1990; PMBOK, 2004). According to these, the process of product innovation should consist of a series of stages and gates toward a desired goal, each one provides and paves the way for those to come (Cooper et al., 1990, 1993, 1994, 1999; Griffin, 1997; PDMA handbook, 2004). A study of 1000 of the largest corporate R&D spenders, found that almost 80% of all North American companies adopt a stage-gate process as a conceptual and operational road map for driving a new product project from idea to launch (Booz Allen Hamilton, 2007). This report revealed that corporations employ a disciplined stage-gate process combined with regular measurement of everything from time and money spent in product development to the success of new products in the market. A general schematic of the stage-gate system is pictured in figure 2.2 below (Cooper et al., 2002):
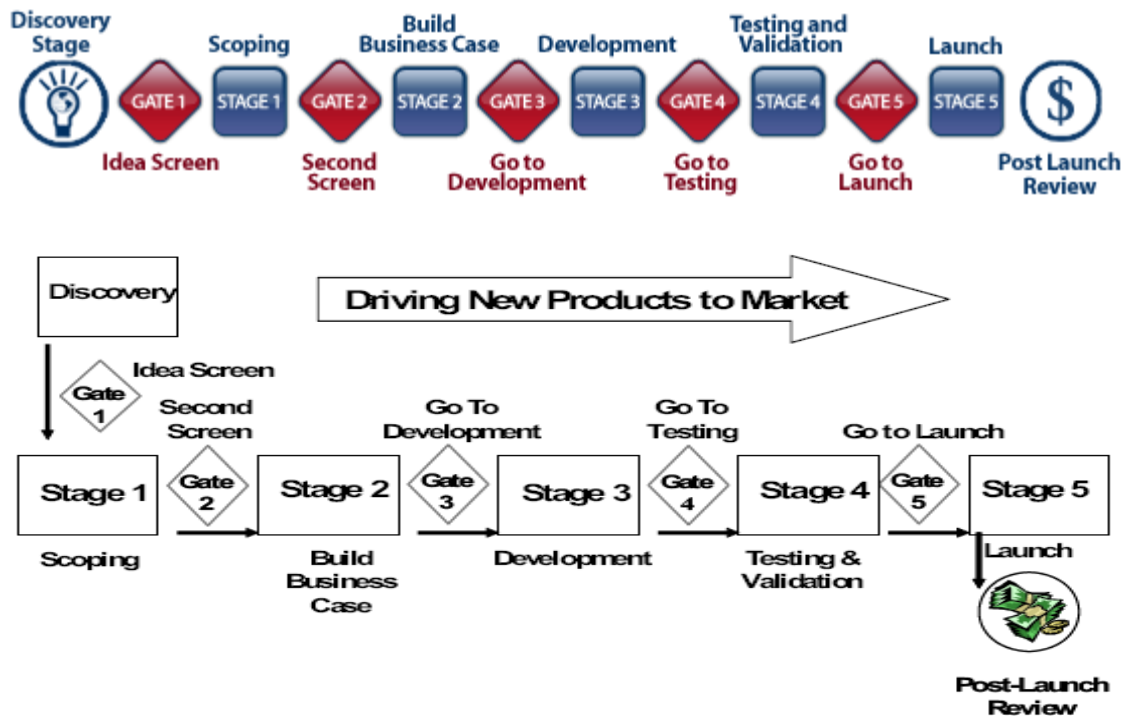
Fig 2.2 The Stage-gate Model of Product Development

In the first stage, i.e. 'scoping', a quick and inexpensive assessment of the technical merits of the project and its market prospects is set forth. Then comes 'building business case' in which a business case is developed and three main components are outlined – product and project definition, project justification, and project plan. Development activities like design manufacturing and operation as well as mapping out marketing strategies and test plans are the components of the third stage. The challenge here is to provide validation of the entire project – the product itself, the production process, customer satisfaction, and the economic outcomes of the project. Therefore, actors ought to choose and swiftly test the most promising idea. Finally there is the route to product commercial launch (see figure 2.3 below):
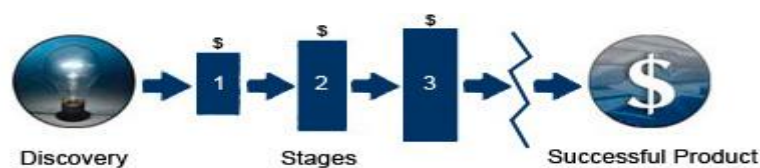
Fig. 2.3 Stages in Stage-gate Model of Product Development

As can be seen, preceding each stage there is a decision point or gate which serves as a go/kill/hold/recycle judgement point in which decisions regarding further 'resource allocation' take place. At gates actors deal with the criteria – usually organised into a scorecard and including both financial as well as qualitative measures – by which projects should be prioritised. Each gate mediates between deliverables and outputs (see figure 2.4 below). Deliverables as the outcome of the preceding stage are judged against the criteria and their contribution to the next stage is analysed according to law-like measures.

Fig 2.4 Criteria in stage-gate model

The process of product innovation should be funnel-like

Rational theorists of innovation presume actors mostly to be 'economic men' to whom rationality is attributed (Williamson 1981: 553). Hence their models tacitly accept 'human choice' as a rational analytic process usually immune from anxiety, emotion, irrationality, fantasy and foolishness (Mahdi, 2003). Simon (1957) questioned this assumption by arguing that unlike rational 'economic man' (which only exist in economic text-books), 'organisation man' is actually endowed with less powerful analytical ability, so rationality can only ever be bounded because of limited information and a limited cognitive ability to process it. Simon coined the term 'bounded rationality' to indicate that people are only partly rational and partly emotional/irrational. Simon acknowledged that boundedly rational agents experience limits in formulating and solving complex problems and in processing, receiving, storing, retrieving, and transmitting information (Williamson, 1981).

As a result, complex phenomena such as product innovation in which practitioners deal with too many competing ideas, contradictory views, and conflicting values inevitably fall prey to

information overload, thereby reducing uncertainty and narrowing down too many choices, and on occasion aggregating compatible ones (Williamson, 1981). Actors simplify to make situations manageable. But there are many opportunities and threats and a great degree of ambiguity at the outset over which portfolio of product ideas will be most successful in targeting fleeting customers, hence the situation initially appears as an ill-defined, treacherous, and tricky dilemma (Van de Ven et al., 1999: 96).

The problem of 'too much yet competing information' experienced by organisations apparently has created its own antidote. In answer to these rationally bounded conditions, some theorists (Hayes et al., 1988: 295) tacitly accept the need for the imposition of a lucid frame for thinking and doing, though they have not made this rationale explicit. The frame or the 'normative template' (Argyris and Schön, 1973: 28) they put on the practice of innovation draws on the idea of 'funnelling' as a generative metaphor which at least in one of its senses points to firms' obligatory selective inattention to an abundance of conflicting ideas and complex information that helps actors tame and tackle complexity in a purposive manner (Mahdi, 2003; Herrmann, 2004; Hobday, 2005).

Armed with the funnelling metaphor (as a model for intervention), organisations are then able to allocate resources to a specific sequence of projects over time, make their choices less complicated to handle through ongoing narrowing, and on occasion merging the set of alternatives available to them. Each successive stage through the funnel, as it narrows down, should also serve the commercial as well as technical feasibility of all stages (Wheelwright and Clark, 1992; Dunphy et al., 1996; Smith and Reinertsen, 1997; Cooper, 1999; Schilling, 2005). Funnelling in fact builds on the view of the sequential stage-gate system so that the combination of the two ideas has become very influential and widely accepted in management of innovation literature (Cooper, 1990; Tidd et al., 2006, Bessant and Tidd, 2007).

According to the typical schema provided below (see figure 2.5), an abundance of new ideas needs to be filtered and refined through a series of screening criteria. The aim is to take the most promising ideas from concept, then channel and converge them gradually into a more concrete reality. The work starts with a broad range of information as the input, so the mouth of the funnel needs to be widened as long as actors can handle the complexity in analysing information. Based on its core competencies the firm should expand its knowledge and information base so as to take in or generate creative ideas. The firm members looks internally and externally to make an interpretation and evaluation within their business context by referring to rational tools and measures (preferably quantitative). New ideas should align with existing technical/human resources, core capabilities, and lines of business so as to ensure a steady flow of good projects within a given time. However there is a hidden challenge here as Tidd and Bessant (2007: 406-7) note:

> The challenge at the start of the innovation process is to search and scan, picking up relevant trigger signals. Most of the time there is an effective filter which channels search activities into spaces where they are likely to be fruitful in helping the organisation with its innovation agenda based on 'doing what we do but better'. Under these conditions the search routines described above work well and the space within which it is carried out – the 'selection environment' – is clearly defined...in the case of discontinuous innovation these signals may lie in unexpected places, often far from the areas covered by the 'normal' radar screen of the organisation...organisations can put in place more open-ended search routines and these include picking up and amplifying weak signals, using multiple and alternative perspectives, using technology antennae (for example via the Internet) to pick up early warning signals.

In order to enhance the merits of the final products, ideas need to be merged and form the nucleus of a dedicated combination within the bounds of available resources (Clark and Wheelwright, 1995). Selected ideas, therefore, need to be directed into new aggregated development projects – designing a portfolio of projects that will also enhance the

corporation's strategic ability to carry out future projects. Managers should ensure that the portfolio deliver on the projected formally-approved objectives
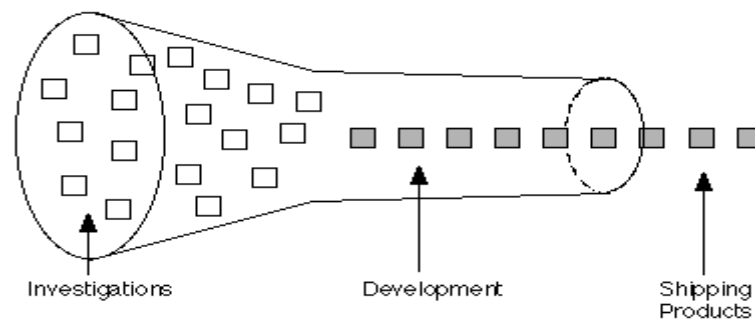
Fig. 2.5. The Development Funnel: In the converging funnel ideas are identified and the most promising ones selected for resource funding. The small blank squares are ideas for investigation while the darkened squares are ideas that are merged and led for development.

The notion of funnel is treated as the bounds of the available resource and pre-determined direction from which actors should not deviate. Any deviation from corporation's pre-defined strategy is continuously screened, controlled and protected from irrelevant ideas, so bad ideas should be recognised as early as possible lest they tie up resources and stop the development from moving to the next stage (Hayes et al., 1988: 339; Forrestal, 2008: 46). Another concern is to keep the funnel neck narrowing progressively while transforming promising ideas into reality at a reasonable speed. So the performance of the project should be under continuous monitoring, instrumental measurement, and systematic coordination. Finally, as the output new products should be tested and launched at a flow rate in proportion to the size and resources of the corporation as well as the outer environment. Firms should follow a path of continuous analysis, learning from feedbacks, and improving the capabilities that determine and drive their innovation performance (Wheelwright and Clark, 1992).

Product innovation is a goal-oriented process

There are organisation theorists who argue that 'ends justify and determine the means' (Hughes, 1965: 13), that what happens early on to clearly set the objectives before development work gets underway has a powerful impact on both development performance

and the outcome. They argue that what goes at the early stages lays the foundation for what follows (Gluck and Foster, 1975; Hayes et al., 1988), so having a coherent strategic direction, consistent choices, and compatible predetermined goals before a project begins gives firms greater leverage over unforseen issues and undesired outcomes (Hayes et al., 1988: 279). At the outset, there should be unambiguous and clearly defined ends on which managers and practitioners can base their account and determine the means for achieving those ends (Tidd et al., 2006). Put differently, goals and the approach for achieving them should be made explicit and deliberated prior to taking action to assure their effectiveness in the face of otherwise overwhelming chaos. There are many planning methods such as product portfolio planning, quality function deployment, aggregate project planning, design for manufacturing, critical path analysis, to name a few, that the rational camp constantly develops (Wheelwright and Clark, 1992). Before the project is begun, such a rational process of planning is done in terms of the likely end products definition and objectives that are supposed to emerge from the process (Ulrich and Eppinger, 2004). Therefore, such practitioners need to prepare rational procedures that formulate and evaluate such clearly-defined ends. Success and winning at new products consists in grounding these ideal ends within available means, i.e. within the boundaries of time, budget, quality, etc (Smith and Reinertsen, 1997). More often the most promising ends emerge from resolving a common riddle – to seek the right product portfolio with the right quality at the right time and at the right cost for the right customer that determine firms' success, survival and sustainability in a competitive environment (Crawford, 1993).

Perceived as such, practitioners are involved in defining a potentially aggregate goal from combination and recombination of many essentially value-conflicting variables including budget, product performance, engineering design parameters, customer behaviour and the proper time for the market launch (Wheelwright and Clark, 1992; Krishnan, 1997; Smith and Reinertsen, 1997). The outcome of these tradeoffs, if arranged well, may or may not reward the host corporation – similar to gambling.

One notion here is that practitioners ought to plausibly anticipate and list all relevant variables that will function in a project. They must identify in advance what technical specialities are necessary to meet certain needs in a systematic approach toward an ideal finality. Therefore, pre-determined goals determine what type of technology and people should amalgamate before a corporation launches a new project. As a result, there is little consideration for the likely addition of new problematic situations (e.g. the uncertainties spelled out in neo-Schumpeterian and three-dimensional views) that can alter or threaten the corporation's pre-defined ends.

Innovation is a gamble of winning or losing, game of success or failure.

Phrases such as 'innovate or die', 'innovation as the attacker's advantage' and 'winning is everything in innovation so there is no second prize for the runner up' suggest the view that organisations must engage in product innovation simply in order to keep up with sustainable growth, survival, and competitive advantage (Clark, 1994; Tushman and Anderson, 2004; Davila et al., 2005). As the White Queen says in *Alice through the Looking Glass*: 'now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!' The explicit use of such analogies and metaphors in innovation literature, in fact has converted the process of product innovation into a game in which there will be winners and losers. Perhaps war as a metaphor could clarify this viewpoint. As Cooper (2001, 2005) and Von Braun (1997) spell out, there is a new product war in which firms have to engage for their survival and continuity. Their battlefield and territory is the marketplace and market share, their weapons and counter-weapons are product and process innovations, their troops are the workforce, their generals are senior executives, their plans are strategies and counter-strategies and their enemies are the competitors. Such 'innovation wars' implicitly draw on Carl von Clausewitz's (1976) dictum: war is continuation of politics by other means. According to more extreme version of this view, new product war is continuation of management and corporate policies to humble

the competitors by other means which is outperforming in a different way, as a different kind of war. In Hamel's words (2000: 14):

> 'Whatever you shoot is dead for a while before it starts to stink…radical, nonlinear innovation is the only way to escape the ruthless hypercompetition that has been hammering down margins in industry after industry. Nonlinear innovation requires a company to escape the shackles of precedent and imagine entirely novel solutions to customer needs'

This point is part of a more general view of innovation, as providing alternatives to allow firms to place their bets that usually top management has participated (Schön, 1967; Nelson, 1993). As Schön states (1967: 62):

> The game, in turn, is played with other corporations in a context that is often more warlike than gamelike. The corporate society sets itself toward other corporations much as a nation sets itself toward other nations.

Here one can notice an overlooked yet crucial dynamism in rational accounts – the high degree of anxiety due to personal culpability in the event of failure. While uncertainty and indeterminacy are inherent in the process of innovation, rational accounts presume the possibility of a systematic listing of all relevant variables that will operate in a project prior to the fact, and the failure to do so as is seen as a matter of personal guilt. Whether such systematic denials be a symbol of unwillingness to know (Beck, 1999), mythological justifications, selective perception and reasoning (Beck, 1999), white-boxing and normalising abnormality (Wynne, 1988), there is a tacit and undiscussable terror of failure which undermines people's confidence and competence and may stand in the way of innovation. Moreover, this war imagery suggests that the notion of 'practitioner as heroic entrepreneur' could be at odds with the notion of 'practitioner as military mechanic and rational agent'.

The management of product innovation entails the management of risks and rewards

Many in the rational camp have become increasingly sensitive to the phenomena of risk and uncertainty, and it has become commonplace for them to speak of managing risk and

uncertainty inherent in innovation (Cooper, 1993). They point to the likelihood of undesired events – or the absence of desired events – that usually disrupt or threaten the order, stability, or performance of the means or ends corporations wish to maintain or achieve. As Hayes et al. (1988: 280) argues:

> Developing a new generation of products or processes is somewhat like taking a journey into the wilderness. One cannot hope to eliminate all uncertainty or develop contingency plans for all potential difficulties before the journey begins, but a little thoughtful preparation can be quite useful. One should clarify in one's mind the purposes of the journey, lay out one or two alternative courses, make sure one's equipment is in order, secure whatever maps are available, study the expected terrain, and develop some plans (and some skills) for dealing with the things that are mostly likely to go wrong. Such preparations reduce the journey's risk and increase the likelihood of a timely and successful conclusion.

As a consequence of this, writers have appeared to feel the requirement for the development of a method by which firms can carefully devise a list detailing a future chain of happenings prior to the fact, and proactively mitigate the undesired and manage the selected risks (Smith and Merritt, 2003). Their inquiry about managing and conquering future dilemmas has resulted in developing a number of analytic tools and predictive models (borrowed from other professional and academic disciplines such as insurance and financial engineering) among which risk management is the most influential and important. Phrases such as 'managing the risk of innovation projects' and 'controlling uncertainty in product development' (PMBOK, 2004) suggest that managers and practitioners should and could predict and quantify the likely uncertainties, hence the dangers and benefits of new product projects can be weighed against the likely risks and rewards of alternative scenarios. It is assumed that by selecting those scenarios whose risks and rewards justify their expected cost, time, and quality, practitioners can capture and formulate realities about future uncertainties and keep them within acceptable bounds.

Implicit here is the notion that much of the future uncertainties can be visualised through crystal ball gazing in which risks and rewards about the clear ends are identified, mapped out,

and monitored. Much of the uncertainty in the process of innovation can be foreseen and translated into a set of measurable risks made to systematic control, prior to the fact. Expressed as such, product innovation becomes a process of stage-gate decision-making associated with a process of risk-reduction and reward-maximisation. In order to reduce the risks and maximise the rewards of innovation, justification of development effort must always precede the effort itself. Consequently, project proposals in which tradeoffs undergo extensive review are always required. A great deal of time and effort is spent at each crucial gate in order to visualise the future stage, persuade 'resource controllers', and legitimise the merits of a project or keep it in motion. During this alchemy process, risks are constantly reviewed, ranked and resolved in a more or less rigid and rational hierarchy. Recognition and evaluation of risks and rewards is determined in an orderly fashion usually by reference to established rigorous measures and mechanisms (preferably quantitative-based). Risk management from this view, then, is a systematic activity together with a series of methodical means, each of which lends itself to effective future visualisation and prediction, quantification, and justification.

For example, 'house of quality' or 'quality function deployment' (QFD) and 'design for manufacturing' (DFM), are standard methods quantifying engineering details, customers' needs, and technical correlations so as to combine them into a coherent and interrelated whole. Although not explicitly termed methods for minimising risk and maximising rewards, these approaches function as a framework for translating and transforming future uncertainty into a calculable piece of reality, into a set of manageable variables that will determine the success factors in an engineering design (Schneiderman, 1998).

Another variant of risk management centres on the depiction of the senior manager's attention during the process of innovation (Peters and Austin, 1985, Wheelwright and Clark, 1992). However, this depiction (see figure 2.6) conveys that innovation is too important to be left to practitioners, it has another viewpoint as well. According to this view, there exists a direct link between the ability to influence risky outcomes and the pattern of senior

management involvement, meaning that to be worried about risks in product innovation only when problems become apparent late in the process leaves the corporation 'behind the power curve and in a reactive mode' (Wheelwright and Clark, 1992: 32-33). Implicit in the actual management activity profile is the notion that an increasing level of risk becomes active from the very start of the innovation, has the potential to get out of control such that managerial intervention is required more often at the later stages of the process. As the following pattern suggests, the increasing level of risk can be offset and controlled by proactive attention in the earlier stages. This point is taken as a vital fact by many authors (Gluck and Foster, 1975: 141; Smith and Reinertsen, 1997: 223), who explicitly advocate rational and technical methods of risk management once the merits of the ideas are to be investigated.
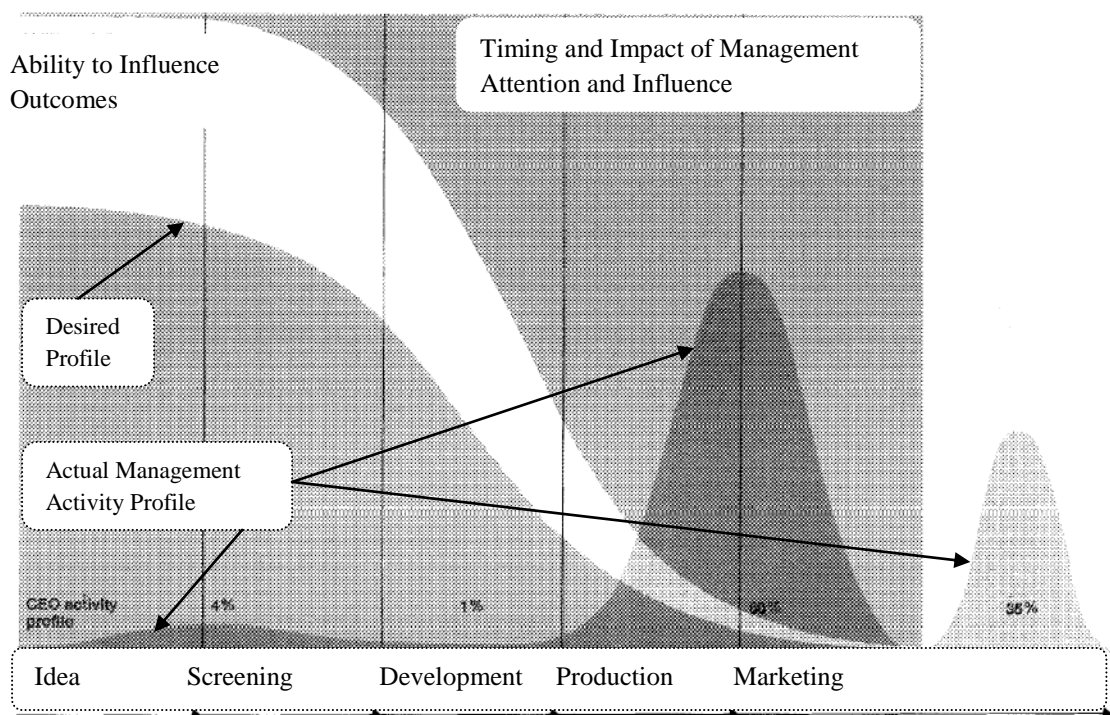
Fig 2.6 Timing and Impact of Management Attention and its Influence

Uncertainty in innovation should be translated into a language of calculation

It should be noted that the aforementioned methods for dealing with ambiguities and complexities under the name of managing risks and rewards, may change the nature of the product development game from a 'language of innovation' to a 'language of calculation'.

This language fosters the establishment of a common and convincing framework for finding measurable tradeoffs between value conflicts. By seeking and justifying a close and clear fit between the risk management plan (means) and the dominant factors that determine future threats to and opportunities for an innovation project (ends), organisations attempt to cultivate a selected market niche. In this way the language of calculation functions as a ritual of verification (Power, 1999), rhetoric and myth, or a recipe to decipher and discipline the future.

However, in David Boyle's (2001) view, when we try to quantify what cannot actually be measured, the non-quantitative character of the phenomena – such as unknown unknowns, anxiety, surprises, intuition, insights, faith, emotion, and the like – may be drowned in a sea of calculations. We foster an exaggerated trust in the language of calculable risks (Power, 1999) in spite of a silence about what precisely the calculation of 'mathematical risk' is able to do.

Nonetheless the ideology of calculation has a number of advantages to recommend it. It fits with the rational justification of a corporation's progress, growth and success, and provides a relatively legitimate basis for less conflictual decision-making through the development stages, gates, and funnels. It also stands out as a concrete accomplishment or as a testimony of things (Latour, 1993) that can be identified in no ambiguous terms, as ambiguity is transformed into measurable alternatives and objectives, hence a valid base for concerted action and decision making is justified (Vlaar et al., 2007). Moreover, the rationality of calculation helps an organisation to reassure and persuade its members by offering them an illusion of foresight or an illusion of manageability (King and Anderson, 2002) as well as a psychological ritual to reduce anxiety (Hainer, 1967; Williamson, 1981; Wynne, 1982).

A comment on the managerial metaphors

Although the diagrams and discussions presented above may portray a sequence of development in a somewhat rational and orderly fashion, Cooper (1999) admits that:

Today's new product project teams and leaders seem to fall into the same traps that their predecessors did back in the 1970s; moreover, there is little evidence that success rates or research and development (R&D) productivity have increased very much.

Crawford (1977, 1987) and Mahajan et al. (2000) support Cooper's view, arguing that due to the enormous complexity of many interrelated factors product innovation failure rates are relatively high. Failure rates have variously been reported in the range of 40% to 90% and of the 1000 companies in the study of Booz Allen Hamilton (of which 80% adopt the stage-gate funnel) fewer than 10% produced significantly better performance per R&D dollar over a sustained period compared with others in their industry (Booz Allen Hamilton, 2007).

It is also important to note that the observation of the limitations and restrictions of rational approaches, not only to innovation but also to management and organisation studies in general, is far from new. From Dewey (1938) and Popper (1968) to Simon (1958), Ackoff (1979), March (1978), and Schön (1982), classical rational models of decision making, innovation, management, and tackling uncertainty in organisations have long been replaced by more realistic views of 'real-time and artistic practice' in the format of 'reflective inquiry', 'piecemeal social engineering', 'bounded rationality', 'formulating the messes', 'purposive muddling through', and 'reflective conversation with the situation'.

In view of what has been discussed, one may ask the question: why, then, do so many prescriptive accounts deliberately promote rational and technocratic models of product innovation? Why as seen in Arthur D. Little's (2004) recent studies, is the sequential state-gate system adopted by more than 80% of all North American companies? What lies beneath this overriding commitment to technical rationality?

Reflection on these questions reveals more than one answer. One key to these questions directs us to the legacy of Frederick Taylor as the founding father of scientific management. Ironically he was one of the most criticised of all organisation theorists but his legacy has proved to be one of the most influential (Morgan, 2006: 23). It is reminiscent of Marx's

definition of ideology: that they do not know it but they are doing it (Zizek, 1989). Taylor as a mechanical engineer viewed organisation as a kind of 'mechanical machine' that should be designed and treated as a mechanical or technical problem. His rational scientific approach called for detailed monitoring and measurement of tasks and people in order to comply with the requirements of organisational mechanisms because he believed that efficiency and productivity is in the interests of all. His total preoccupation with control, goal setting, repetition, prediction, measurement, standardisation and other engineering and machine metaphors has influenced many rational/technocratic analyses of innovation. Phrases such as, 'innovation as stage-gate system', 'making innovation-process work', 'flow rate of new products', 'channelling a steady stream of good projects', 'driving new products to the market' and 'concurrent engineering in new products' are a few markers in the proliferation of engineering metaphors for innovation.

Although these kinds of mechanical metaphors, technocratic and analytical demonstrations are decried for paying little attention to the complexity of social and human factors in shaping new technology (Morgan, 2006: 30) and standing at times in the way of innovation (Van de Ven, 1999), it should be noted that they are convenient and very attractive. Morgan (1997: 209) declares that such rhetoric helps managers use the rational myths as a legitimate umbrella under which they pursue their political agendas, provide stimulus and purpose for action, and justify vested interests. Seen from this view, the rational model also acts as a myth to overcome the contradictions inherent in corporate innovation, and to justify paradoxes that would otherwise make innovation peculiar and far from possible. Armed with the 'myth of rationality', management presents inherently uncertain innovation subjected to rational control (MacKenzie, 1996) and provides actors with a basis for 'reciprocal simplification' of interactions between resource controllers and practitioners in the face of the complexity of the process (Callon and Law, 1992). This offers a powerful tool for persuasion, politics and at times disguise and deception (Aronson, 1973; Van de Ven et al.,

1999) that enables players to simplify the project complexities, to exhort each other in the exchange of deliverables, and to mobilise resources.

In a similar vein, Williamson (1989) argues that organisational proposals regarding the future are always incomplete in the sense that it is impossible in the real world to anticipate all contingencies. People have to focus their attention on post-project opportunism as a fundamental concern in the design of structures for transactions. This opens the door for bounded rationality, specifically in terms of 'plausible farsightedness' instead of 'hyper-rationality' (Williamson, 1981: 174). Likewise, Brunsson (2006) argues that maintaining the dream of rationality in fact prevent us from relinquishing our Platonic notion of ideals. Rational models are 'mechanisms of hope' that protect and encourage 'homeostatic and conservative systems' to continue and to avoid looking absurd in spite of the experiences that befall to them and contradict their sense of stability and security as well as their pre-defined ideals.

Although there is always uncertainty in innovation projects, some uncertainty may be amenable to the rational approach. So there is another sense in which belief in the rational view can be justified. There is utility in rational and technocratic models when organisations deal with marginal, incremental or derivative innovation projects. As Wheelwright and Clark (1993: 92) argue, the more radical the innovation the more its development process involves significant change in product and process technology, hence it is more uncertain, less rational and less predictable; and more creativity, insight and initiative are required at the outset (Wheelwright and Clark, 1993: 97). The more incremental the project the more its process tends to be sequential, straightforward, unambiguous, orderly and predictable. Wheelwright and Clark (1993: 95) state that incremental innovation ranges from cost-reduction in versions of existing products to add-ons or enhancements to an existing production process. Such projects usually require substantially fewer resources than more radical innovations and their acceptance requires a smaller amount of change both in product and process technology.

2.4.3 Sociological Metaphors: A Sociopolitical/critical Way of Seeing Innovation

Despite the attractiveness of the managerial and economic approaches, it conflicts, in many ways, with actual experiences documented by scholars (Bijker, 1995; Bucciarelli, 1994; MacKenzie, 1996). So in contrast to them, we find a variety of theoretical schools examining the complex, socially constructed, and political nature of innovation beyond the confines of technocratic and economic prescriptions for organisations.

These schools of thought come from a variety of intellectual perspectives: from the social construction of science and technology (MacKenzie and Wajceman, 1999); symbolic interactionist (Garrety and Badham, 2000), interpretivist (Lester and Piore, 2004) or sense-making views of organisations (Weick, 2000); and schools of critical management ranging from Foucauldian (Clegg et al., 2006) and discourse theory (Morgan and Sturdy, 2000), through feminist theory (Wajcman, 1991) to more traditionally Marxist views of organisation and innovation (Badham, 2005). These studies, despite their different viewpoints, include antecedent debates and new developments which characterise three generations of social process approaches in the study of technological change and innovation over the last three decades (Mcloughlin and Badham, 2005).

One-dimensional and two-dimensional views

The first generation remains restricted to a one-dimensional view, investigating the effect of the technical on the social or vice versa. The second generation takes a more complex two-dimensional standpoint, recognising the mutual influence of the technical and the social. (McLoughlin, and Badham, 2005b)

In spite of their sophistication and value, the first and second generations continue to operate within either a one, or two-dimensional frame. They focus their investigation on the interaction between spheres of the technical and the social (Badham, 2005). These views in their strongest form either see technology shaping society or society shaping technology

while softer approaches seek to identify mutual shaping effects or the interaction of the technical and the social. But as Ogburn (1964) observes, technological innovation is the merging of 'people' and the 'tools' in which intertwined identities of 'material' and 'non-material' cultures are employed. One and two dimensional views, therefore, have been questioned by some sociologists of science and technology who argue that these theories overlook the false divide between social and technical.

For critics such as Latour (1993), the splitting of the 'technical' from the 'social', 'man' from 'machine', 'mind' from 'matter', 'nature' from 'society', or 'subject' from 'object' has always been a mythical divide, never real. Latour believes that the rationalisation of the world has always been a myth, but has provided the ability for the right hand to ignore what the left hand is doing, obscuring the ways in which technical was intertwined with social, political, and cultural identities. The questioning of the 'modernist' assumption of a clear divide between 'human' and 'non-human' or 'people' and 'things' has raised fundamental questions about how we understand technology and society.

The three-dimensional view: socio-technical ensemble, actor-network, actant, cyborgs

This argument is based on the proposition that every 'social system mirrors a technological plenum' (Schön, 1970 p: 37), and there is never an absence of technology, but always a particular technology around which the social system has been developed. Hence new technologies do not enter a vacuum but may undermine prevailing technological and social settings, and generate change and at times disruption in the older social-technical structures.

In *Of Bicycles, Bakelites, and Bulbs*, Bijker (1995: 105-106) reanalyses the development of the Bakelite as the first commercial plastic. By describing improvements in both plastic and in celluloid chemistry, Bijker shows how problem-solving strategies in celluloid chemistry came as a variant solution to the problems of natural plastics. One problem with celluloid in the view of certain actors was its flammability. The relevant social group of celluloid chemists were aiming to modify the production process of celluloid to harness its

flammability and to develop new applications. Widespread concern about the safety of celluloid had posed a problem for practically all relevant social groups in the search for a substitute for celluloid. Many chemists were patenting substitutes for celluloid and similar plastic substances, however, none of them had succeeded in developing a successful enterprise around the new materials. By 1900 many celluloid chemists knew that the materials we now call phenol-formaldehyde plastics, as a substitute for celluloid, had flexible and interesting properties. In the course of this search and research, interest had shifted to the reaction of phenol with formaldehyde but all efforts stayed within the tradition of celluloid research and production.

Bijker draws our attention to the diverse tradition, activities and interactions of the celluloid engineers. He calls this diversity of interactions a 'technological frame'. Technological frame, refers to the point that existing practice does guide future practices, though without necessarily rational determination. In the words of Bijker (1995: 123):

> A technological frame structures the interactions among the actors of a relevant social group. Thus it is not an individual characteristic, nor a characteristic of systems or institutions; technological frames are located between actors, not in actors or above actors. A technological frame is built up when interaction around an artifcat begins. Existing practice does guide future practice, though without logical determination...a technological frame comprises all elements that influence the interactions within relevant social groups and leads to the attribution of meanings to technical artefact – and thus to constituting technology...[it is] probably most similar to Constant's (1980) tradition of practice [however] technological frames are not purely cognitive but they also comprise social and material elements.

Bijker then draws attention to the invention of Bakelite by Baekeland, an active amateur photographer and professor of chemistry who first followed a path similar to celluloid engineers and chemists but was able to break away from their tradition or technological frame, finding new ways which were actually old for him (Bijker, 1995: 126, 141). Bijker describes how Baekeland's social involvement with other technological frames (i.e. photo-chemistry and electrochemical engineering) and his interest in full-scale production implied a

specific way of approaching problems and modifying goals and strategies. While the main objectives of the celluloid chemists according to their technological frame, were to focus on and modify the solvent, to control the flammability of celluloid or find a substitute, those of photo-chemists and electrochemists were to defeat corrosion, to analyse all reaction variables in detail, and to scale up the volume of production output. Successive membership of or inclusion in different technological frames contributed to Baekeland's socialisation into the relevant cultures or social groups. This 'degree of inclusion of an actor in a technological frame', which indicates to what extent the actor's interactions are structured, informs and shapes actors' thought, technical tricks and tacit knowledge. When Baekeland became interested in the research on phenol-formaldehyde, his work was primarily structured by the technological frames of photo-chemists and electrochemists, in which focus on the solvents was not the main concern. Rather, a detailed analysis of all variables in a reaction was one of the key objectives. But during patent litigation and literature review Baekeland gradually became more involved in the celluloid technological frame and this difference in relation to his actual work led to the invention of the first commercial plastic, i.e. Bakelite.

The effect of the background Bijker sketches here is to make the invention of Bakelite appear as one in a long series of inventions, sub-inventions and related innovations, a capping invention that took up and unexpectedly united threads of theory, technique, technicians, social groups and technological frames which had long been present. Bringing new products and new technology into being is in fact building on previous processes or technical patterns such as 'technological configurations', 'scientific and technological paradigms' (Constant, 1980; Kuhn, 1970) or 'technological frames' (Bijker, 1995), which are made of other sub-innovations. Technological innovation takes time and requires different 'tacit knowledge' (Polanyi, 1966), 'traditions of practice' (Constant, 1980) and degrees of inclusion in varied technological frames. Each stage in the innovation process is itself a complex socio-technical process, a series of discontinuous and unexpected developments in which unforseen actors, together with their novel techniques and old traditions, play the interconnecting role.

Technological innovation is, then, a process, made of many sub-innovations, each of which responds to the problems and objectives of earlier attempts and which creates new goals, ambiguities, paradigms, and strategies.

The story of Bakelite is similar, in many respects, to the stories of other less or more celebrated inventions and product innovations. From the construction of the safety bicycle (Bijker, 1987) to the origins of the turbojet (Constant, 1980), all reflect the fact that every invention and innovation unexpectedly clings to the threads of the work preceding it. A product or a new technology undergoes unforeseen and nonlinear change in a series of improvements and sub-innovations. It is by no means clear how the past or present 'technological frames', 'traditions', or 'paradigms' contain the solution to technical and social problems that are yet to emerge. Therefore, it is a process riven by uncertainty in the sense that it is far from possible to fully predict which actor or social group with what kind of technological frame will enmesh so as to change, disrupt or contribute to the evolution of an artefact.

Many studies of technology in a similar vein to Bijker's analysis (Law and Callon 1992; MacKenzie, 1993; Van de Ven et al., 1999; Wotherspoon, 2001) have documented that progress does not usually move in a linear fashion from a clearly defined idea to inventing or innovating new technologies. Rather, the process takes desired and undesired rises and falls as well as controllable and uncontrollable twists and turns (Schön, 1967), not only once but many times. If the relevant retrace their earlier stages when re-examining the development process, the post-mortem plot may resemble 'fireworks' (Schroeder et al., 1989; Van de Ven et al., 1999: 14). The post-mortem plot looks like a jagged path in which there is a frequent shift of direction and leaps of decision in response to new problematic situations (Van de Ven, 1999; Wotherspoon, 2000). Moreover, the requirements needed to solve a technical problem are usually interlinked and it is usually difficult to have an effect on one part of the product without facing technical setbacks or sociopolitical side-effects (e.g. people's resistance and defensiveness).

In Dewey's sense (1938), in innovation *means and ends mutually determine each other*, and an end in one technological frame may become the means in another. So social groups cannot fully visualise the ends until they have specified the technical means by which these ends are to be reached. Both means and ends change continually in response to both intended moves and unexpected effects.

Consequently, in more recent years the terms of debate have shifted from 'social shaping of technology' or 'technological determinism' to the character of 'socio-technical construction', 'socio-technical configurations', 'actor-networks' (Law et al., 1992; Latour, 2005), or 'socio-technical ensemble' (Bijker, 1995) – exploring a third dimension.

Bijker indicates that each time 'machine' or the artefact is written as shorthand for sociotechnical ensemble we should, in principle, be able to sketch the (socially) constructed character of that machine'. Each time social institution is written as shorthand for sociotechnical ensemble, we should be able to spell out the technical relations that go into stabilising that institution. The term 'socio-technical' is therefore not merely as a combination of social and technical factors, rather it is a new reality with dynamics and characteristics made up of complex interwoven 'human' and 'nonhuman' elements, a unique concept and a new unit of analysis.

Rephrased, in sociotechnical both social and technological systems interlock (Law et al., 1992; Latour 1993; Bijker, 1995) in construction of technology and formation of the society. The technical is determined by the social and the social is not determined by the technical. Seen from this view, self, social classes, organisational life, occupational groups, firms, professions and products are all bound together as much by the technical as by the social. Change in one provokes change in the other and has its impact on the theories of product innovation, theories of organisation and theories of social and technological change.

The key issue here is an attempt to break down commonsense ideas about the existence of separate spheres of the 'technical' and the 'social'. As Latour (1993) emphasises, we cannot

think of 'human' and 'non-human' in isolation from one another, hence modernist rhetoric of separation between 'technical' and 'social', 'subject' and 'objects' has never been realised in practice. We simply cannot understand who we are without taking our tools into account. Likewise our tools are so imbued with our knowledge and sociocultural interests that they cannot make much sense without us. Accordingly, some scholars argue that 'objects' too have agency (Garrety and Badham, 2004; Latour, 2005) and that the actual content of technology is itself a socio-technical construct.

Thus, from this perspective we all are 'actants', 'collectives', 'cyborgs' (Haraway, 1991), part 'human'/part non-human'. Anything that can act or to which activity is granted by others must be taken into account, whether it is a 'text', a 'traffic light' or a 'trade union'. Law (1992), Callon (1980), and Latour (2005) use the term 'actor-network theory' in order to argue that any collective that can act or provoke 'action' or 'change' has agency. An 'actor' or 'actant' according to actor-network theory (ANT) can be anything if it could be the source of an action. Perhaps the core message can be found in Latour's comment: thanks to the hammer I become literally another man, a man who has become 'other'. This is why the theme of the tool as an 'extension of the organ' makes such little sense. Those who believe that tools are simple utensils have never held a hammer in their hand, have never allowed themselves to recognise the flux of possibilities that they are suddenly able to envisage (Latour, 2002). Product innovation, form this view, can be seen as the unpredictable flux of possibilities that spring from the interaction of heterogeneous actors in an evolving web of relationships.

Principles of the three-dimensional approach

Given the novelty of such a three-dimensional view it may be useful to suggest some guidelines. The following principles are a recent attempt (Badham, 2005) to provide general guidance to help translate the complexity of a three-dimensional view into more specific insights for innovation studies.

Principle 1: Technology as socio-technology

Any 'technique' or 'technology' that comes into an organisation or a network of organisations should be recognised as 'socio-technology', 'socio-technical ensemble', 'collective', or actant.

Principle 2: Organisation as socio-technical configuration

Organisation should be understood as a 'socio-technical configurations' that mobilises complex networks of the human and the nonhuman within and between its loose boundaries. This involves a focus on loosely integrated 'socio-technical arrangements' of the goals and means of the organisations, a focus that should be prior to analysis of the disruptiveness of new technologies. This means not examining the interaction as one between 'external' technique and the 'internal' social relationships of the organisation but seeing the organisational dynamics in socio-technical terms.

Principle 3: Innovation as socio-technical practice

The third principle argues that 'innovation' is a practice that occurs through the interaction of the aforementioned socio-technologies. This interactive process is partially captured by Fleck (1999) as 'innofusion' and Leonrad-Barton (1995) as 'mutual adaptation'. But the difference here involves a focus on the interaction between two fundamentally socio-technical, rather than 'technical' and 'social' entities.

A schema of social process approaches

One-dimensional structural impact and social agency approaches as schematically pictured in figure 2.7 below provide clear-cut approaches to examining the impact of the technical on the social and vice versa.
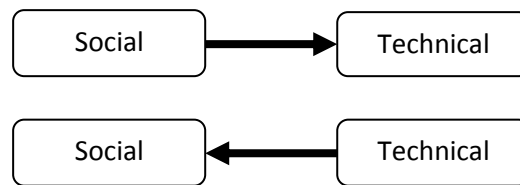
Figure 2.7 One-dimensional View of Technology

Two-dimensional views as outlined in figure 2.8 below examine mutual interaction between the social and the technical.
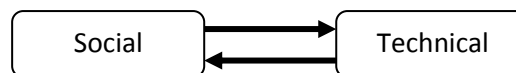
Figure 2.8 Two-dimensional Views of Technology

Three-dimensional views as illustrated in figure 2.9 below recognise the interwoven and emergent nature of socio-technical entities – technology, organisation and innovation.
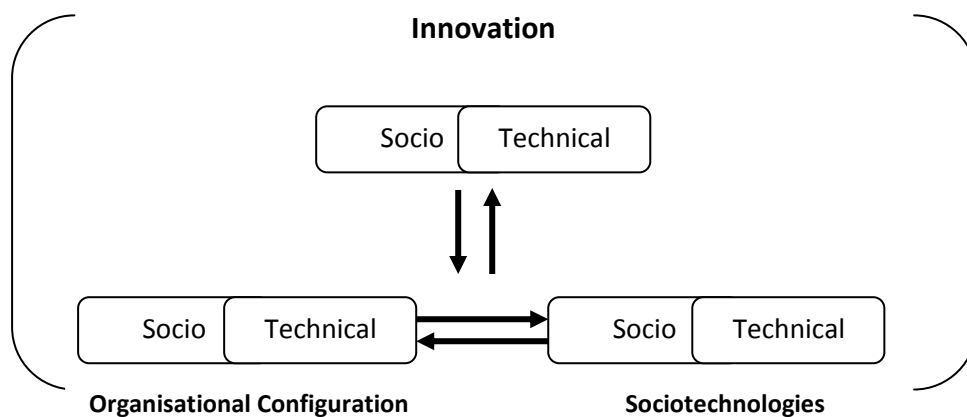
Figure 2.9 Three-dimensional Views of Technology

Innovation as fireworks

In contrast to managerial/economic metaphors, one can find metaphors such as 'navigating uncharted waters', 'fireworks', 'spaghetti', 'rolling a snowball', and 'emergent networks' (of

those some appear non-actionable) that provide more radical, reflective, realistic, skeptical and critical lenses with which to scrutinise and study the dynamics of innovation (Argyris, 1999). In the metaphor of uncharted waters, for example, Van de Ven et al. (1999) use a river rafting trip analogy to craft a critical model for the process of corporate innovation – a three stage model including initiation, development, and termination/implementation. By this metaphor Van de Ven and others depict a jagged path that shows how practitioners helplessly flow through three indeterminate stages involving 'divergence' and 'convergence' and full of surprises, serendipities, and setbacks.

However, if we are to integrate these views and encapsulate them in a *single* metaphor perhaps no notion other than 'innovation as messy fireworks' could simply convey their critical message. More recently some scholars (Van de Ven et al., 1999; Schroeder et al., 2000; Scudder et al., 2000) heralded the recognition of this unruly trajectory thanks to nonlinear dynamics.

Van de Ven and others formulated such a model to represent the jagged process of innovation, generating a seemingly unmanageable exemplar in which the unit of analysis is project/product. The authors take such a critical standpoint to note the discontinuity in actors' behaviour, complexity in the information environment, the vicious circle of impression management, the shifting goals, and the ambiguities surrounding a development project.

Some limitations of Socio-political/Managerial/Economic metaphors: A comment on the conservative function of metaphor

If one looks closely, the metaphors of trajectory, stage-gate, paradigm, dominant design and the like, more or less as variants of funnelling, act as a tool which is a way of giving policy designers, management, or practitioners a distance by which they assume as if they can rationally manipulate their ideas, assumptions, values, and theories, thus preserving their sense of control over the problematic situation.

Consider the funnel itself. When actors 'expand the size and mouth of the funnel using technology antennae, scan and pick up signals covered by the radar screen of the organisation, filter and screen the incoming proposals and channel the promising ones, progressively narrow the neck of the funnel and concretise the seemingly good concepts, ensure that a constant stream of appropriate projects flows down, drive the outgoing new products into the market at a speed that fits with the strategic thrust of the business they in fact characterise the language of innovation based on the use of tools. The actor regards tool-using in terms of progressive adaptation of means to ends, assumes a distance between the tool-user and the problem, and treats certain aspects of the tool (which are carried over) as unchanging, as answers to well-defined problems.

This unchanging character of the tool, however, suggests a generative lens that can be used to construe and frame problematic situations but the analogy remains premature if actors treat the process of product development in the manner of a familiar pattern (i.e. funnelling) without questioning and changing the pattern. Hence, this set of funnel-type metaphors while generative is also uncritically dealing with innovation in an unchanging technocratic configuration, which suggests actors use a restrictive technical or tool-like frame to impose upon the situation prematurely, to frame the process as an instrumental problem, and to discard the phenomena that may not fit this frame.

We speak of the innovation funnel (Schilling, 2005), innovation as a stage-gate system (Cooper, 1990), driving new product to the market (Cooper, 1994), quantum leaps in the development speed (Clark and Wheelwright, 1993), engineering the materials of innovation problems (Carter and Baker, 1992), making innovation work (Davila et al., 2005), innovation at the speed of information (Eppinger, 2001), channelling the ideas, concretising the product concept (Clark and Wheelwright, 1993), etc. We *literally* apply funnelling and channelling tools and techniques in order to concretise seemingly good ideas more rapidly and to drive new products to the market. There is an implicit technocratic quest in all of these ideas to control the problematic situations inherent in innovation using familiar tools and techniques

without questioning or changing the confines of the tools – to convert the messy, distressing nature of innovation into a mechanistic, disciplined process, perhaps into a family of mass production.

A psychological comment on managerial/economic/sociopolitical metaphors

It can be also argued that sociopolitical/economic/managerial approaches converge in the sense that they all highlight the cognitive behaviour of actors and remain unaware of people's emotional reactions, resistance to change, dogmatism, and defensive routines (Argyris, 1999). Their discourse centres on the belief systems, cognitive behaviours and structures, hence issues such as 'emotional attachment to pre-existing technology' (Morrison, 1966) and 'fear of innovation' (Schön, 1967) remain unexplored and undiscussed. All of these metaphors can be decried for taking little account of the human side in the establishment of a technological pattern or frame – the intolerable disruption that 'change' *per se* brings for any kind of social structure.

Dynamic conservatism

Established institutions normally respond to the threat of change with what Schön (1971) terms 'dynamic conservatism' – they fight to remain the same once they have adapted to their present course. Schön, among others, argues that any social system as a whole has the property of resistance to change – the tacit tendency of subjects and objects to move steadily along their present course. Schön continues that any social system is in a state of dynamic conservatism which strives for survival, stability, security, and continuity. The life of a social system is a constant response to threats either to its survival or its identity. It has prevailing technologies and related theories around which it is organically built. And innovation in any aspect of the system threatens the system as a whole. Innovation undercuts the sense of self on which the commitment on a particular technology depends (Schön, 1967). Dynamic conservatism, therefore, implies an intrinsic resistance to change while also confronting

major systematic transformations. Ironically, once a pattern of relationships around a particular technology is established, relevant social systems which have been exposed to change *naturally* advocate that pattern, and maintain their boundaries from dangerous other which otherwise would be a threat to their stability and survival.

More than seventy years ago, Cannon (1939), too, identified this tacit tendency by demonstrating that social systems strive to remain in a state of 'homeostasis.' Homeostasis as the property of living systems is a natural self-reinforcing tendency toward regulating its internal environment so as to maintain a stable, secure, and constant condition. Cannon (1939 p: 299) remarks:

> In an open system, such as our bodies represent, compounded of unstable material and subjected continually to disturbing condition, constancy is itself evidence that agencies are acting, or ready to act, to maintain this constancy...if a state remains steady it does so because any tendency toward change is automatically met by increased effectiveness of the factors which resist change.

Hence, corporate society as a homeostatic structure has its prevailing social and technical configurations around which it is organically and emotionally built. In proportion to the significance of innovation, creative destruction threatens conservative social systems.

It is worth spelling out some of these distinctions with regard to the *degree of change* required (Schön, 1963). The innovations that invade an organisation and carry very little similarity to organisation's old configuration are those which require greatest change in pre-existing settings. Drawing on Maslow, Schön (1971) argues that an organic system is similar to a ring (see figure 2.10). The more central the change, the more it is intimately tied to other values; hence the less organisations are willing to let their pre-existing arrangements go. In contrast, the more peripheral the change, the less intimately it is tied to other values, the less crucial to the whole system, and the less dogmatically and conservatively protected (Schön, 1971: 95).
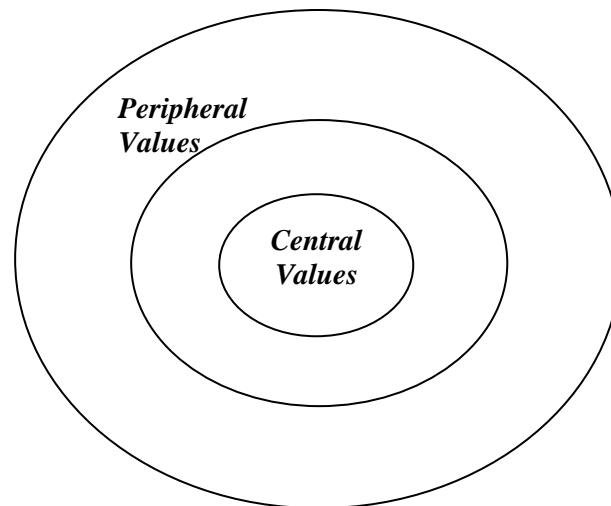
Fig. 2.10 Maslow Ring

The more significant innovations are those whose acceptance would require radical transformation of pre-existing central values and arrangements, increasing the extent of resistance to change as well as the *degree of anxiety* experienced within the invaded organisation.

These characteristics are by no means limited to corporations. Similar features exist in broader patterns of technological change. Therefore, any of the suggested patterns of technology (i.e. paradigms, regimes, trajectories and dominant designs) could get much of their momentum from a camouflaged *defensiveness and resistance to another major change*. This 'resistance to change' is so powerful that some historians such as Morrison (1966) read it as an emotional involvement with a pre-existing pattern of technology. In order to enable people to accept technical change without losing their sense of continuity, Morison argues that another 'emotional adaptation' is required. Perhaps that is why Christensen (1999) tacitly accepts innovation as 'disruptive', as a bad thing that *others* do or as a 'destruction' that must be creatively reconfigured and exploited.

Hence technological frames, trajectories, dominant designs, paradigms, and regimes as metaphors should include both the *cognitive and emotional* attachment of social structures to pre-existing routines, arrangements and norms. These attachments come from natural tendencies, i.e. dynamic conservatism and homeostasis, and so overarching and central are

these tendencies that they distinguish social systems and groupings from one other. Perhaps this emotional dimension is one of the fundamental yet underrated factors in sociological approaches, and technological frames and social systems cannot be viewed as mutually exclusive spheres but as collectives (Latour, 1993), part human/part nonhuman.

A pragmatic comment on the limitation of sociopolitical/critical metaphors

Sociopolitical views tends to be distant from practice in that they are theoretical and non-prescriptive, sceptical of managerial/economic claims, and open to the view that product innovation may be good or bad. Critical approaches to innovation exemplified by the work of Van de Ven et al. (1999), likewise, adopt a sceptical stance toward managerial prescriptions but tend to formulate descriptive yet non-practical models such as the idea of fireworks to recognise, depict, and criticise the typical pattern of corporate action during innovation. However, as Argyris and Schön (1996) observe, such critical accounts continue to be neutral with respect to the definition of 'actionable knowledge' (1999) necessary to reflective practice.

Argyris and Schön (1996: 208-9) have reanalysed one of the Van de Ven et al.'s (1992) accounts, and argue that all innovation projects encounter puzzling phenomena to a greater or lesser degree but the key concern should be to explain how and through what kinds of behavioural worlds and interpersonal inquiry actors in a project generate and deal with such problematic situations. Argyris and Schön document that these authors (i.e. Van de Ven et al.), however rigorous, offer no coherent theory to explain and guide the patterns of behaviour implicit in such a predictable vicious circle (often triggered by the anxiety of being in situations of uncertainty) and which makes the process take such a fatalistic shape. Put differently, the fireworks metaphor implicitly suggests that actors in these accounts do not seek to make public their tacit beliefs, values, doubts, and governing assumptions. They do not invite inquiry to challenge their positions or surface the problems with which they are dealing and employ theories-in-use modelled for games of mystery and mastery. To protect

themselves from the threat or embarrassment associated with situations of ambiguity, actors keep dilemmas, doubts, and deceptions undiscussble. They also make the undiscussablity also undiscussable or mysterious in order to achieve mastery. Since they tacitly accept such defensive routines as inevitable and natural, immune to management and influence, unsurprisingly the most common reaction of actors is a sense of helplessness (Argyris and Schön, 1996: 102). This vicious circle goes on until denials, errors, and setbacks become unavoidably visible, at which point people have to rush from one failure to the next, never really fixing flaws, just stopping them from getting worse, making the development trajectory eventually take the shape of seemingly unmanageable and fatalistic fireworks. These limitations simply suggest that we must seek to construct an integrated view.

2.5 The need for Multifaceted yet Actionable Models

I have tried to build up a picture to show that the way new technology and product innovation impinges on organisations and society as a whole is not only very much a function of technical settings and economic organisation but also of sociopolitical, psychological and pragmatic considerations.

Nevertheless, with a few notable exceptions (Schön, 1982, 1987; 1988; March, 1991; Lester and Piore, 2004), what is largely missed in all of these approaches is the willingness to both bridge the academic chasm so as to make these competing yet complementary perspectives well-recognisable and well-understood, and to effectively integrate the insights from other schools into the innovation literature to contribute to the development of more realistic yet practical models – what Argyris calls 'actionable knowledge' (Argyris, 1999, 2006).

Actionable knowledge or models are 'normative theories', 'normative templates' or 'theories for intervention' that purport to define the activities through which intended consequences can be produced and achieved in such a way that these consequences persist despite unanticipated effects (Argyris, 1999). This is because the unstable and uncertain world of

product innovation is fearful and shifting and actors are usually overwhelmed by too much competing and contradicting ideas and information, which demands interventionists put a 'normative template' or 'actionable model' on an information-overloaded situation. Development of such a template offers a basis for concerted action, yet any model, metaphor or template *must be treated as an intellectual hypothesis* rather than a psychological certainty.

The implications of such considerations inevitably underscore the importance of integrating two influential and overarching yet contrasting models or metaphors – 'convenient yet conservative funnelling' and 'realistic yet restrictive messy-fireworks'. In a sense, linear models of innovation (e.g. Rothwell, 1985), evolutionary models, technological regimes, dominant designs, technological trajectories and paradigms, and stage-gate models can all be considered variants of the 'funnelling metaphor', either as a descriptive theory (evolution, regimes, trajectories, etc) or as prescriptive (stage-gate process, development funnel, etc.).

The thrust of this argument is not to replace one view with another. I believe that managing product innovation needs to engage with all possibilities, as Tidd and Bessant (2009) argue. My aim, therefore, is to combine these viewpoints into a single metaphor because very few have created an all-encompassing metaphor. However, although I believe that advances in the theory and practice of innovation can be enhanced by a willingness to adopt a multifaceted or hybrid view, as something beyond purely managerial, economic, or sociopolitical, as Morgan (1993) argues, there can be no single theory, model, or metaphor that gives an all-purpose view, and there can be no simple 'correct model' for organising the activities in innovation.

2.6 A New Generative Metaphor: The Ribbed Balloon

In the studies (Schön, 1967; Schroeder et al., 1989; Bucciarelli, 1994; Rogers, 1995; Bijker, 1995; Van de Ven et al., 1999; Wotherspoon, 2001) from which the new metaphor is drawn, several innovation projects (in particular R&D and advanced development projects) are examined. Despite projects' uniqueness, I found similarities of which the central theme points

to three main periods or intertwined stages/phases in innovation process. Like these studies, I also adopt a three stage/phase model of product innovation and try to understand how such phases, by and large, take shape, but I seek to go further.

I designate the three stages/phases/passages as: (I) the 'fuzzy front-end' and 'project approval passage point' (II) 'development' and the 'decision to adopt and commercialise passage point' (III) 'implementation and diffusion' and the 'evaluation of success passage point'

I also draw on a few bodies of literature: 'rite of passage', obligatory points of passage', 'uncertainty in technology', 'anxiety, discontinuity, and defensiveness in actors' and the subsequent 'product development pattern'. The first is Arnold van Gennep's 'rite of passage' (2004), which is associated with rituals and activities that mark a transitional change in social development status. The next is Law and Callon's (1992) 'obligatory point of passage', the tendency of an actor or the demands of a development process to present itself as an obligatory check-point for the progress of a project to its next phase. The third is about uncertainty in technology and the role of engineering methods in this regard. In the fourth I talk about some threatening situations during innovation and how they affect actors' behaviour. Finally 'product development pattern' builds on a three-dimensional view of actors, action, and interaction (McLoughlin and Badham, 2005) of which the unit of analysis is a 'socio-technical ensemble' (Bijker, 1995).

Figure 2.11 presents these themes diagrammatically as a 'ribbed balloon'. The metaphor of 'ribbed balloon' provides an illustration of how common themes and phases loosely fit together so as to shape a self-transforming web of moves and relations. While this process may appear to be 'linear' or 'rational', I show that it is not inevitably or rigidly linear as it may involve iterations, reversals, setbacks, discontinuity and deceptions, repetitions, and cycles. The concept of the ribbed balloon has been introduced in order to capture both the flexibility and the 'lumpy' nature of the innovation process, something not fully captured by the funnel metaphor. In addition, there is always the possibility that innovation does not

proceed down the defined 'path' to a 'successful' conclusion. If this is the case, the balloon 'bursts'. While allowing for this possibility of 'bursting', the ribbed balloon metaphor remains valuable for practitioners as it provides the necessary guidance for the practice of forcing innovation towards a desirable outcome. It combines pragmatic directionalism with sociological flexibility in a new attempt at synthesis. There remains an ongoing danger that this will be misunderstood and misrepresented as a modified 'funnel', but this is not inherent in the use of the metaphor.

These phases and passage points, as a result, do not represent a sequence of linear stages and gates through which all the product sub-components must pass in unison (Wotherspoon, 2001). Nor do they represent predictive factors through which the final shape of a product may be foretold. Rather, they represent change in social and technical interaction around product sub-components and its web of moves as means and ends evolve over time. The process is, also, no simple sequence of moving from more to less uncertainty or concreteness. Finally, it is a process driven by sociological, technical, and political dynamics.
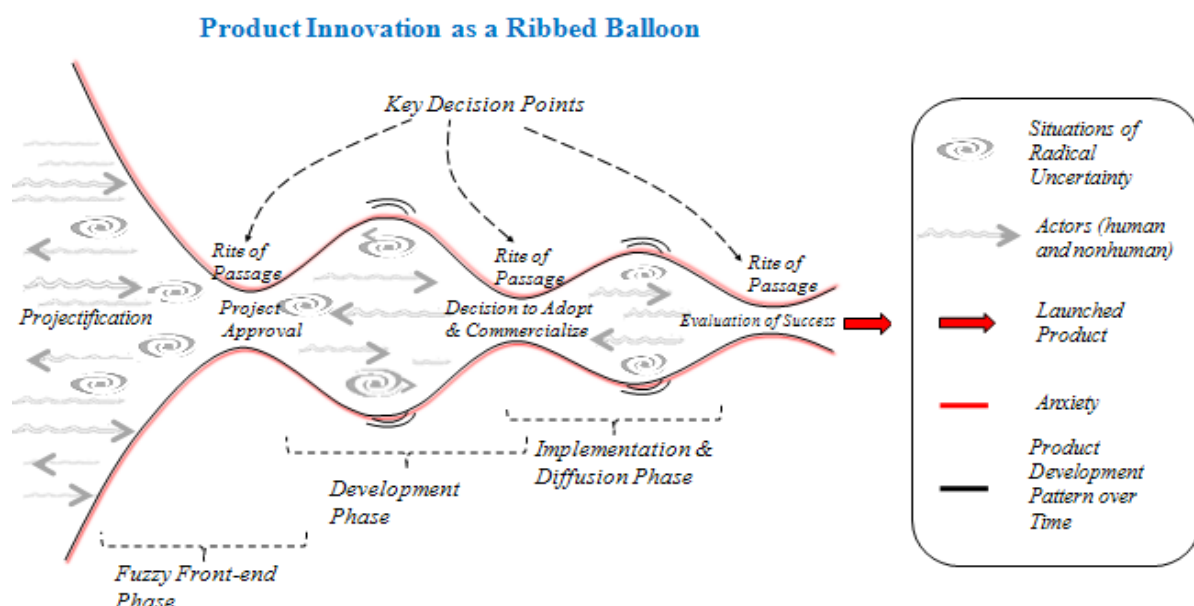
Figure 2.11 Product Innovation as Ribbed Balloon

The purpose of this metaphor is to generate a more creative, sociopolitically informed, yet pragmatic and outcome-focused approach to the practice of innovation. This image is also

grounded in what Schön characterised at various times as the 'artistic' approach to practice. Our purpose here is not to simply argue that the 'ribbed balloon' metaphor is 'correct' but, rather, that it plays a 'generative' and 'projective' role as a creative, elastic metaphor capable of throwing new and important light on how innovation might occur, and can be influenced in practice.

The Rite of Passage (ROP)

For van Gennep (2004), change in social dynamics can be segmented into several mutually dependent stages and distinguished by several 'passing points' or 'rite of passage' between two different yet overlapping stages. Thus, my notion of 'passage point' rests on van Gennep's theory of passage which is based on the 'phasic change' in the social dynamics of product innovation. In passages, as van Gennep treats them metaphorically, social movement through space takes place. Passages involve several irrevocable 'turning points' or 'phases' that are riven with intense energy and anxiety, yet rituals or routines help, as the primary means, to navigate safely (Grimes, 2000). In other words, in passing points we benefit from rituals or 'rites of passage' so as to safely move from one stage to another while coping with stress and anxiety. A rite of passage (ROP), therefore, is a phasic process of transition, making a movement from one social 'space' to another.

In van Gennep's sense, ROPs are the primary means of effecting these transitions. When we speak of ROPs we are implicitly invoking the spatial metaphor, that an individual or social system passes between two adjacent states. The separation between two states might be characterised as geographical or symbolic. In either case, initiation of rites of passage affects a social transformation from an old state to a new one. As Grimes (2000) argues, ROPs depend heavily on 'posed group portraits'. They are a people's way of putting themselves on display and such portraits are never objective or neutral. Rather people subjectively perform these rituals so as to present themselves in the best light; even if these rituals are regarded as

artificial (Grimes, 2000: 98), they are 'mechanisms of hope' necessary for transition (March and Weil, 2005).

Obligatory point of passage (OPP)

The rite of passage seems to be resonant with the actor-network theorists' 'obligatory point of passage' (Latour, 1987; Law and Callon, 1992). The analysis in actor-network theory relies heavily on contextual networks of heterogeneous actors (human and non-human), interaction between people and artefacts. The discussion of 'heterogeneous actors and networks' introduces a number of concepts among which 'passage points' has proven particularly useful in characterising human/non-human interactions when developing a product. Actor-network theorists argue that many interactions between 'actors in a web of relationships', between the product and its relevant network of actors and artefacts, is subject to management authorisation. They see management and managerial norms in product innovation often as an obligatory point of passage (OPP), which exercises power and permits further transactions among subordinate actors in a network. Hence, an obligatory passage point occurs when certain reinforcing rituals and conditions are created within a project that 'actors and artefacts' must perform and/or fulfil for management in order to allow the project to continue (presenting a report, providing scientific evidence, presenting facts, defining and redefining means and ends, etc.). In order to progress through the stages, actors comply with 'obligatory rites' in the form of compulsory checkpoints, similar to van Gennep's ROPs.

I draw on the idea of the 'obligatory point of passage' to support the notion of 'rite of passage'; however, the context of my research differs from that of van Gennep in one main aspect. I study change in product innovation and not general ceremonial change within a society as a whole. In spite of this difference, my way of identifying the passage points appears to be similar to that of van Gennep, specifically, in the sense that ROP refers to social and psychological rituals that help some actors as they move from one stressful obligatory social space to another.

Uncertainty in technology

In the process of product innovation, scientific theories and technical engineering interact so closely that they can be regarded as parts of the same technological frame (Nelson and Rosenberg 1993; Bijker, 1995). These frames help actors create the best change in a vague and poorly understood situation within the available resources (Koen, 2003) because practitioners usually deal with a multifaceted and fuzzy situation in which technical, economic, marketing, social and political issues are all mixed up together. At times they encounter a tricky process and if they look back and replot their progress (i.e. time vs. demand for change due to difficulty) the picture can be seen to be like the diagram shown in figure 2.12, as documented in studies of Van de Ven et al. (1999) and Bucciarelli (1994). In a development project, practitioners initially seek a linear transition from difficulty peak A to peak C. A series of new designs is identified with the aim of creating a product that effectively addresses or solves perceived problems. But the process appears to be treacherous and other problems unexpectedly emerge and new concerns are added. Variables such as new regulations, a powerful player, a disruptive technological frame, a budgeting problem, lack of time, trade-offs and the like usually pop up and create new and unforeseen difficulties such as B and D which are not equally desirable or the same in terms of difficulty as A and C (Koen, 2003; Schön, 1967). B and D might be dead ends from which the practitioner has to retreat. So the process defies a direct line from a known A to a desired C.

Such nonlinear and indeterminate processes that spring from the technical difficulty of a product development process have been the subject of Koen's (2003) research on engineering methods. Koen argues that engineering methods involve different kinds of uncertainty, many of which spring from three main sources i.e. technical uncertainty due to: (i) unexpected technical changes, (ii) available resources, and (iii) questions of doing 'best'.
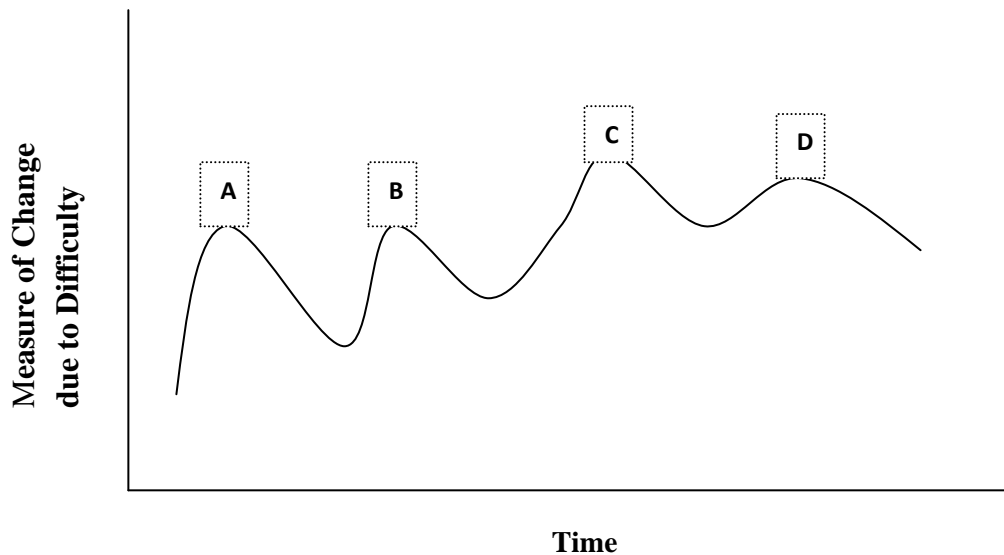
Figure 2.12 Timing and Difficulty in Engineering Design

Unexpected technical changes

According to Koen (2003), when a practitioner is at difficulty point A in the above diagram, s/he does not know where s/he is, or rarely knows exactly where s/he is going, given that no one could claim s/he has perfect state-of-the-art knowledge in the field at the time represented by this point. The next state, B, is also unknown when the practitioner has to start his/her job at the first state. The practitioner is willing to develop a deliberate change from A to C within a desired period of time. During the process suddenly s/he may face a noise, a surprise, a drawback in technical design, and a deviation from the initial plan. Consequently, new unanticipated variables are added to his/her frame of discourse and there is a path dependency to other design sub-components (Van de Ven, 1999: 37). In other words, an unexpected technical change or failure in one part might have implications in other interrelated components, resulting in slipped schedule, budget overrun, or revising frozen designs hitherto developed (Ulrich and Eppinegr, 2004). Therefore attention is drawn from a desired C to another problematic situation or difficulty peak B. At the end of the project when the practitioners look back and re-plot their progress over time in terms of the magnitude of effort and degree of difficulty they may recognise B and D as having added issues unforeseen

in the initial assumptions and formulations which might be interpreted as either serendipity or setback. Sometimes, it is even difficult to distinguish positive issues from the negative ones swiftly when the situation in question is overloaded with too many mixed and conflicting scenarios.

Available and stable resources

The second indeterminate and nonlinear aspect of the process derives from the availability of technical or economic resources for an innovation project. Different problems require different technical solutions according to available resources, hence a practitioner seeks an answer to a problem according to the limits of resources accessible in his/her organisational arrangement. An evaluation of available resources is itself difficult, and as in Van de Ven's et al. (1999) analysis of a cochlear implant program, there is always uncertainty in first determining what/where the right technical specialties are and second whether one's access to resources is reliable and stable. When a project enters into a set of highly interdependent technical interactions it is inevitably transformed into a highly political and unstable case. When any of these transactions fail, the entire set of technical interdependency may collapse in a domino fashion (Van de Ven et al., 1999: 50).

Questions of doing best

The notion of finding the right or the 'best solution' in engineering and technical design is different from the rational notion of right or ideal. A best solution is what is technically defined as an optimum solution which is used less often in non-technical fields. Engineers' notion of 'best' usually points to the process of finding technical solutions based on 'insufficient evidence and information' (Koen, 2003). Optimisation is what Koen (2003) calls a 'compromising process', or a trade-off. Hence, the best possible outcome cannot be achieved but one can hope that the best has been combined according to the demands of the situation. This 'best combined' is subjected to significant discrepancies between our ideal

image of best design as an instrumental process and the reality of design as a historically situated social process that is full of uncertainty and ambiguity (Bucciarelli, 1994: 13).

Rephrased, science, technology and product design are based on 'heuristics' (Koen, 2003) which provides a plausible aid or direction to the solution of a problem but in the final analysis is potentially fallible. A heuristic may guarantee the best solution within limits of time and cost yet it could contradict other problems. Changing the colour of a cosmetic product, for example, may bring other sorts of contradicting variables into play. Heuristics helps to reduce the search time for solving a problem and final solution acceptance depends on the immediate context instead of an absolute standard (Koen, 2003: 29). Hence, setbacks, iterations and cycle are inevitable components of product innovation no matter how carefully and reasonably practitioners devise a project. In the words of Smith (Smith and Reinertsen, 1997):

> People (including most engineers themselves) tend to infer from evidences...and from the fact that engineering is a precise science. In some ways it is. Engineers learn how to calculate precisely how much a cantilever beam will deflect or what the loss will be over a transmission line. *The pitfall in this logic, which is rarely explained, is that there are no ideal cantilevers or transmission lines in the real world*. Engineers [and practitioners] have to start making guesses as to how unideal their solutions actually are. The precise techniques that compromise the bulk of their academic trainings, are ultimately of only limited use in actual design problems. And above all when established techniques fail to apply, the process quickly becomes more empirical than analytical.

Anxiety of uncertainty, defensiveness, and discontinuity in actors' behaviour

Some of the discontinuities and uncertainties in the innovation process spring from more traditionally defined social dimensions such as 'defensiveness, anxiety and fear of failure' and the 'complex web of human/nonhuman relationships' involved in a project.

One area of uncertainty is raised as an object of inquiry in such questions as, 'do we espouse or resist innovation?', and 'can we act according to rational models when there is a high fear of failure?' As Anatole France (1918: 315), puts it: 'of all the ways of defining man, the

worst is the one which makes him out to be a rational animal'. Similarly, human attitudes toward innovations are complicated and contradictory. Salaman and Storey (2005) document this in a comprehensive study by examining 'management theories about the process of innovation' in a large telecommunication equipment manufacturer. Their study points to the nature of barriers to effective development of new products. These include:

- Total consensus that innovation is vital for the company's survival but a lack of true commitment, courage and will

- Conservativeness such as (i) neglecting tomorrow to sustain today, i.e. emphasis on traditional and established routines as well as current structures which are inimical to the kinds of innovation required, and (ii) a preference toward incremental innovations at the expense of radical developments

- Lack of the courage for strategic foresight, a failure of nerve and an unhelpful concern with short term profit making and financial metrics confines

- Dominance of pecking order and scapegoat mechanism in the event of failure

- Unwillingness or inability to take responsibility for confronting obstructions

- Fear of taking risks and dealing with uncertainty and the presence of a myth of risk elimination due to the dominance of science-based metrics and values

- Lip service paid to new ideas instead of a big shift in attitude to new ways of thinking

- The corporations attitudes toward the risk involved in innovation result in a fatal hesitation

The list of barriers can be extended, but what is evident in this study and other similar analyses (Morrison, 1966; Katz et al., 2003) is that, generally speaking, people are ambivalent toward innovation. They tend to espouse innovation in theory but they resist it in practice (Morrison, 1966; Schön, 1982). Surprisingly barriers and resistance to innovation has remained overlooked when compared with the wide recognition of innovation itself (Salaman and Storey, 2005).

In order to recognise the 'people problems' that in this section centres on 'anxiety of uncertainty' and 'fear of failure', let me have a very brief look at corporate life. A corporation's of innovation as in other modern social institutions offers its members identity and a sense of self by providing relatively unambiguous organisational values, visions, policies, and role models (Goffman, 1961: 186) intended to protect members from experiencing embarrassment, fear, and ambiguity while they attempt to construct and play out their own life drama and practice their own identity or project of selfhood (Foucault, 1988). An organisation provides its members a setting for emotional involvement, supports them socio-economically and intellectually but also imposes a code of organisational discipline (Burns and Stalker, 1961), outlining acceptable norms of behaviour deviation from which would result in blame and punishment (Douglas, 1992). A practitioner, for example, might devote him or herself to a very particular line of work with the promise of rewards in money, power, secure livelihood, fame, competence, or even self-esteem (Burns and Stalker, 1961: 21)

Put differently, for organisations as homeostatic organisms there are formal and informal rules, hierarchy of values, blaming mechanisms (Douglas, 1992), identities, culture and sub-cultures (Martin, 1992) by which a dynamically conservative system defines its values and overall identity and seeks to hold itself together from threat, embarrassment, inconsistency, and ambiguity.

Corporate members individually and collectively regulate their internal and external environment so as to maintain their essential integrity without losing their relatively consistent and stable sense of continuity. This is indeed a struggle for security and stability while protecting the organisation's survival and established identity form threat (Schön, 1971). This struggle gets much of its momentum from a natural 'anti-anxiety system' (Sullivan, 1965) whose function is a constant response to external and internal threats to its continued existence – protecting the members form terror, embarrassment, and radical uncertainty. Each member of a corporate community as an 'anti-anxiety homeostatic sub-

system' then strives to omit or to minimise incidents of anxiety and uncertainty so as to maintain the system of self-security while protecting his or her own established sense of self (Sullivan, 1965: 165).

The situations of anxiety are the ones that provoke the most threatening changes – changes that would plunge the members into fearful zones. Of the various threats capable of throwing the corporate community into fear, anxiety, uneasiness, and ambiguity, perhaps none is more effective than innovation and technological change (Schön, 1967, 1971). In the case of external threat to the organisation, for example, people may suddenly be faced with a new disruptive technological paradigm, a new regime of competition, an unforseen decline in the market, new government regulations, or a change in their principal competitor's behaviour. Internal threats may come from members' commitment to the development projects, leakage of sensitive information, political games, defensiveness and resistance to change, poor communication, conflict of values, mistrust and self-sealing, decision making on the basis of inadequate information, games of pecking order and camouflage of culpable but powerful actors in the event of crisis, and terror of failure.

Viewed from a different yet supporting perspective (the psychological adjustment to uncertainty), in more routine and repetitive work people have more space and time to reflect and see things coming, hence they show a smooth sequence of action and adaptation (Knight, 2006: 199). But innovation entails a great deal of surprises, shocks, irregularity, unexpected change, engineering setbacks, iteration, dealing with insufficient information, shifting situations, handling ill-defined problems, and swift decisions which cannot be easily justified (Schön, 1967; Van de Ven et al., 1999). This means that, the level of uncertainty and anxiety imposed on a corporate community in the course of innovation is much higher than during other routinised organisational functions.

Thus, the 'human side of innovation' as Schön (1967) and Katz et al. (2003) suggest, is the source of many non-linear responses, defensive routines, surprising behaviours, and intrigue.

By and large, people tend to develop characteristics that not only reflect their own vested interests but also protect them from stress and insecurity, thereby they tend to defend their own established identity and self-esteem and have a tacit tendency to push uncertainty off onto others, to suppress negative feelings, to bypass embarrassment and threat and to cover up the bypass with white lies (Argyris, 1999). As, McMahon (1967: 6) has argued:

> A new product, particularly if it is radically new, can be a 'hot potato' that no one wants to handle. It may pose financing problems that are embarrassing to defend in the absence of complete conviction of success. It may require new experience and skills that the company does not have. It may threaten the position of some of the vested interests. Or it may appear to require more time, energy, and devotion than is available on a managerial level. If top management reacts to these distressing uncertainties by insisting on more and more reassurance of commercial success from research and marketing, fewer and fewer new product suggestions will be made as time goes on...everybody in the organisation will be hesitant to join wholeheartedly in the launching of a new venture unless he has an inner conviction that top management is fully aware of the risks and is willing to experiment.

For actor-network theorists and those who adhere to the social constructionist of technology, a significant source of discontinuity and uncertainty can be realised by observing the interaction of heterogeneous actors (humans and nonhumans) as they progressively shape an unpredictable and emerging web of relationships. More specifically, the outcome and the shape of such interaction, especially in innovation, is far from possible prior to the event. The sequence and consequence of actions may only be realised in hindsight because actors in these accounts resist full control and identification in advance. Their behaviours and the emerging interactions cannot be modelled or even mediated. There is often a huge gap between actors' initial intention and later realisation. Analysts can only follow the traces left behind and connect the dots to understand what has really happened.

In a similar vein, Van de Ven et al. (1999: 50) argue that changing relationships in innovation create a variety of discontinuities and uncertainties. They explain that as innovation develops over time, more and more players are brought in or depart and their shifting web of exchanging relationships usually cause both desired and undesired consequences. For

example, they point to aborted attempts to establish 'cooperative relationships' with other organisations engaged in an innovation project that only a few years later resulted in 'competitive relationships' (Van de Ven et al., 1999: 50).

Passages through the Ribbed Balloon

In this section, I will show the interaction of the aforementioned issues and elements in the three main stages of the ribbed balloon – the fuzzy front-end, the development stage, and the diffusion and implementation stage.

The fuzzy front-end

The fuzzy front-end phase is the conceptual stage that analyses and determines the structure and strategy of the process and new product ideas. It sets the stage for the design and development of the artefact(s) and determines the scope of involvement for involving actors. It includes the preliminary evaluation for technology analysis, establishing target specifications, analysing competitive products and market identification, concept selection, refinement of specifications, investment and economic analysis, project planning, and how to map out a game plan that identifies specific details of the product and process to guide actors. All of these elements must be orchestrated into a manageable program with momentum. During this phase there is often a lack of clear insight into the nature and importance of the fuzzy front-end and how to proceed. At times, chance plays a role. The profile of the targeted customer is often variable and fuzzy, and consequently the willingness for investment and involvement is not high.

During what is generally understood as 'concept generation' (Bessant and Tidd, 2007), or the 'gestation period' (Van de Ven et al., 1999), actors usually begin to propose and probe ideas without knowing exactly where these propositions might lead or what the final product/s should look like. In many cases, fuzzy front-end do not address a particular need or problem, or the problem became apparent only after the product is in use. 'In the absence of a specified

outcome in the form of a well-defined product, it is often unclear how to break the problem up into a set of separable parts that can be assigned to different specialists. Indeed, it is not even clear what those specialties should be' (Lester and Piore, 2004: 42). There is a high likelihood of misunderstanding and miscommunication and many possibilities for opportunistic behavior, which can easily lead to disguise, deception, mistrust and a complete breakdown of the constructive conversation. So in such cases, practitioners are not really involved with incremental innovation and the uncertainty surrounding the activities cannot be described analytically or in terms of probabilities. The degree of radical innovation and uncertainty may differ between products and organsiations, ranging from radical invention to apparently less ambiguous incremental innovations. In its various forms, however, the process is always political, haphazard, ad hoc, a matter of trial and error, and at times chancy situations. As a result, it is difficult and misleading to technically formulate and anticipate the 'parallel activities', 'multiple coincidental events', 'unintentional confluence of ideas', 'random throw of the dice', 'chance', 'hostility', or 'shocks' that eventually gather enough support and momentum for triggering innovation (Hainer, 1967; Schroeder et al., 1989; Wheelwright and Clark, 1992). Confusion and ambiguity usually reign at the front-end and actors have several incompatible and incomplete ideas, which makes it difficult to predict the nature of the forces that might convince a single champion (Schön, 1963) or potential stakeholders to coalesce some of the promising ideas into a formal project. Yet in a few years or months, depending on the nature of the stimulus, some managers or practitioners who are at the focal points begin to do what they treat as formal steps toward commencing a new project – what Maylor et al. (2006) term projectification. They seem to have achieved a convergence.

In the course of achieving a convergence, actors attempt to familiarise themselves with the problems, and early simplistic ideas about the nature of the product/s may be tried and discarded. To make this transition (i.e. to projectification), actors often initiate a passage point in which a series of early yet crucial decisions must be made. This transition – whether

in the form of meetings, letters, informal discussions, etc – gets serious conversation started and provides the first occasion for probing, reflection, and feedback, which all parties are very likely to find political and complex. This complexity usually reflects a mismatch between a firm and its members' 'theories-in-use' and their 'espoused theories' – when what actors say differs from what they do and such conflicts of power and interest may result in the dominance of one group and submission of others, compromise among actors, or even stalemate.

As Argyris and Schön (1978) show, some practitioners, for example, wrap up and propose best-case scenarios with 'fluffy' estimates, what they see as a promising idea and evince their understandings and reasoning to impress management. Resource controllers or managers, in turn, interrogate the practitioners and their proposals in order to dispose of them or to discover what further inquiry, scientific evidence, technical details, and economic resources are required to test the merits of the ideas, in order to suppress or support the proposals, to kill or commence the project. At times – especially when an idea seems rewarding but very risky to put into practice – practitioners are faced with management or resource controllers' unwillingness to decide or a tacit willingness to leave much of the responsibilities, initiatives, and ambiguities, on the shoulders of proposers or product champions.

Nevertheless, however confusing, conflictual, political, and insufficient the initial moves may be, the first passage point allows parties (i.e. resource controllers, managers, and practitioners) to exchange new instructions, information and demonstrations in order to inquire about the likely risks and rewards and distinguish between decision and discussion (Argyris and Schön, 1978). Passage points, therefore, are set for the convergence of 'conflicting and competing ideas' and the confluence of 'diverse and differing activities' and, of course, continuing conversation and reciprocal inquiry, within which actors probe the situation to determine how the development effort could begin, how the tasks should be assigned, where the activities may branch out, how the components might bunch together,

and often who or what might be the scapegoat for any failure (Schön, 1967; Lester and Piore, 2004).

The plunge into the first obligatory passage point, without knowing in advance what a product will exactly look like or what actors need to inquire and learn, or what means they must invent as future events require, provokes anxiety and a sense of vulnerability as result of being in radical uncertainty. The first passage point usually poses financing problems and requires making crucial decisions that are difficult and distressing to defend in the absence of complete conviction of success. More often actors' initial sense of vulnerability turns into conservatism and camouflage, hence the search for defensive and self-protective routines or self-deceptive mechanisms to disguise and smooth over undiscussable dilemmas, to deny doubt, and to suppress uncertainty or pass it off to others (Hainer et al., 1967; Argyris and Schön, 1978; Argyris, 1999). Van de Ven et al. (1999: 30), for example, observed such behaviour in product champions who usually attempted to deflect suppliers' attention from uncertainties into a set of overly optimistic projections, knowing that a funded project would eventually rescue itself. Not surprisingly, such a game of 'reciprocal deception' (Argyris and Schön, 1996) is usually accompanied by what Schön (1967) sees as the replacement of the 'non-rational language of invention' with the 'rational language of investment' to which future failures and errors are easier to attribute.

By and large, these responses may also happen in other stages of product innovation and are masked by conventional habits of selective inattention, repression, deception, and myth making. This game may go on until a crisis happens or an error becomes unavoidably visible at which point management attempts to play the role of the omniscient one and be the judge and jury of what was good and bad and what shall be done.

The ability to avoid such destructive behaviours depends on the actors and how their surrounding rituals, routines, values and assumptions help them to foster a milieu open to critical reflection, ongoing conversations and interpretation, experimentation, and reciprocal

inquiry – when theories-in-use usually remain congruent with espoused theories (Schön, 1982; Lester and Piore, 2004). So, in order to become credible the rite of passage (ROP) and obligatory passage point (OPP) must become a behavioural world with its own values and culture, including its own norms, exemplars, practices, and language that constantly acknowledges and tackles uncertainty resulting in surfacing governing variables, conflicting frames, valid information and assumptions. Otherwise it risks being overwhelmed by too much information and the anxiety that surrounds actors. But if ROPs and OPPs succeed too well in establishing and rationalising a clichéd language, norm, or symbolic gesture, immune from recognition of self-fulfilling processes, explicitly testing theories, and inquiring into other actors' view, then the innovation process may again fall prey to games of secrecy and evasion, myth making, suppression, and defensive reasoning. As Argyris and Schön (1978) observe, in product development, managers conform to a norm or ritual of denying the problems revealed in the preceding stages or decision points, and practitioners keep to a norm or ritual of accepting such denials.

The antidote is to treat the obligatory rites as both a 'psychological certainty' and an 'intellectual hypothesis' (Argyris and Schön, 1974) – psychological certainty in the sense that rituals, norms, or routines might suggest a basis for action yet must be regarded not as undiscussable but as an intellectual hypothesis, as something subject to error, test, scepticism, inquiry, modification, or entire change. This apparent paradox is heightened especially in situations of unsteadiness, instability, uncertainty, unpredictability and chaos when people cannot know what truth is, but such critical inquiries create the condition for dialectic (Argyris and Schön, 1996: 210). In passage points, techniques and theories learned and drawn from the past may not be literally applicable or actionable. Like exemplars or metaphors, they may suggest analogy, family resemblance, projective models, or symbolic relations, which help actors develop a feel, make sense of, set and solve problems in each troublesome piece of reality (e.g. each passage point) but only provisionally, because old theories and orthodoxies are always subject to critical inquiry, test, refinement, doubt, or error. This type

of progress in problem-setting and solving, in organisational inquiry, and in theory building, therefore, grows out of the present state and is then re-examined against the next state, which may turn out to be different. This tenuous, provisional stance is also necessitated in many instances of product innovation, and is often marked by uncertainty, unease, and unsteadiness.

Thus I represent the ROP or OPP as the framing and formulation of a set of manageable problems out of many competing alternatives. This can be seen as a narrowing in the interaction amongst people and things, between supervisors and subordinates, which represents certain conditions and specifications that have been identified by management as well as a product's web of relationships as being imperative for project continuation. But passage points demand actors access their tacit assumptions, surface the dilemma with which they are struggling, detect errors and incongruity between their theories-in-use and espoused theories, achieve a provisional convergence of meaning, and package uncertainty with valid information and problems. At each passage point actors may need to test and invent new means while reconciling conflicting ends. Actors need to juggle competing ideas and manoeuvre around rituals and restrictions, considering that *there is no unique correct decision* and their choice (designing solvable problems) may produce both an intended and unintended web of moves and implications as well as happy accidents. Thus actors are usually in situations that in Dewey's sense must make an effort to institute new environing conditions that occasion new solvable problems. In other words, approaching each passage point demands more reflection on 'problem formulation' than 'problem resolution'. This means that in many cases, early stages of innovation do not address a well-defined need or problem, or the problem may become apparent only after the product is in use. Moreover, 'in the absence of a specified outcome in the form of a well-defined product, it is unclear how to break the problem up into a set of separable parts that can be assigned to different specialists. Indeed, it is not even clear what those specialties should be' (Lester and Piore, 2004: 42). There is a high likelihood of misunderstanding and miscommunication and many possibilities

for opportunistic behavior, which can easily lead to disguise, deception, mistrust and a complete breakdown of the constructive conversation. So in such cases, practitioners are not really involved with incremental innovation and the uncertainty surrounding the activities cannot be described analytically or in terms of probabilities.

This phase is interwoven with personal ambitions, jealousies, rivalries, hesitations, and occasional desperate gambles (Hamlet, 1984). It is a process within which contending groups should iteratively define the next decisions to be made, the new ends to be achieved or to be defined, and the new means which may be chosen or constructed. New problems are framed and constructed from the messy materials of each piece of reality which is compound, conflicting, puzzling, angst-driven, and obscure. The process as a whole often represents a protective or conservative plenum in which actors usually avoid a greater ambiguity and anxiety, but they can select a lesser one by ongoing formulation and resolution of problems, by detection and correction of implicit errors and by transforming problematic situations into solvable problems with the result that there is no such a thing as an ideal or final settlement.

The quest for an ideal settlement is, in part, always an illusion – and radical and shifting uncertainties do not just stop after the initial 'settlement' process is over. The practice of uncertainty reduction continues throughout the whole innovation process. This said, however, processes of uncertainty reduction, define the problems and context which make the later application of more instrumental/analytical/rational methods and practices possible. It does not mean that the problems have been solved, or that the context has been correctly defined or do not need to be redefined. Such uncertainty reductions are temporal and tenuous. The reduction of uncertainty is a way of selecting, interpreting, viewing, and organizing information to construct a resolvable problem, encouraging constructive conversations. It involves construction and reconstruction of shared frames of meaning which can encourage concerted action useful in situations of conflict and complexity. This ongoing handling (reduction) of uncertainty is, therefore, an iterative process which can apply to all spheres of

organisational life as well as each phase of innovation. It is, however, <u>generally</u> at its height in the earlier phases of the innovation process.

The development phase

If actors in projectification eventually organise around a champion or a powerful group or gravitate to some appropriate choice of product ideas, then the second phase, development, begins.

When actors formally approve a full-scale development they still deal with an ill-defined situation in which marketing, engineering design, financial, economic, social and political problems are mixed together. Some of these problems are tightly interrelated by a division of labour or a technical component. Some interrelationships show themselves as hidden political games or explicit disputes among actors who hold conflicting viewpoints and use their respective politics and power to promote their interests (Burns, 1961; Bijker, 1995). Still many others are loosely linked due to alternative scenarios available for developing product components and sub-components (Bijker, 1995; Van de Ven et al., 1995). This all means that shortly after project approval, detailed development is initiated and activities proliferate into diverse pathways (Schroeder et al., 1989) which makes the course of development diverge again, and become chaotic and complex to manage. The initial proposal branches out into many loosely related technical sub-components and activities due to the diversity of technical means, development options, and contending groups' multiple goals and interests. Moreover, each technical sub-component may require iterative cycles of linking research with manufacturing and marketing, tacking technical setbacks, testing, prototype development, and financial justification.

Part of the development phase involves the visualisation and ultimate realisation of the product and its possible sub-components (Wotherspoon, 2001). Actors appear to use, amongst many other things, both the concept of 'technological frames' and what I have identified as 'obligatory passage points and rites'. Technological frames are used by

practitioners to inform and influence the shaping of an artefact, and restrict and influence the range of possible final products that actors make an effort to envision or visualise.

As the process begins to move up the slope of the development phase S-curve, product details continue to increase and specialised across technological frames and corporate lines of activity. The widening route reaches what appears to be a point of no return, a yielding point that may need management intervention for a 'go/no go' decision or where actors themselves link overlapping and parallel cycles of the development effort by framing a set of product choices, packaging uncertainty and fragmented activities once again with valid assumptions and information. Depending on the timing of deadlines for completion of the tasks at this irrevocable point, the pressures for convergence mount and anxieties about completion run high. These anxieties force actors to achieve some resolution of the problem of multiple amalgamations and possibilities. The project may fragment around its several competing actors and may emerge with several competing designs. The project may fail altogether to resolve the intellectual and sociopolitical issues involved and may come up with no optimum design. Alternatively, some actors may coalesce around one design tied to one powerful group or figure which emerges as the dominant design (Schön, 1971: 216).

More often, massive and escalating commitments, heavy psychological investment, mounting development costs in labour and materials, and above all the fear of admitting failure, usually give the project the momentum to stay alive – no matter how contrived (Argyris and Schön, 1978; Van de Ven and Polley 1992; Van de Ven et al., 1999). Also, actors tend to avoid stopping questionable projects once they are under way (Schön, 1967) but such events can shake the actors' confidence, and particularly resource controllers, so that they start paying serious attention (see figure 2.6)

If at this point enough causes combine to rescue the project, then some actors attempt to build stronger links by aligning product sub-components, discarding the seemingly irrelevant concerns, and again imposing a frame, a discipline, or a structure on jagged lines of activity.

Out of these usually comes an amalgam of one or two dominant product designs while others cease to exist. As part of the same movement, the struggle to achieve a dominant final design helps actors to decrease complexities and confusions by increasing 'stabilisation' (Bijker, 1995). This newly merged, penultimate product continues through a moulding process until completion of the development phase, where a final form of the product emerges. This implies that actors from different social groups negotiate and attempt to bring the final form of the product to closure. Whether stabilisation takes place due to power and political interaction among social groups (Bijker, 1995), or the technical dominance of one design (Suarez and Utterback, 1995), the process concludes with 'closure' when the involved actors, no matter how reluctantly, officially approve the final product form.

It is important to note that, the dynamics regarding final amalgamation at times occur on the basis of insufficient information and in the face of relative ambiguity and anxiety (Schön, 1967). It is always difficult to determine whether the final design would match market demands, or whether it could achieve the volume anticipated for it, or help organisational growth. There is also ambiguity about how the final product form will satisfy all stakeholders or the reliability of engineering trade-offs and heuristics. After all, tests and quality control have to be completed and despite the likely 'bugs' in the final form, marketing strategies have to be settled. Actors observe and evaluate the product with respect to its negotiated final form. If this evaluation proves favourable, and agreement is reached, then the final stage of development is complete. In social constructionist terms, the process concludes with 'closure' and 'stabilisation' (Bijker, 1995) – this includes the decision to adopt and commercialise.

Similar to the front-end of the process, the attempt to mix up sub-components results in another passage point. Here, decisions regarding closure and commercialisation take effect when the formal agreement is approved. As actors negotiate final forms of the product they squeeze sub-components together so tightly that they effectively limit any further digression of the product. Reaching the end of the development phase is heralded by the emergence of

the final product design, and of course setting another condition that occasions new problems, i.e. implementation and diffusion.

Once this closure takes effect, it becomes difficult to change the previously negotiated final product form. The passage point seems to be designed to limit further product modifications within the development process. However, this does not mean that the 'technological frame' or the 'dominant design' of the product will not evolve in the future with reinvention (Rogers, 1995), repair and replacement, or mutual adaptation (Leonard-Barton, 1995). It merely means that, with respect to the current stage of development, the technological frame of the product is considered to be almost complete (Wotherspoon, 2001).

Implementation and diffusion

When actors respond to the demands of the second obligatory passage point, the implementation and diffusion phase has already begun. This phase, as its title suggests, includes market introduction, mass production and implementation, and the diffusion of the innovation. If the product is developed elsewhere, the implementation centres on the conditions necessary to adopt and commercialise the innovation.

What is of great importance in the third phase as well as the earlier ones is the unit of diffusion. While the unit of diffusion in both 'funnel' and 'fireworks' is usually a product or project, that of 'ribbed balloon' is more nearly a self-transforming 'social-technical web' that resists management by a single actor. Actors, along with their techniques, interests, and understandings, intervene at various times to influence and forward the product diffusion. Each step, therefore, in the diffusion of innovation represents a reconfiguration not merely of a product but also of its associated stakeholders' web of moves.

Given unintended as well as intended changes in a product's use over its life, diffusion does not evolve systematically or sequentially. Many emerging interrelated and reinforcing web of relationships are likely to be involved, that stem from a cluster of decentralised actors and

technologies that cause unexpected reorientation in a product application. The diffusion of a product such as YouTube.com, for example, permits simultaneous international witnessing of events and its application may change from political elections to music shows and information. Therefore, the diffusion process must be seen as one of improvising (Orlikowski, 1995), a shifting and evolving whole in which decision making is widely shared (Rogers, 1995: 365), with new adopters.

The evaluation of success and failure (the third obligatory passage point) may occur according to corporate specific demands, objectives and measures. With respect to product application, there are differing interpretations in terms of project success or failure. Like other social phenomena (Berger and Luckmann, 1966) success or failure, too, are socially constructed realities rather than fixed objectives. Success or failure is not usually explained impartially and symmetrically. 'Working' and 'non-working' are contingent properties and cannot stand for a product success or failure (Bijker, 1995: 15). A product may work from a technical viewpoint but may not be acceptable from marketing or sociological perspectives. For example, display of the rate of acceleration as a marketing criterion, on the dashboard of six and eight-cylinder cars during 1970s and 1980s has been displaced by the rate of fuel consumption and frugal driving since the late 1990s. To this I should add that as new social groups and technological frames from unexpected quarters mesh with the diffusion stage, new product meanings and applications will emerge and take shape. Introducing platform products such as operating systems with bugs to the market by dominant and powerful IT firms, for example, has given birth to a new generation of products – a fertile soil for gap-filling products such as those of anti-virus companies (Tabrizi and Walleigh, 1997).

A comment on the shape of ribbed balloon

The flow of men, material, money, and information in each phase is flexible enough to accommodate varying levels of complexity and uncertainty as well as shifting requirements over time; the overall shape in phases are, therefore, elastic and can vary in size. In other

words, although this metaphor may appear to be a funnel in which problematic situations occurs less as actors go through later stages, I argue that there is no guarantee that in the second or third phase, actors face less ambiguity and anxiety compared to the earlier stages. Viewed as such, two situations, I believe, may happen. In the first one, actors attempt to package uncertainty as they approach each passage point. They progressively tackle problematic situations and temporarily put aside issues that cause unresolvable conflicts and complexities, attempt to define a set of manageable proposals for the convergence of differing ideas and stabilisation of the process in an ongoing and iterative manner (as in key decision points). In this sense, the ribbed balloon metaphor seems to be appropriate as actors try to selectively attend uncertainties, frame and reframe the context to which they want to attend, set new conditions that occasion solvable problems – bringing ambiguity and anxiety into tolerable bounds.

In the second situation, if in any case within the development phase, for example, actors encounter more surprises and higher degrees of difficulty compared to the early stage, then the shape of this phase may vary in size. In a particular industry, actors may encounter more pitfalls, problems, and challenges, as they try to respond to the ever-changing landscape of demanding customers and concerned stakeholders. Although actors try to package uncertainty but they experience higher degrees of difficulty and stress compared to the preceding stage; many problematic issues may remain unanswered and become repressed or undiscussable. The dynamics in the development phase can generate ideas that may initiate a fuzzy front-end stage for exploring another product(s). And despite this the initial project continues. In this sense, the term ribbed balloon may not be the most apposite metaphor to capture all the complexities but, I think, the underlying pattern in both situations, on the whole, can remain similar as far as actors, in approaching each key decision point, set their boundaries of attention to a selected set of issues and formulate manageable problems. Given that my main concern here was to bridge two contrasting yet complementary notions (funnel and fireworks) in the innovation literature and the contrast between conservative and radical

function of metaphors, I do not conduct an empirical research to precisely observe, illustrate, and elaborate on these two situations.

2.7 Summary

This chapter has explored the use of metaphors in handling the uncertain, unruly nature of the innovation process.

The use of metaphors/models as guiding tools for situations of uncertainty has, nevertheless, created its own dilemma which centres on the conservative use of metaphors in innovation management and studies.

On one hand, there is a managerial/economic quest to rationalise and control the complex and nonlinear nature of innovation, contributing to a burgeoning literature pursuing instrumental metaphors/models for the effective management of corporate innovation usually as an orderly, goal oriented, risk-reducing, measurable, and paradigmatic (mostly funnel-like) activity.

Neo-Schumpeterian theorists attempt to reduce these uncertainties by searching for and formulating regularities and patterns in technological changes. Their studies have produced terms such as 'technological trajectories', 'regimes', 'paradigms', and 'dominant designs'. Although their analyses are stimulating, suggestive and technically informative for practitioners, their suggested models fail to acknowledge that innovation and technical change affronts the continuing effort of social systems to remain as they are. Corporate members often respond to the uncertainties of innovation in a variety of defensive ways such as 'pushing off uncertainty onto others', 'escaping from the anxiety and embarrassment' and 'hiding in tall grasses'.

On the other hand, some writers have used nonlinear metaphors such as fireworks to argue that innovation entails significant discontinuity, uncertainty, politics, stress and anxiety and as a result a fatal helpless activity for practitioners.

It has been the argument of this chapter that in order to move beyond the 'practical but unrealistic' limitations of the funnel metaphor and the 'realistic but impractical' character of the fireworks metaphor, a new generative metaphor is required to support 'actionable knowledge' (Argyris, 1999).

To help provide such actionable knowledge, this chapter has sought to elaborate the foundations of a ribbed balloon metaphor to guide understanding and practice. In establishing the nature and value of this metaphor, this chapter revealed the weakness of the central ideas of rational managerial approaches to innovation practice guided by the 'funnel' metaphor. This weakness included the failure to recognise multiple uncertainties relating to engineering heuristics, the dread of failure, and all the complexities of the web of human/nonhuman relationships involved in the innovation process. It was argued that these uncertainties include a view of innovation (and organisation) as a society of interwoven human/nonhuman entities in which the interaction of technology and human elements are inherently unpredictable and product innovation is understood as an indeterminate and treacherous socio-technical practice. On the other hand, it was revealed how methodologies governed by a 'fireworks' metaphor, that capture many of these dynamics, fail to provide a critically rational or practical set of guidelines about how to approach innovation in practice.

Consequently, an outline and explanation was provided of the alternative 'ribbed balloon' metaphor, one that, it is argued, provides an alternative vehicle for creative thought about and intervention in innovation practice. My model of innovation, as a result, is not simply a critique of rational/economic/critical views of product innovation. By combining both critical (innovation as fireworks) and rational/managerial views (innovation as a funnel-like process), and including background neo-Schumpeterian and sociological studies of technology, the chapter developed what can be understood and deployed as an elastic, projective, radical metaphor of innovation as a ribbed balloon.

Chapter 3 Reconstructing Risk: From Managing Risk to Handling Uncertainty[6]
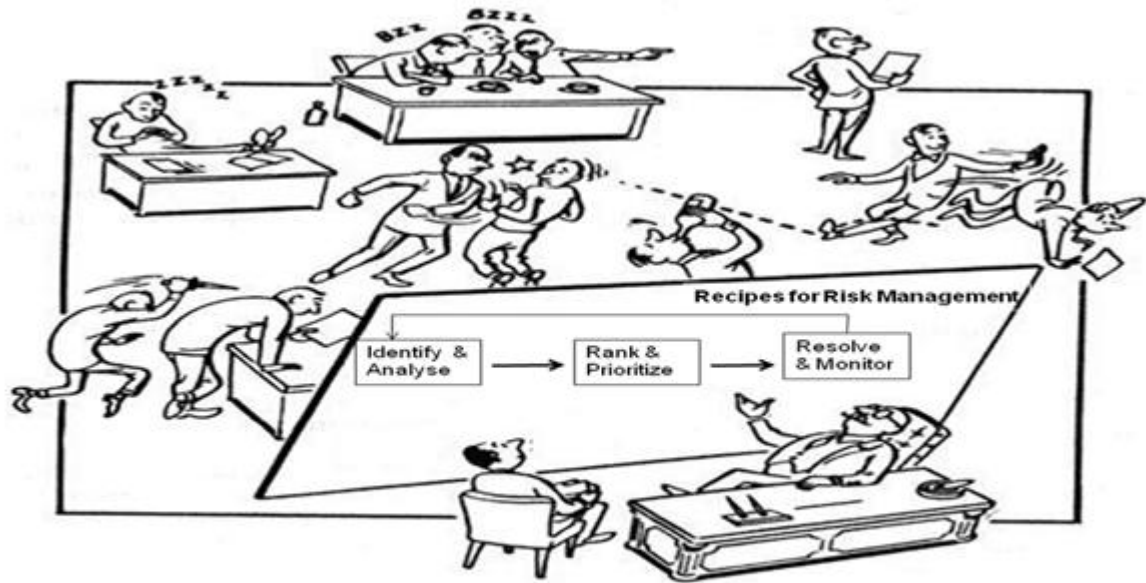
In the varied topography of professional practice, there is a high, hard ground which overlooks a swamp. On the high ground, manageable problems lend themselves to solution through the use of research-based theory and technique. In the swampy lowlands, problems are messy and confusing and incapable of technical solution. The irony of this situation is that problems of the high ground tend to be relatively unimportant to individuals or a society at large, however great their technical interest may be, while in the swamp lie the problems of greatest human concern (Schön, 1987: 3). This dilemma has two sources: first the prevailing idea of rigorous professional knowledge, based on technical rationality, and second, awareness of indeterminate, swampy zones of practice that lie beyond its canons: uncertainty (you have more information about it than you can handle), uniqueness (you cannot apply to it standard categories of analysis and action), and conflict (it is impossible to be instrumental because you can't adjust means to ends when you don't know what the ends are or when ends are not consistent) (Schön, 1995).

3.1 Introduction

Implicit in technical/rational approaches to innovation is the belief that organisations can predict, quantify and control the uncertainties of an innovation project to an acceptable level, weighing them against the likely risks and rewards of alternative scenarios. It is assumed that by selecting those scenarios whose rewards justify their expected cost, time and quality

---

[6] This cartoon has been modified from its original version, Murdick et al. (1990), Information for modern management. Prentice Hall.

requirement, corporations can master the risks and keep them within acceptable bounds (Smith and Merritt, 2003).

Risk management from this technical/rational viewpoint, then, is a sanitised discourse (similar to that of traditional 'funnel' models of innovation), in which corporate action proceeds through a series of orderly stages, each of which serves to relate special efforts to corporate goals, and each of which lends itself to effective threat management. This implies that corporations see risk management procedures as tools or aids for decision making rather than as assertions about the future. This chapter argues that there are two problems with this perspective.

Firstly, as noted by broader sociocultural perspectives on risk and its management (e.g. Beck, 1992; Lupton, 1999b) such approaches are unable to effectively address situations of instability, discontinuity, politics, anxiety, and value conflict within organisations. Broader perspectives on risk, as we shall see, provide insights for our analysis and deepen our understanding of situations of radical and irremovable uncertainty – conditions that are clearly prevalent in many stages of the innovation process, but which are particularly prevalent in the 'fuzzy front-end' of innovation. One of the problems of such broader views of risk, however, is that they often fail to provide detailed guidelines for how reflective practitioners should effectively handle such problematic situations. In this sense, they have a number of similarities with the 'fireworks' approaches to innovation. They are realistic and critical in character yet much less concerned with the competences needed by practitioners and corporations for effectively talking about and handling situations of uncertainty.

Secondly, following on from the aforementioned argument, this chapter argues that there has been distinction between managing risk and handling uncertainty. While this distinction has figured prominently in the works of a few scholars (Knight, 1921, Schön, 1963, 1967, 1982; Lester and Piore, 2004), in common usage the distinction is either unclear or practically

unusable. In this chapter I shall discuss some of the ways in which the distinction has been made, and some of the difficulties involved. The chapter proposes a new characterisation of the distinction between risk and uncertainty that helps address these problems.

In making this case, this chapter will review both theories of risk and risk management, as well as the nature of uncertainty and theories about how it should be handled. It then presents a view of risk management in innovation as involving interplay between two sets of practices that covers different elements: (i) reflective practice of 'problem setting' or 'settling risk' that involve packaging the uncertainty of problematic situations into a well-defined piece of reality that can be handled, and (ii) rational and quantitative 'problem solving' or 'managing risk' and addressing what are essentially pre-packaged problems. These practices have to do with both the ways in which practitioners explore and identify potential vulnerabilities and opportunities, recognise inherent uncertainties and convert them into frameworks of risks and rewards to be managed, and the subsequent selection of technical means for managing them. Such problem-setting or risk-settling is, of course, provisional, as new variables, criteria, and values always come into prominence and these may yield unanticipated consequences, resulting in the inadequacy or failure of the previous settings or settlements. It is, however, because the literature on risk management and uncertainty has to be addressed in combination in order to capture and address such practices in their 'totality' that their review is integrated in this chapter.

3.2 A Brief Genealogy of Risk

The history of risk goes back to the history of probabilities and a Hindu/Arabic/Persian language of numbers that reached Western societies in the thirteenth century – the time that much of the earth was seen as being systematically explored and its resources exploited by humanity as the servants of God or God's gardeners (Bernstein, 1996). Many scholars link the emergence and development of the contemporary concept of risk, however, with the

venturesome voyages and voyage insurance of navigators and explorers (in the Middle Ages) who attempted to identify and grapple with the perils of the sea (Luhmann and Barrett, 1993). In previous times, risk was regarded as a natural event, carrying its own intrinsic meaning – what nature could do to human affairs. Following Calvinism and the Renaissance[7], however, one of the special contributions of contemporary understandings of risk was the notion that humanity could and should discover gods' agenda and, if necessary, opposes that agenda and take the responsibility for the consequences (Bernstein, 1996: 17, 20).

3.2.1 The Scientisation of Risk

Such instrumental views of risk gradually extended to social order and global trade arrangements during the eighteenth and nineteenth centuries when modern European states increasingly sought to harness society and nature using science, scientific deduction, and positivism (including the laws of probability and statistics). This development paralleled the modernist belief of the sixteenth and seventeenth centuries that the social and natural world follows laws that can be measured, modeled, and mastered by humankind.

As positivism became the only source of positive knowledge of the world, positivist methods became increasingly sophisticated in explaining scientific knowledge. Positivist methods were then applied to morality, management, sociology and politics as well.

It was in this light that people's minds were seen as being cleansed of mysticism, superstition, and other forms of pseudo-science and the concept of risk was scientised drawing upon probabilistic reasoning, and conceiving of the future (assuming the future as a mirror of the past) as fundamentally coloniseable and programmable through rational/scientific measures of risk (Bernstein, 1996; Lupton, 1999a). The question 'how I shall act in situations of ambiguity and uncertainty?' was thus converted into a scientific one,

---

[7] The argument here seems to be too broad a sweep of literature. However, it links to a more extensive debate elsewhere in the thesis (see p. 64-67)

and the best 'risk management' tools were seen as being to be selected by the use of science-based knowledge.

Risk management as a tool for colonising future

Conventional wisdom, however, came along with scientised risk (Giddens, 1999). There was a belief that the modern market economy is a universal plan to be mapped and mediated by an instrumental/rational process of risk management as a value-neutral tool, which would bring humanity unparalleled accesses to the good things of life such that nations around the world should hasten to join this plan (Bernstein, 1996). Bernstein defines the boundary between modernity and traditional society in terms of 'mastery of risk and risk management' in which humanity no longer exists as passive and the future is no longer subject to whim of the gods. With its associated principles, techniques and assumptions about the contingencies in the world, proponents of scientisation of risk treat 'risk management' as the 'modern' means to discipline the order of nature and society. Modern societies use risk management as a guide 'over a vast range of decision making from allocating wealth to safeguarding public health, from waging war to planning a family, from paying insurance premiums to wearing a seatbelt, from planting corn to marketing cornflakes' (Bernstein, 1996: 2). This view therefore sees a great divide between traditional and modern societies which in the latter, risk management has acted as a device to model and master a utopian imagery of the future through the rational process of risk-taking rather than letting 'rational gods' dictate their agenda.

This approach has been also applied and promoted in academic disciplines such as economics and cognitive science (Tversky and Kahneman, 1974); science, engineering and project management (PMBOK, 2004); as well as medicine and epidemiology (Lupton, 1999b), to name but a few. The focus is upon the acquisition and application of expert and research-based knowledge and scientific methods and measurement as the most appropriate approach to managing risk and making decision under conditions of uncertainty. Lay people's response

to risk is usually pictured as 'biased', 'unscientific' and 'ill-informed' (Lupton, 1999a: 2) compared to what are seen to be 'objective' scientific calculations.

The focus in scientific approaches to risk is more on how well a risk is identified or measured, what is the level of seriousness in terms of its likely consequences, and how rigorous and comprehensive are the analysis that has been employed to measure, map and understand the relevant chain of consequences and responses (Lupton, 1999a: 18). The individual, as the unit of analysis (particularly in the psychometric analysis of risk), is treated as an emotion-free information processing actor whose behavior in the face of a pre-defined danger is rational, and hence can be modeled, measured, and manipulated. The formulations and calculations produced by researchers tend to be regarded as objective scientific facts and absolute truths (Bradbury, 1989). This means that one can make observations, form hypotheses to explain them and deduce consequences from these hypotheses, and benchmark to confirm or disconfirm the hypothesis according to given science-based standards. Hence, the process of construction and measurement of risks is taken to be value-free and tends to exclude the subjective role played by the selective 'world views', 'ways of seeing' or 'frameworks' of the researchers that design and develop risk management models (Lupton, 1999a).

There is however a 'balance scale' assumption in this approach – the likelihood of positive events (upside gains) balanced against the likelihood of threatening or negative events (downside losses). Upside gains or downside losses are two dimensions of risk in general, that one should find a trade-off between the likelihood of the risks and the rewards of making a decision or undertaking an activity (Sortino and Satchell, 2001).

Whether positive or negative, this view positions risk in the language of probabilities and quantitative reasoning. Risk of an event (positive or negative) is then the probability of the

event multiplied by its estimated loss or gain if the event actually occurs (PMBOK, 2004). Risk can be dissected into its probability and impact component as shown in figure 3.1:
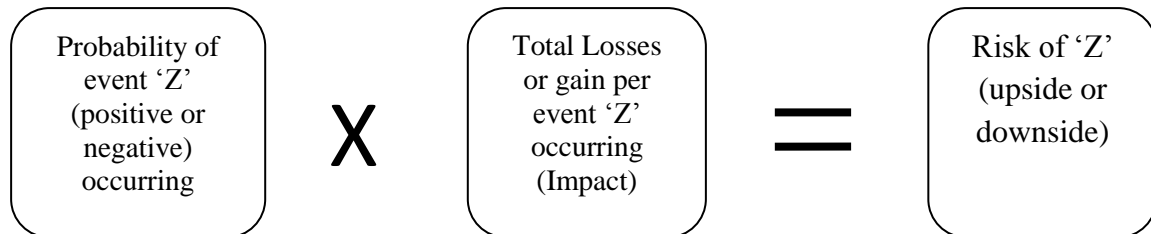
Fig. 3.1 The risk of an event Z (which may have positive or negative impacts) = (Probability of an event Z occurring) x (Impact of event Z)

By and large, the concept of risk in this view, has become construed in terms of probabilities (Bernstein, 1996) and, as such, it lends itself to measurement, bringing assessment of an event into decision making frameworks using probabilistic likelihoods (Clegg et al., 2006). As Hansson (2007) points out: 'In decision-making under risk, we know what the possible outcomes are and what are their probabilities. Perhaps a more adequate term for this would be 'decision-making under knowable probabilities.' The loss or gain can be measured in financial terms, time, corporate reputation, and the like (Smith and Merritt, 2003). In the context of innovation, the risks are the probability of occurrence of knowable threats or failures multiplied by the measurable impact of these threats or failures if they were realised; for example, how much money a company would lose or gain (e.g. in terms of foregone revenues) if it could or could not launch a new product according to the planned schedule or budget.

Innovation theorists that base their arguments on such a definition (e.g. Smith and Reinertsen, 1997; Tidd and Bessant, 2007) argue that uncertainty is present in all projects (e.g. we can never be sure that a particular line of R&D inquiry will provide the required knowledge about a process, materials, or product; or that the resulting innovation will be commercialisable),

but contend that the possibility of future events can be anticipated through practical reasoning and probabilities can be estimated. One can 'guess' the outcomes but cannot confirm in advance that an event will occur in full conformity with predicted probabilities. In other words, uncertainty *is* in the likelihood of an event causing future loss and gain not the event per se. The probability in risk formulas is always less than 100 percent, which represents a situation of complete certainty, otherwise it is not a risk (Smith and Merritt, 2003).

Hence, explicit here is the assumption that in conventional risk management a threat can be knowable and its probability of occurrence estimated through probabilistic reasoning (e.g. based on previous experience, as in actuarial tables, or some other formulation). In such a rational process of risk management (see figure 3.2), known risks are those that have been (a) systematically identified, analyzed and classified, (b) ranked and prioritised in terms of likelihood and likely impact, (c) resolved, i.e. pre-empted, avoided, mitigated or transferred, and monitored continuously. Therefore, underlying this approach is the fundamental assumption that through a series of orderly judgments it is possible to list and manage selected risks proactively so as to secure a desired future state rather than leave them to fate (Giddens, 1990) or to the whim of the gods (Bernstein, 1996). This is analogous to stage-gate models of innovation in which it is possible to manage and control the process proactively in a series of steps subject to instrumental measurements and systematic control.
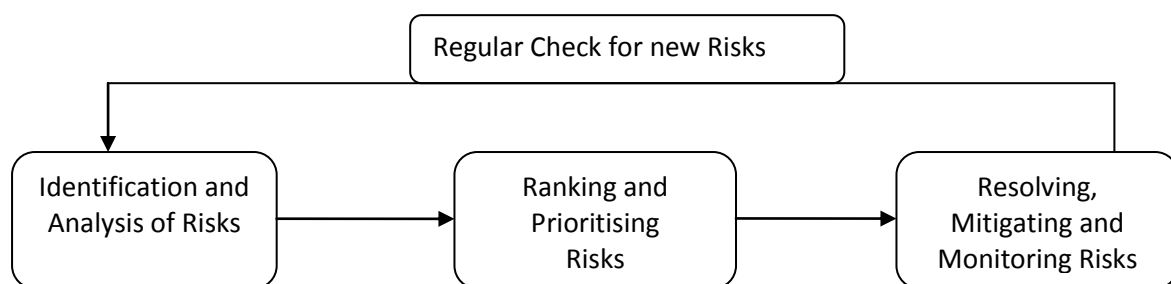
Fig. 3.2 The Linear model of Risk Management

The Dilemma of Non-rational Gods

There are, however, unknown risks that cannot be identified in advance and, according to the Project Management Institute,: 'unknown risks cannot be managed proactively, and a prudent response by the project team can be to allocate general contingency against such risks, as well as against any known risks for which it may not be cost-effective or possible to develop a proactive response' (PMBOK, 2004: 240).

Implicit in this statement is the possibility of 'unknowable' events that mean both the character and their associated loss or gain are in a state of uncertainty. This implies that 'tackling situations of Knightian uncertainty' (as I spelled out in the first chapter) simply fall outside the logic of these instrumental treatments of risk. Apparently, those who develop contemporary risk management models are not very much committed to engage with the recent and broader sociocultural perspectives (Lupton, 1999a) or willing to develop theoretical frameworks that can integrate both narrow technical/rational and broader sociopolitical/cultural processes (Wynne, 2002, Giddens, 1999, Beck, 1999). Recognition of 'unknown unknowns' (Hoffmann and Wynne, 2002) or reflecting upon the depth and details of professional practice in situations of handling uncertainty (use of intuition, emotion, hunches, cues, etc.), for proponents of scientisation of risk, usually means the termination of discussion rather than opening up inquiry.

It is common, therefore, for scientific approaches to risk to regard ambiguity and uncertainty in hypotheses as relevant only in so far as the logic of their standards and scientific methods are concerned. As Wynne (1988) argues, this school addresses only those uncertainties that are tractable to scientific analysis that would otherwise bring them complexity. Those contingencies that fall beyond the scientific scope of investigations or cannot be interpreted in the sense of a cause-effect relationship are considered to be irrational, hence overlooked or selectively screened. Instead of an emphasis on uncovering the limits to knowledge, scientific

approaches to risk usually tend to prove existing knowledge of risk to be legitimate and correct (Hoffmann and Wynne, 2002).

3.3 The Social Reconstruction of Risk and Its Management

The problematic and inadequate nature of the scientific/technical approaches to risk has been more recently recognised by social scientists (Beck, 1992, Giddens, 1999), sociologists of technology (Wynne, 2002), policy analysts and urban planners (Flyvbjerg et al., 2003), organisation analysts (Power, 2004) and practitioners of innovation (Bucciarelli, 1994). These scholars have become increasingly sensitive to uncovering broader dimensions of risk. They speak of chaotic, unique, puzzling and fluctuating environments in which problems and risks do not lend themselves to technical/scientific models of benefit-cost or probabilistic reasoning. Likewise, practitioners have become acutely aware that they are usually confronted with problematic and messy situations to which they must respond under conditions of anxiety, limited time and budgets which leave no room for probabilistic quantification and risk calculations. Practitioners argue that surprises, ambiguities, material properties, and dread of failure are drowned in a sea of calculations as the risk management process fosters an exaggerated trust in the language of calculable risks (Flyvbjerg et al., 2003).

In response to these limitations, broader approaches to risk and risk management have been formulated including these: (i) heroic firefighting, (ii) system accidents, (iii) high reliability and mindfulness, (iv) cultural theory of risk (v) governmentality and normalisation, (vi) Risk Society, (vii) the new conservatism. Each approach is a major theme, or metaphor around which there are many variations. Some approaches must be, however, understood as hybrids but their views can be better clarified by consideration of a major theme.

Because I seek to develop a broader and sociopolitically informed theory for managing risk in innovation, I focus on the links between social psychological, political, and philosophical

ideas about 'risk'. Because I seek to develop a 'conceptual framework' for 'converting problematic situations into packages of manageable problems' in organisations, I emphasise the common rather than the idiosyncratic features of individual and organisational experience in the following approaches to risk and risk management.

3.3.1 Heroic Firefighting

Proponents of this viewpoint treat risk management as the readiness for prompt and heroic reaction. They believe that in spite of careful decisions, and detailed formalisations and planning, the practice of risk management under the pressure of uncertainty not only proves difficult to follow (Repenning, 2001) but is also insufficient to avoid every potential pitfall and crisis that might threaten the performance of the system (Smith and Merritt, 2003). To this, inability to predict surprising events must also be included. The capability to be reactive to emergent risks and crises is indeed the firefighting behavior dear to some organisations and cultures (Hayes, 1981). Hayes, for example, argues that one reason American organisations are more chaotic compared to Japanese organisations is the difference in culture. He observes that American managers actually enjoy crises and often get their greatest personal satisfaction, recognition, and rewards from solving crises. The ability to heroically 'fight the fires' of crises is part of what makes work fun for them. Conversely, to Japanese managers, a crisis is evidence of failure. The more a culture or organisation embraces firefighting behaviors in dealing with risks and crises, the more proactiveness proves to be difficult and challenging to implement (Smith and Merritt, 2003).

As a result, the firefighting approach to risk management thrives on the excitement of waiting until situations are almost hopeless, then attempting to manage and rescue them courageously and heroically. Bohn and Jaikumar (2002) argue that firefighting is an old and familiar way of doing risky businesses such as product innovation. They observe how people rush from one crisis to the next, never really fixing problems, just stopping them from getting worse. Firefighting, however, is not always a desired choice. Bohn and Jaikumar emphasise that

some businesses are victims of this behavior when the number of problems are more than problem solvers, when solutions are inadequate, when there is a lack of time and space, and when urgency supersedes importance. Although firefighting offers a broader view of risk management dependent upon cultural differences and preferences, it does not consider the micro social psychological dynamics or processes that involve actors' improvisation, coping with stress, on-the-spot judgment, and intuition amid the firefighting.

3.3.2 System Accidents

Some of the more traditional approaches to risk analysis such as Failure Mode and Effect Analysis (FMEA) are based on an accident model that focuses on failure events and draws heavily on causality and the notion of linearity (Ben-Daya and Raouf, 1996). But with the advancement of potential highly complex systems along with parallel research and invention of notions such as 'normal accidents' (Perrow, 1999) and 'organisational accidents' (Reason, 1997), traditional approaches proved to be too narrow and unable to address the complexity and non-linearity of both social and technological elements.

As organisation theorists began to think of organisations as complex and conflicting systems (Vaughn, 1996; Perrow, 1999), traditional linear views toward accident were increasingly succeeded by the notion of the 'system accident'. Such accidents are, however, 'normal' in the sense that in *The Challenger Launch Decision*, Vaughan (1996) concludes that in approving the launch, managers were simply following a conflicting yet established culture that inevitably had *normalised* deviance. Vaughan documents that years before the Challenger accident, irregularities used to occur but engineers believed that they could account for such 'normal irregularities' or what Brian Wynne (1988) terms as 'normal abnormalities'.

Charles Perrow in *Normal Accidents* (1999) offers this definition for 'normal system accident' (Perrow, 1997: 23, 66, 78):

> The interaction of multiple failures that are not in a direct operational sequence…linear interactions are those in expected and familiar production or maintenance sequence, and those that are quite visible even if unplanned. Complex interactions are those of unfamiliar sequences, or unplanned and unexpected sequences, and either not visible or not immediately comprehensible…[Hence] most normal accidents have a significant degree of incomprehensibility. A failure in a subsystem or the system as a whole, that damages more than one unit and in doing so disrupts the ongoing or future output of the system. An incident involves damage that is limited to parts or a unit, whether the failure disrupts the system or not. By disrupt we mean the output ceases or decreases to the extent that prompt repairs will be required.

Conceiving of an organisation as a technological complex, risk can perhaps be understood as a form of systemic failure, engineering error, or technical accident. Coming to understand high or low risks depends in the likelihood and magnitude of technical failure/s and their effect on system performance. System accidents often result from adaptation and degradation of safety over time: the move to a high-risk state occurs without any particular decision to do so but simply as a series of decisions or adaptations that move the system into a high-risk state where almost any slight error or deviation can lead to a major accident (Levenson, 2004).

Despite the merits of these ideas, some authors (Hopkins, 1999) argue that system accident theory applies to only a very small category of accidents and it does not apply to many of the failures which involve some element of misinformation, misconduct, etc. How practitioners in an organisation, for example, deal with intractable situation in which both technical and political concerns interlock, scientific evidences are selectively interpreted by contending groups, and conflicts of power may result in stalemate? The focus in this approach is more on the analysis of the interaction between two separate spheres – seemingly rational actors in their encounter with high risks thanks to coupling of complex technological systems. With

the exception of Vaughan's (1996) study, micro/macro social psychological diagnoses, political debates and cultural contexts which inform and shape the concept of risk in any organisation (Lupton, 1999a) are not often categorised or examined in this approach.

It is likely for an organisation to overlook those problems that fall outside the logic of system accident theory (e.g. personnel discontinuities or deliberate error) until an error become unavoidably visible, provoking a crisis for the system. However, as Hopkins (1999) argues, the lasting legacy of normal accident theory is that it provoked the development of high-reliability theory, which has contributed to researchers' understanding of how disasters can be avoided.

3.3.3 High-Reliability and Mindfulness

While complex systems may generate major accidents, there are orgnisation theorists who argue that crises and technological risks are not necessarily an inevitable consequence of systems complexity (Bigley and Roberts, 2001; Chiles, 2001; Weick and Sutcliffe, 2001). These theorists explore the ways some complex organisations, namely high-reliability organisations (HROs), avoid being derailed by unpleasant surprises, and keep operations on track. HROs hone their abilities to act reliably and handle adversity by heading off the disruptive escalation of low risk problems into high risk crisis because for them 'do-or-die' is the principle (Weick and Sutcliffe, 2001). HROs assume that the system is endangered until there is conclusive proof that it is not. HROs include aircraft carriers, nuclear power plants and firefighting crews, which consistently deliver high performance in unpredictable situations where the potential for error and disaster is overwhelming.

As one family of firefighting, high-reliability theorists assert that fighting fire is probably one of the best approaches an organisation can do, if applied as a day-to-day approach to deal with problems. These theorists debunk that the urgency of the reaction to fight fires prevents organisations from proactively concentrating on important matters and instead build on both

normal accident and fire fighting theories to offer a new risk management approach that revolves around moment-to-moment monitoring and proactiveness rather than rigid pre-planning or merely reaction. In their view, organisations must make sense of activities continually, anticipate problems in advance and respond promptly to undesirable events in a flexible rather than rigid way. When things do go wrong, they must identify and empower those with the expertise to contain or minimise the risk of the situation, and then rely upon organisational resilience to bounce back quickly after the emergence of an error. By operating 'mindfully' and making critical adjustments in a timely manner, organisations are better able to manage the risks in a challenging, highly competitive environment (Weick and Sutcliffe, 2001).

Therefore, for those adhering to this approach, in order to enhance organisational ability and to be more reliable in managing the unexpected risks, five key practices of 'mindfulness' can be implemented at all levels. These five practices develop a collective state of awareness of the important details in organisations (Weick and Sutcliffe, 2001):

- A preoccupation with failure**:** this is a departure from complacency, overconfidence, antagonist ideas to encourage the reporting of errors and pay attention to any failures.
- A reluctance to simplify interpretations**:** this implicitly draws on Kenneth Burke's (1969: 324) principle 'entities should not be reduced beyond necessitates'. It, therefore, requires a more complex and diverse analysis of each occurrence and looking for disconfirming evidence that foreshadows unexpected problems.
- A sensitivity to operations**:** this requires serious attention to moment-to-moment operations and making ongoing assessments and continual updates.
- A commitment to resilience: this requires intelligent reaction and improvisation and making every effort to return to a state of preparedness as quickly as possible once the error is fixed.

- A reference to expertise: this requires a departure from pecking order in the time of crisis. This means a kind of leadership that relies on expertise and experience to deal with the problematic situations.

Adherents to this approach, properly delineates the situations of uncertainty, uniqueness, and crisis that unexpectedly occur and which not only defy systematic pre-planning such as risk management but also undermine orderly activities. They also call for a 'mindful practice' that involves the departure from complacency and the pecking order, intelligent reaction and improvisation, and sensitivity. However, what high-reliability writers underestimate, is that in such uncertain situations although 'mindfulness' is a necessary condition to avoid the unexpected technical problems, mindfulness itself involves broader non-technical contexts (i.e. further recognition and formulation of actors' insights, intuitive judgment, emotion, non-rational inference, and craft) where the writers disappointingly terminate their discussion.

3.3.5 Cultural Theory of Risk

For cultural theorists of risk, risk is a phenomenon that cannot be isolated from cultural processes and components such as symbols, rituals and shared meanings. Therefore, the cultural theorists of risk have regularly criticised scientific approaches to risk for being purely technical or cognitive and free of political, ethical, and commonly held norms and values by which communal or individuals' behavior are shaped and influenced. Douglas and Wildavsky have written extensively on the moral and cultural frames of equality and justice, and the beliefs, biases, and symbolic factors that affect risk analysis within diverse cultures; hence for them a sociocultural construction of risk prevails over a purely individualistic and technical interpretation (Douglas, 1982, 1992).

Douglas's approach to risk is typical of functional structuralist analyses of sociocultural phenomena (Lupton, 1999a: 56). Central to her analyses of ideas and rituals concerning pollution and cleanliness, is the notion of the 'human body' as an apt metaphor for any

bounded system such as a society or an organisation (Douglas, 1966; Lupton, 1999a: 40). Just as the individual seems often to abhor disease and has ideas about what constitutes dirt and disorder for human body, so too societies seem often to identify the good life with 'health', creating visions of purity and making social progress synonymous with the eradication of 'impurity' and 'disease'. This social construction of a sense of the obviousness of what is dirty and dangerous and what needs to be avoided or fixed, is the function and property of impurity and purity metaphors. These metaphors shape the individual's perception and understandings of different phenomena in a society.

Just as the human body has certain boundaries between the body and the dangerous 'Other', inside and outside, so too the notions of society and other social systems can be seen as having form, internal structures, margins and boundaries between 'inside' and 'outside' which are continuously policed from threat. Classification systems with regard to what is pure and what is polluted are constructed, and operate in all social systems such that members have unambiguous ideas and visions of what constitutes a 'good society', and how they should behave in order to support and bolster social ties. Visions of the 'good society' according to which members regulate themselves hold and reproduce shared values, norms, meanings, and concerns, and provide satisfaction for their constituent members. Such visions of a 'good society' provide members with clear definition and boundaries between clean and dirty, conventional wrong and right, good and evil, order and disorder (Douglas, 1966; Lupton, 1999a: 3). This helps members of society to not only cope with the anxiety of the unknown in their encounter with the phenomena (including situations of uncertainty) but also lets them know what is expected of them for interpreting anomalies which have the potential to disturb or disrupt the good society. Inherent in such definitions and visions of a good society is a need for all individuals to behave in an orderly manner policed by cultural demarcations between 'us' and 'them', 'saints' and 'sinners', 'responsible citizen' and 'dangerous other', the 'normal' and the 'deviant' (Douglas, 1966).

Douglas' theorising about danger and purity underpins her later works, i.e. *Risk and Culture* (Douglas and Wildavsky, 1982) and *Risk and Blame* (Douglas, 1992). Here Douglas argues that risk as a modern interpretation of uncleanliness, impurity, wrong-doing and disorder has come to dominate thinking about an irrational and dangerous 'Other'. Risk, as a Western strategy for dealing with danger, replaces older versions of misfortune, mysticism, taboo, and sin that still function in more so-called 'primitive' societies. In contemporary secularised societies, risk acts as a forensic resource in providing sanitised explanation when things go wrong. 'Taboo' or 'sin', once the rhetoric of moral retribution and accusation against a specific individual, has increasingly given its place to a more modern and forensic structural concept, i.e. risk. Whatever appears as an 'anomaly', an 'ambiguity', or a 'thing that does not fit' or, in short, a threat to the cultural homogeneity of a good society is considered dangerous and anxiety-producing, and that is thereby treated and politicised as a 'risk' that should be avoided, marginalised and blamed (Lupton, 1999a: 39, 44).

Douglas argues that contemporary social systems need a common forensic vocabulary with which to hold persons accountable and further that risk is a word that admirably serves the forensic needs (Douglas, 1992: 22). This common vocabulary functions as a 'cognitive schema' or 'mechanism' to facilitate and form individuals' perception of risk. These mechanisms are mostly in the form of 'ritual' (Douglas, 1966: 80) which guide members' experience and help them maintain meaningful and safe interactions among themselves, containing disorder, and creating unity.

Such cultural treatment of risk by Douglas and others (Lupton, 1999a) frame risk management as a kind of orderly practice in which relations of culturally shared visions are apprehended by pre-existing routines and rituals. Within this schema, rituals or beliefs about risks do not often change, or perhaps it is better to say that there is little explanation, in such cultural theories of risk, of how things change that cause critical reflection, rethinking and

reframing governing assumptions in the context of ambiguity, uncertainty, and change. Consequently, some scholars view such cultural approaches to risk as being somewhat static, suitable for stable state systems, and politically conservative (Adams, 1995; Lupton, 1999a).

In my framework of risk settlement, I argue that in the context of corporate innovation, managers and practitioners tend to selectively regard some phenomena as unsafe, treacherous, and threatening to their vision of a productive collaboration, generating anxiety. Depending on their cultural framework and their collective inquiry, they metaphorically carry over the familiar and ritualistic ideas of good and bad to these selected phenomena and construct risk schemes. They frame a behavioral world and focus resentment and blame on those who defy risk schemes, establishing an organisational setting in which something in their professional activity should be seen as immoral and risky and others seen as moral and rewarding.

3.3.6 Governmentality and Normalisation

With the collapse of feudal systems in Europe and the development of administrative states, institutions and states began to think of their citizens in terms of 'populations', developing numerous and diverse technologies for achieving the subjugations of bodies and the control of populations (Foucault, 1998: 140). Michel Foucault, a landmark figure in exploring this phenomenon, formulated an historical analysis regarding modern Western governmental systems as a territory or social body requiring a new form of power which is not vested in the individual but is a totality which is pervasive in taken-for-granted and daily routines that constantly shape people's thinking and behavior (Buchanan and Badham, 2008: 296). This new model of government is supported by the invention of new technologies of power which continuously create further opportunities for domination, medicalisation, regulation, intervention, and normalisation with the aim to maximise wealth and national vitality, and minimise danger and despair. According to Foucault and subsequent thinkers (Dean, 1997, 1999; Ewald, 1991), modern social systems are characterised by the circulation of ideas,

people, materials, and money involving complex interactions of human beings and huge networks of expert knowledge. Modern governments encounter an infinite world of possibilities, which if not regimented and protected by advanced technologies of power, have the potential to threaten social order and security as well as public 'sanitation' and productivity. This demands excessive and costly interventions which may undermine individual freedom and rights.

For proponents of the governmentality approach, risk is a moral technology of power for creating a non-coercive form of social and material order. By using the rhetoric of risk, institutions and states calculate and constitute what is socially normal, virtuous, and permitted and what is socially deviant, abnormal, and risky, categorising and controlling people's relation in the systems under their sovereignty with the aim to maintain an obedient, utilitarian body. The rhetoric of risk helps government 'securitise' the conditions of life by mapping out, measuring, monitoring, and regulating public performance (Nadesen, 2008). Security is a matter of maximising positive outcomes, for states or institutions, whereby they design the best possible circulation of members, materials, money, and minimising what is risky and insecure, while knowing that these risks will never be completely suppressed (Foucault, 2007).

Two ideas, therefore, are central in the governmental approaches to risk, although both are inextricably conjoined in that each requires the other. First, is an ongoing identification of normal modes of behavior in populations and sub-group of populations, i.e. how to keep events, facts, and artifacts within socially and economically acceptable limits and around an average that will be considered as optimal for a given social functioning (Foucault, 2007). This helps individuals apply, in concert with governmental strategies, those norms most appropriate to the tasks in which they are engaged. Their performance can be monitored and assessed according to accepted norms. Second, the categorisation of the individual and

society in terms of populations rejects the traditional dualism between state and society, 'external control' and 'internal will'. Governmental strategies are not simply imposed from above but are adopted as practices of self-government in everyday life. This means that citizens construct and reconstruct their own web of power when they accept, articulate, and advance governmental definitions and structures of normality (Buchanan and Badham, 2008). In this way, norms become integral to the fabrication, protection, and proliferation of certain types of individuals within a network of regulating tools, technologies of mass surveillance, and power-play techniques emerging not only from the state but also other regulating agencies and institutions such as mass media and police forces as well as legal and educational systems who protect and promote governmental stature and narrative. These regulating agencies and institutions exercise a powerful grip on the norms and narratives because the established order in which the majority of members live their lives 'is not the natural order of things, after all, but always a temporary accomplishment, that could, at any time, be overturned, displaced, and transformed' (Dick, 2005: 1384).

The non-coercive aspect of governmentality emphasises the active participation of members in designing and developing the rhetoric of risk. Gathering and analysing of information about risk very much relies on individuals' voluntary participation to acquire and accept knowledge about the problematic areas. Rather than being mainly passively subject to a government's coercive interventions, individuals become active agents of the state that police their own behavior and exercise power upon themselves as normal members in a crowd (Gordon, 1991). Active individuals become entrepreneurs of the self, voluntarily engaging in government's project of risk-detection and risk-correction. They are privileged as autonomous agents who can produce calculable risks. Active members contribute to self-knowledge, self-responsibility, self-improvement, self-discipline or are marginalised, or subordinated as dangerous or invisible (Nadesen, 2008).

Proponents of this approach do not very much talk about corporate life directly but the idea of governmentality does address changing regimes of professional conduct in contemporary organisations as well. To take one small example, in the context of corporate innovation, knowledge spillovers to competitors are regarded as an important aspect of the product innovation process (Czarnitzki and Kraft, 2008). While a corporation possibly benefits from incoming information on successful R&D conducted by other corporations, a generally high probability of leakage of sensitive knowledge will negatively affect profitability. So top management may ask: What is the average rate of information leakage in our organisation? How can we predict statistically the numbers of leakages at a given time, in a given division? How much does this kind of phenomenon costs the organisation or the larger society in which we function? Does severe and strict repression cost more than one that is more permissive? What is the comparative cost of the leakage and its repression, and what is more worthwhile: to tolerate a bit more knowledge spillover or to tolerate a bit more surveillance and suppression, and so on? Management analyses the phenomenon in question within a series of probable events and the possible reaction to it and this is inserted in a calculation of cost. Instead of a binary division between permitted and prohibited, management attempts to establish an average considered as optimal and a bandwidth of the acceptable and normal that must not be deviated away from. In this way, a special classification of a phenomenon and a special deployment of mechanisms of security within an oraganisation take place. The phenomenon in question becomes important due to its probability and its impact on the organisation. A mechanism of security – a risk management model – is then implemented for detecting and correcting the risks due to knowledge spillovers. This model is used to get members, materials, and movements to conform to the norms, detecting those who are unable or unwilling to conform. So the norms, and not the members, become fundamental in this kind of management discipline. The primacy of the norm in relation to the normal is what is involved in such disciplinary process (Foucault, 2007: 84). The identification of the normal or safe from abnormal or risky, then, becomes possible in relation to these posited norms

when members voluntarily accept and exercise such norms in their practical activity. Self-disciplining might occur by providing organisational members to the rightness of norm adherence as a central part of their performance or purpose, making metrics available for members to apply to themselves and others, and instituting new forms of peer-pressure to conform to such norms.

For adherents of governmentality nothing is essentially risky (Ewald, 1991) rather it is through discourses, representations, processes, and practices that some phenomena come to be known as threatening to a social institution and are constructed as risks. These efforts produce 'truths' on risk as a calculative rationality (Dean, 1999) rather than something real in itself.

Such theories have been criticised for focusing too much on governmentality discourses and policies and giving fleeting attention to how people or practitioners actually practice risk management as parts of their everyday or organisational life (Lupton, 1999a). The processes and dynamics through which risk-related discourse is selectively taken up, negotiated, settled by stakeholders or rejected by contending groups remain overlooked. Moreover, governmentality theorists usually advocate a universal approach, and further recognition and elaboration of the varied responses of people of a different gender, age, social class and ethnicity seems to be under-examined (Lupton, 1999a).

3.3.7 Risk Society

These theorists treat risk and uncertainty as the products of 'late modernity'. Beck (1992) argues that late modernity itself has undergone metamorphosis. We are in a period of transition from an eighteenth century Enlightenment-type of modernity toward a second one in which the logic of industrial production and the distribution of wealth is shifting increasingly to the logic of the social production of risk. Beck states that the dominant

concern in industrial society or the first modernity, was material inadequacy or underproduction. This concern has now been replaced with overproduction and an abundance of undesired production (Beck, 1992). The metaphor of 'I am hungry' which was the driving force in industrial society, now has been replaced by the 'I am afraid' of risk society. There has been a replacement of the commonality of *need* with the commonality of *anxiety* (Beck, 1992).

Initially, Beck used the term 'risk' mainly to mean 'danger', disregarded its origins, its technical application and its intimate connection with probability and rational choice (Douglas, 1992: 45). However, his more recent view argues that risk is a modern tool that fulfills an overriding aspiration to control and colonise the future (Beck 1994, 1999, 2005).

For Giddens (1999), there is, however, a separation between two kinds of risk – external and manufactured. External risk belongs to the first two hundred years of industrial societies in which risk is expressed as fairly predictable and insurable, and as a kind of exogenous entity to people's life. There were unambiguous boundaries between sources of risk and human activity, argues Giddens. But in the notion of a risk society a transition from a predominance of external risk to a prominence of manufactured risk has occurred. 'Manufactured risks' (Beck, 1992) point to the shift from origins of unpredictability and uncertainty in nature to the very growth of human knowledge and activity. In this transition, the character of risk has also changed from something exogenous to something that becomes an integral feature of the society, hence more endogenous. In risk society, people increasingly encounter production and reproduction of high-tech means but they are not able to understand to what ends this trend is leading them. Scientific and technological progress has, therefore, shifted from something to be respected to something to be doubted and something distressing. All of this has made risk societies to witness two major transformations – the 'end of nature' and 'de-traditionalisation' (Giddens, 1994, 1999).

First, in risk societies there are few aspects of the world untouched by human intervention, such that now we are worried about what we have done to nature and this for Giddens is the 'end of nature'. This is life in a society preoccupied with a future no longer lived as fate or destiny, where tradition and traditional beliefs – valid concepts in first modernity – have been displaced by a continuous process of de-traditionalisation. History provides little previous experience given that patterns of progress no longer follow one from another as it was the case in the first modernity. Progress itself seems to be nonlinear, confusing, contentious and uncertain as the basis we have known for a linear and a stable state of affairs is now destabilised and shifting.

These nonlinear changes differ in terms of magnitude and global effect compared to the change of the first modernity. It is far from possible to clearly predict and measure the magnitude and nature of the manufactured risks and their side effects because old techniques of rational calculation have now little advantage to offer. Hence, contemporary risks could only be described in terms of 'scenarios' that are open-ended and at times problematic as they inevitably involve politics, value conflicts, antagonistic debates and contradiction that paralyse constructive action. So it is not surprising that, as Beck says, there is a transition from risk as an object to risk as a nonlinear and paradoxical sociopolitical process or movement (Beck, 1992, 1999).

This process is paradoxical in the sense that people and institutions are at times responsible as they are risk authors, but no one is held specifically accountable. They are responsible when they produce and legitimise the threats that they cannot control but they can escape from 'culpability analyses', because most risk discourse involves politics, rhetoric, selectivity, and does not even rest on knowledge but also on non-knowledge and unawareness as we at times deal with the 'unknown unknowable' (Beck, 1999; Giddens, 1999). This means that the character of the majority of manufactured risks mismatches prevailing risk knowledge or

cannot be construed according to established rules of causality, blame and liability (Beck, 1999: 77). The implications of these paradoxes are what Beck and others term as 'organised irresponsibility' (Beck, 1999) which points to the diversity of humanly created risks for which people and organisations are certainly responsible in the sense that they are its authors but no one is held specifically accountable.

Perceived in this way, individuals of the late modernity differ from the individuals of first modernity. In making their biography, as Lash (cited in Beck, 2003) argues, individuals increasingly face indeterminate situations and pressing problems. They ought to make decision quickly as they have little time and space to reflect. They are cut off from the anchors of tradition and have to invent valid bases for their action while facing with diversity of possible yet puzzling future scenarios. Their performance inevitably includes both the 'reflex, knee-jerk type' and the 'reflective' responses of which the latter was the norm in the first modernity. Consequently, the individual in a risk society does not usually have sufficient reflective distance from which to construct a linear, predictable, and narrative biography. There has been a transition from a position of reflection to one of becoming more reflexive.

Despite their sophistication, insights and values, risk society theorists have disappointingly little to offer in terms of the ways institutions or individuals (including practitioners) might tackle 'unintended consequence', 'organised irresponsibility', and 'manufactured risk and uncertainties'. Their preference is more toward describing the macro-structural factors and dynamics of late modernity rather than suggesting what precisely can be done. Nevertheless, the notion of risk society and its nonlinear dynamics is an illuminating and vivid example of situations of radical uncertainty, despite the fact that the distinction between risk and uncertainty remain under-examined in these accounts.

3.3.8 The new Conservatism

Power (2004) argues that all types of organisation – public and private – have been invaded to varying degrees by ideas about risk and its management. 'The risk management of everything' has become one of the major challenges of the early twenty-first century. More and more events are being interpreted in terms of risk and risk management, even though the concept remains vague, controversial, and contested. Definitions that stem from various specialisations, construct risk in order to reflect their own specific institutional interests – financial risk, health and safety risks, social and technological risks, risk to governments, etc.

Power (2004) observes that the risk management of everything has had a major effect on organisations. Organisations are becoming more preoccupied with managing their own risks in areas such as 'organisational reputation' and 'social responsibility', which are being interpreted by risk management ideas. This type of managing of self-risk, or what Power terms 'secondary risk' has outweighed primary professional risk management. Secondary risk has given birth to intense internal control systems and auditing – a new 'corporate conservatism'. It has made corporations 'focus more on their personal, legal and reputational risks, rather than on the primary risks embodied in their formal mission' (Power, 2004: 15).

As the dark side of 'risk management as the new protectionism', secondary or reputation risk management poses a different agenda of concern, which is to become increasingly aware of managing the risk of responsibility and there is a deep anxiety about the possible negative outcomes for being accountable for a specific activity. Risk of reputational harm, therefore, is becoming as significant as the primary risks for which experts have been trained. The distinction between primary and secondary risks may engender risk aversity. Reputational risk management primarily conceptualises stakeholders as the sources of the threat to legitimacy, and, in this way, the rise of secondary risk management reflects the 'decline of

the public' as organisations become more conservative and less willing to 'risk themselves' in public.

By and large, Power tends to emphasise that there is a new regime in organisations of all types – i.e. risk management as a new tool for protection and conservatism. This represents an organisational obsession with 'dread of failure' which has been translated into the language of risk. Nevertheless, Power pays little attention to the fact that the new obsession with conservatism, protectionism, and using risk management in this sense is in fact an old characteristic of all homeostatic systems including organisations. It is another variant of Freud's 'defence mechanism', Argyris' 'defensive routines' or Schön's 'dynamic conservatism' in organisations. The risk management of everything serves as a protective instrument for the organisations, lest they become subject to blame, fear, and anxiety. As we observe in cultural/governmental theories of risk, social systems develop internal blaming patterns but at the same time regulate and police their own performance according to broader structures of risk. Hence, the new regime of risk management is in fact a natural response of social systems in order to avoid danger, fear, and blame, a response that in increasingly globalised organisations has emerged in forms of risk analysis, risk avoidance, and risk aversity that have been quite unanticipated.

So what might be done given the picture outlined above? Power proposes an intelligent risk management approach under which: (i) control systems should not swamp and distract managerial attention from broader organisational narratives of uncertainty (ii) risk management is characterised more by learning and experiment than rule-based processes (iii) public trust and transparent understanding is promoted by acknowledging how risks are 'selected' by institutions for a mixture of cultural and economic reasons (iv) legitimacy is generated for the possibility of failure and finally (v) institutional conditions created for intelligent trust in expert judgment to flourish.

3.4 Social Reconstruction of Risk and Managing Risk: The Handling of Uncertainty

This overview of the literature on risk may seem to be both extraordinarily comprehensive and extraordinarily incomplete. I think whoever attempts to describe the literature of risk and tends to place or formulate an all-encompassing approach in relation to it may be confronted with at least two sorts of difficulty. The first difficulty of the review is that risk as an elastic concept has been analysed and applied in very different academic discourses and disciplines. The notions of risk and managing risk have different meanings in all of these broader points of view. Nevertheless, it is clear that many of these theorists would not make use the term 'risk' unless they believed that risk sometimes in an important sense means dealing with something potentially complicated, unmanageable, unpredictable, and troublesome – what Knight (1921) describes as 'unmeasurable uncertainty' and Dewey (1938) reads as problematic situations – something decisive in many aspects of human practical activity and not limited merely to organisations. So for all of these risk theorists, their approach to the study of risk and risk management *carries an implicit view of handling or dealing with uncertainty*, as I described in chapter 1, but they do not put this notion of handling of uncertainty into coherent frameworks.

The social/cultural/political approaches to risk, however, have a strong message – that if we are to reason practically about risk, we have to move outside the restrictive and narrow practice of risk management because this process includes social/psychological/political/cultural dimensions. What these views do not tell us, however, is how practitioners can pragmatically grapple with the problem of risk management which is the focus of this thesis. Those researchers who have grappled with this problem have done so in the discussion of handling uncertainty and its relation to risk. Theorists such as Knight, Keynes, Schön, and Lester actually use the term uncertainty and try to describe what they mean by it, how they distinguish uncertainty from risk, and at times prescribe what one could or should do about handling of uncertainty.

Given this difficulty and drawing on their insights, we quickly arrive at an important and sharp distinction between 'managing risk' and 'handling or dealing with problematic situations of uncertainty' in these broader approaches to risk. I ask a central question: why has so little attention been paid to this distinction? As Lester and Piore (2004) argue, this question directs us to the very definition of risk and uncertainty in the writings of Frank Knight (1921) and to Reddy's (1996) argument about the triumph of risk over uncertainty in contemporary society.

Therefore, if we are to develop this argument, we firstly need to understand situations of Knightian uncertainty, which is unique in form and function, and uniquely characterises many poorly theorised instances of organisational life inclduing indeterminate zones of practice during innovation (Lester and Piore, 2004). In situations of Kinghtian uncertainty practitioners cannot simply employ clear-cut means to achieve pre-defined or measurable ends and there is ambiguity about the likely undesired or desired events that appear. in situations of professional practice, for example, practitioners encounter unformed, multifaceted, unfamiliar, and very unique yet pressing situations in which action is required but they do not have a clear definition of the problems because the phenomena are, by and large, compound and ill-defined. It is not surprising that situations of Knightian uncertainty do not easily lend themselves to precise quantitative expression because possible outcomes appear to be fuzzy, vague or indeterminate and the smallest impulse may generate unintended consequences or unforeseen opportunities which can change the whole course of action.

So the second and indeed the essential difficulty in compiling this review is that for some, uncertainty and risk function in the same way, i.e. as explanatory notions that illuminate one facet or feature of humanity's practical activity and organisational experience. For a few (whom I want to defend), the notion of uncertainty is primarily important because of its relevance not only to organisational life but something fundamental and crucial for

'improving' organisational competence in handling problematic situations of practice such as risk management.

The terms 'risk' and 'risk management' have been widely used to describe the goal of minimising threats and maximising opportunities in the face of problematic situations, often within well-defined scenarios and strategies. But I want to argue that the notion of 'risk management' should imply the associated notion of 'handling uncertainty' not merely at the level of espoused theory (words) but at the theories-in-use level (actual practice). I believe that the main challenge is not merely to help organisations and practitioners become more effective at the performance of well-defined tasks (as in instrumental risk management in innovation) in the light of rational, stable assumptions and to repress situations that defy such formulations, rather to help them reflectively recognise and resolve ill-defined, ambiguous and multifaceted phenomena. A term like 'handling uncertainty' then becomes central in order to improve not only the practice of risk management in innovation but also other practical activities across professions in which uncertainty plays a central role. For this reason, I propose a theory of handling uncertainty in juxtaposition with conventional views of 'risk management'.

The observation that organisations fail to handle uncertainty effectively does not count against the utility of the term 'risk management'. On the contrary, I believe it is because organisations fail to notice that one should first arrive at the importance of 'handling uncertainty' for improving reflective practice in uncertain environments.

It, then, becomes important to examine both the risk and the uncertainty literatures to distinguish efforts that foster *a priori* logic, rules of relevance, and proceduralised action for solving well-formed problems of risk from efforts that actually recognise open-ended situations of uncertainty in which one needs to find or formulate the problems and settle the

risk and rewards rather than to resolve the knowable risks. I do so to provide a basis for such artistic inquiry that involves non-rational inference, ongoing reflection, on-the-spot experimentation, and creative intervention. All of this then leads me to identify and illustrate the two contrasting yet complementary 'ways of knowing and doing' in practitioners' encounter with 'radical/Knightian uncertainty'. The principal challenge, then, is to invent a productive yet plausible synthesis of the variety of perspectives on risk and uncertainty. I believe that such a synthesis is more likely to be achieved from a stance that has very much to do with handling Knightian uncertainty in organisations in a reflective and pragmatic manner, one that is grounded in the requirements of actionable theory.

3.4.1 Knightian Uncertainty

According to Frank Knight, uncertainty is something quite different from risk (Knight, 1921: 233):

> Uncertainty must be taken in a sense radically distinct from the familiar notion of risk, from which it has never been properly separated. The term risk as loosely used in everyday speech and in economic discussion really covers two things which, functionally at least, in their casual relations to the phenomena of economic organisation, are categorically different...the essential fact is that 'risk' means in some cases a quantity susceptible of measurement, while at other times it is something distinctly not of this character; and there are far-reaching and crucial differences in the bearings of the phenomenon depending on which of the two is really present and operating.

Knight says that we should use the term 'risk' for measurable uncertainty, and *restrict* the term 'uncertainty' to unmeasurable cases that are not, in effect, uncertainty at all from a philosophical point of view (Knight, 1921: 20) because actual situations of uncertainty involve a dynamism more complex and broader than 'immeasurability'. In situations of uncertainty both the outcomes and their chance of occurrence are either unmeasurable (because of their uniqueness) or only measurable with insufficient precision.

3.4.2 Defining Uncertainty

My notion of uncertainty in this study rests on Knight's conceptualisation that in uncertain situations we deal with a high degree of uniqueness and unsteadiness (such as many instances of product innovation) for which it is impossible to precisely formulate the character and chances of all possible outcomes in advance (Campos et al., 1999, Piore and Lester, 1999). In order to shed some light on this argument I refer to Schön (1967) whose explanation for uncertainty is very similar to that of Knight. Schön's account of uncertainty is worth quoting in full here (Schön, 1967: 21):

> A situation is uncertain when it requires action but resists analysis of risk. A gambler takes a risk in an honest game of blackjack when, knowing the odds, he calls for another cards. The same gambler, unsure of the odds and of the honesty of the game is in a situation of uncertainty. He can act but he cannot estimate the risks or rewards of his action. Even so, he operates in a risk-like situation because, at any rate, he has two well-defined alternatives – to call for another card or not to call for it. But an explorer lost in the woods, short of food and water, confronts a greater uncertainty: he must act even though relevant alternatives are undefined. He must invent what to do. He has no way of calculating with any precision the risk of action. He has only rough guidelines of skill and experience to help him. A usual model of uncertainty is this: two alternatives are presented – which shall I take? But this model presupposes a great deal of structuring, of work on the situation. A more relevant model consists of a man in a situation which is both unfamiliar and problematic. Action is required. But it is unclear not only to do this or that but what there is that might be done. The situation is like a game of chance in which not only the odds but the moves themselves are undefined. The situation can be described as one in which there is either too little information (not enough to permit decision) or too much. On the second model of uncertainty above, 'too much' is more appropriate. There is more information than our theory of the situation can handle.

Schön seems to be making a threefold distinction: the gambler in a fair game, a gambler in an unfair game (or one suspected of being unfair), and someone lost in the woods. In the first situation we are talking of a well-defined problem in which alternatives are clear, outcomes are known and the likelihood of outcomes is measurable. In the second one we still have a well-defined problem (unfair game) for which there are still two clear alternatives but their

likelihood is in the state of uncertainty, hence not measurable. In the third situation something needs to be done but the situation itself is ill-defined and the problems are not clearly given. Schön here seems to be suggesting there is uncertainty around the actions that are required; hence both the possibilities/problems and their relevant probabilities involve a state of uncertainty and are not measurable. They must be invented and reinvented as events require.

Explicit in the third situation is recognition of the existence of situations that display multiple, complex interactions of variables and for which no relatively simple, highly predictive theory is adequate or even available at the outset. In these types of situations, one deals, in fact, with high degrees of uniqueness and novelty; situations that are doubtful, dicey, unstable, and of course problematic (Dewey, 1930). The distinctive characteristic of these situations, one which is so inherent that it cannot be eliminated, is the uncertainty associated with each situation one encounters. Action is required but one must act at one's peril because judgment regarding actions to be performed can never attain more than a precarious probability (Dewey, 1930: 5).

In Economics, Keynes, in particular, built on the Knightian distinction to argue that any approach to stabilise the economy would have to come to terms with the fact that investors' behavior is essentially radically uncertain and indeterminable and not subject to probabilistic or risk analysis (Reddy, 1996). Keynes believed that humans' animal spirits could be rightly viewed only from the perspective of uncertainty, or radical and truly uncharacterisable indeterminacy. In Keynes' words (Reddy, 1996: 229):

> By 'uncertain' knowledge…I do not mean merely to distinguish what is known from what is merely probable. The game of roulette is not subject, in this sense, to uncertainty… The sense in which I am using the term is that in which the price of copper and the rate of interest twenty years hence, or the obsolescence of a new invention are uncertain. About these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know…now a practical theory of the future based on these principles [for dealing with uncertainty despite its incalculable character] has certain marked characteristics. In particular, being based on so flimsy a foundation, it is subject to

sudden and violent changes. The practice of calmness and immobility, of certainty and security, suddenly breaks down. New fears and hopes will, without warning, take charge of human conduct. All these pretty, polite techniques, made for a well-paneled board room and a nicely regulated market, are liable to collapse.

One difficulty with Knightian uncertainty is that unfamiliar, unformed and uncertain phenomena are a pervasive feature of professional, organisational, and social life, to which we pay, understandably, little attention (Lawson, 1985). From a philosophical and psychological perspective both William James (1953) and Harry Stack Sullivan (1965) indicated that our entire frame of discourse is designed for formed situations, thereby we consciously or unconsciously put aside unformed and uncertain phenomena as the sources of fear, confusion, stress, and anxiety.

The triumph of risk over uncertainty

Perhaps that is why Reddy (1996) has observed a triumph within Economics of the notion of risk over uncertainty such that that most people including economists confuse the two. Confusing the two has led to what von Hayek (1974) saw as 'the pretence of knowledge' in many risk management methodologies.

In a similar vein, in the context of innovation, there are innovation scholars (Bucciarelli, 1994; Piore et al., 1994; Van de Ven et al., 1999; Lester and Piore, 2004) who argue that dealing with these kinds of situations is central to the world of product innovation.

Dewey (1938) and Schön (1992) recognised that under uncertain circumstances the construction of a manageable problem is an invention or a creative attainment and their treatment of such problematic situations shows that there seems to be a categorical distinction between situations of risk in which alternatives, outcomes and their likelihood are defined and relatively measurable and those of uncertainty for which we need to reframe an ill-defined, puzzling and unfamiliar phenomenon so as to *convert* it into a problem with a

relatively ordered character, with boundaries, trends and, on occasion, probabilities that allow risk management.

3.5 Approaches to the Handling of Uncertainty

These definitions and descriptions suggest that however we may see a continuum with degrees of uncertainty, often there is little similarity between conventional risk management on the one hand and dealing with high degrees of uniqueness and uncertainty on the other hand. We shall see that risk management theories, for the most part, suggest a secondary set of rules and routines that are made possible through a set of primary activities, a prior overarching process that iteratively *converts* the uncertain phenomena into packages of manageable problems. By reviewing some of the different approaches we shall see how each of these define uncertainty and how they might be used to capture and accommodate the complexities of processes involved in such conversion. I examine the following approaches to see what sort of insights they might offer to the integrated conceptual framework I shall develop for handling situations of Knightian uncertainty that are common during the process of product innovation.

3.5.1 Handling Uncertainty by Hindsight

For actor-network theorists, organisations are networks of heterogeneous actors. Because the notion of 'actor' for them can be attributed to both the social and technical, object and subject, human and machine, this theory treats uncertainty as something that springs from viewing the interaction among heterogeneous actors (humans and nonhumans). The interaction may eventually shape an emerging and evolving 'network' with its unpredictable 'web of moves and relationships' (Callon, 1986, 1991).

The relationship between actors may, however, remain stable and predictable so long as they remain unchanged, untransformed, determinate and faithful to a pre-settled network – wherein Latour reduces actors to *intermediary*. Some societies or organisations can make the

cost of alternatives too high to reduce uncertainty and make sure that social actors remain *intermediary*, and hence predictable in the pre-defined social arrangement (Latour, and Woolgar, 1986). Apparently for actor-network theory (ANT) this is not the case.

Metaphysically speaking, Latour treats uncertainty as something inherent in the world and as a mystery that springs from the mastery of an outside agency (perhaps of the highest order) that provides resources for every single course of action that is to be fulfilled by actors (Latour, 2005: 244). In *Reassembling the Social* (Latour, 2005: 242) Latour argues that 'the world is not a solid continent of facts sprinkled by a few lakes of uncertainties but a vast ocean of uncertainties speckled by a few islands of calibrated and stabilised forms'.

Viewed as such, Latour presents a theory for understanding 'uncertainty' that comes from this outside inspiration. He believes that uncertainty and the emergence of new actions must be inclined toward considering a world spirit, a plasma, an ether, a background, an everything that resists prediction and full control, for this outside agency is itself not made of social stuff. It is not itself from the property of human/nonhuman actors.

ANT theorists particularly draw on Garfinkel (1984) who argued that the 'ratio of what human has formatted to what he ignores is astronomical' (Latour, 2005: 242), that the stability in social forms and fashion as well as the unity in social aggregates are exceptions. Instead uncertainty and indeterminacy are the norms (Latour, 2005: 40). By uncertainty, ANT theorists emphasise the unpredictability of the behavior of actors as *mediators* rather than *intermediaries*. In the words of Latour (2004: 39):

> An intermediary is what transports meaning or force without transformation: defining its input is enough to define its output…mediators transform, translate, distort, and modify the meaning or the elements they are supposed to carry…their input is never a good predictor of their output; their specificity has to be taken into account every time.

The outcome of actors' interactions and the shape of their associations remain uncertain prior to action. Mediators that render change and renew social ties and arrangements appear to be indeterminate, unstable, and unpredictable, yet their character and their associated output can be explored and examined by tracing their movements and connecting the dots but only after-the-fact. The resultant networks, or the 'web of moves and relationships' can be depicted and explained when action is fulfilled.

An unknown outside agency provides an immense repertoire of missing masses for every action. Missing masses are unknown to us but balance the accounts (Latour, 2005: 245). This outside agency travels through everything and between the meshes in a network (Latour, 2005: 241). It imposes the laws of the social world on actors (human and nonhuman) in their web of relationship (Latour, 2005: 246). If we are to make sense of the uncertainty from which it springs we have to explain the laws that it imposes on actors only *after* action. We cannot formulate causality, rather we have to 'follow the actors and connect the traces left' and get 'back to the things themselves', including mediators and intermediaries.

When reference to uncertainty is treated as the ending rather than the beginning of inquiry, this approach to understanding of uncertainty become theories of mystery, theories of after-the-fact, or 'understanding uncertainty by hindsight'. This perspective takes the 'mediating actors' they are trying to explain and put an 'uncertainty about their likely behavior' in place of their reluctance to influence or inform their behavior or the outcome. What stops inquiry prior to the event is not merely uncertainty but also the inscrutability actor-network theorists attribute to the will of an outside powerful agency.

Since this perspective addresses uncertainty mostly to an outside agency, powerful but unknowable, from which ideas spring and action is inspired, it advocates an unreflective (Whittle and Spicer, 2005) and passive approach to dealing with conflict and ambiguity in social systems. What resists inquiry about this unknown outside agency is our ignorance and the inscrutability attributed to it. Actually, the notion of idea transmission from an outside

agency helps to account for some features of the emergence of new action: the sense of uncertainty, uncontrollability, and unexpectedness from outside. But the process of transmission of ideas, intuition, or insight in dealing with situations of uniqueness, indeterminacy and uncertainty is pictured mysterious and to be understood in hindsight. The problem of explanation is merely shifted: the idea, movement, action that are transformed and mediated, how did they come to be framed and formulated in the first place?

In the context of organisation, this view properly shed light on the ongoing existence of uncertainty and chance in professional practice. It provides a valuable framework for the empirical analysis of the organising process, yet it does not provide a critical account for pursuing a pragmatic and reflective stance important in handling indeterminate zones of practice.

3.5.2 Handling Uncertainty by Selective Inattention, Rejection, and Suppression

Selective Inattention

For psychologist Harry Stack Sullivan (1965) there are two sources of motivation for people: the pursuit of satisfaction and the pursuit of security. On the one hand, people seek to maximise the satisfaction of individual (mainly biological) needs to reduce tension. On the other hand, people desire to minimise the insecurity that arises from cultural and social needs. The main motive force of personality, for Sullivan, is to avoid and reduce anxiety. In his approach, Sullivan argues that human beings seek to avoid a greater anxiety by selecting a lesser anxiety according to their entire frame of discourse which has been designed to put aside, consciously or unconsciously, sources of insecurity or anxiety. For Sullivan (1965: X):

> Anxiety is a symptom of all threats to security, particularly threats from unwelcome dissociated impulses which are part of the entire personality; and the hint of anxiety is the signal ordinarily for the self system to control the spread of awareness.

It is important to note that Sullivan focuses on 'interpersonal relationships', hence anxiety for him is an 'interpersonal phenomenon' and 'inherently social', so more than a merely psychological experience.

According to Sullivan, anxiety is mainly caught from our caretakers since childhood. Infants are born with an anti-anxiety system (what Sullivan terms 'self-system'), having an empathic capacity to sense the attitudes and feelings of significant people. Based on the network of relationships in which the infant is enmeshed, the anti-anxiety system gradually leads them to experience and develop two modes of behavior: euphoria and dysphoria. Infants experience euphoria when they sense approval from significant others and dysphoria when they sense disapproval. A non-anxious persona is experienced as the good mother as opposed to an anxious persona who is experienced as the bad mother. Accordingly, the 'good me' is the one who evokes approval, tenderness, satisfaction, and less anxiety in the other and the 'bad me' is the one who evokes disapproval, discontent, angst, and insecurity. Sullivan identified one additional infant mode of experience, i.e. the 'non-me'. In 'non-me' states the anti-anxiety system feels and experiences the unknown, uncertain, undefined, uncanny, unfamiliar, and the un-integrated. The situation appears to be irregular, fearful and confusing, accompanied by intense anxiety (e.g. nightmares and schizophrenic experiences). To avoid this intolerable level of anxiety, the anti-anxiety system attempts to convert the confusing situation into the familiar 'good me' or at least 'bad me' states to achieve a lesser state of anxiety.

Depending on the tacit frames of disapproval/approval individuals, begin to also employ dynamisms, strategies, maneuvers, by which they can avoid, terminate or reduce anxiety. Such efforts are in fact 'security operations' by which the anti-anxiety system avoids derogation and abandonment, assuring the individual of affirmation and social security. Sullivan (1965: 4) argues:

In avoiding or minimising the anxiety that is inherent in the unceasing struggle to protect the self-system from the diffuse referential processes that cannot be admitted into awareness, various specific dynamisms come into play…these dynamisms have a relation to the protection of the self-system from the minor but effective manifestation of anxiety and the more threatening possibility of the collapse of the self-system.

To achieve security, individuals develop certain 'defensive dynamisms or strategies' to control their awareness, namely 'selective inattention'. Selective inattention, then, readily restricts and regulates personal acts and thoughts in its encounter with insecurity or uncertain and puzzling situations. Such 'defensive routines' (Argyris, 1999) influences ones' observation and analysis of the phenomena, and this helps the self-system notice what it desires to see and remains inattentive to what it does not, navigating awareness on those actions that bring approval and win rewards and escaping disapproval and punishment and, more importantly, the 'non-me' states. As Sullivan puts it (1965: 4, 6, 7, 38, 50, 56):

[o]f the most important dynamisms for controlling awareness I would like to refer to is selective inattention…the explanation, I believe, is to be found in a universal bit of human equipment – selective inattention – which to great extent enables us to stay as we are, despite remarkable experiences that befall us simply by keeping the attention on something else, in other words by *controlling awareness* of the events that impinge upon us…selective attention in the classic means by which we do not profit from experience which falls within the area of our particular handicap. We don't have the experience from which we might profit that is although it occurs, we never notice what it must mean; in fact we never notice that a good deal of it has occurred…in many cases, there is an unfortunate use of selective inattention, in which one ignores things that do matter; since one finds no way of being secure about them, one excludes them from awareness as long as possible…in other words it is the way we avoid having to change as a result of the experience that we have had

Thus, people have a repertoire of self-censorship and self-deception tools in order to deal with sources of insecurity and 'non-me' situations of uncertainty, and to seek to reduce the anxiety stemming from puzzling phenomena to an activity within their satisfaction or at least familiar range. Hence it is not surprising that uncertainty usually escape from our awareness

in spite of the experiences impinging upon us. As William James argued, irregular and unclassified phenomena are easier to ignore than to attend to (James, 1953). Reduction of anxiety into acceptable bounds might be achieved by the reduction of complexity by institutionalising cultural norms and rituals (Douglas, 1982, 1992), rationalisation (Aronson, 1971; Lupton, 1999a), the reducing of information, and downsizing the scope and the conceptual reduction of a problematic situation as we usually see such matters in narrow technical/rational explanations (e.g. see 2.4.2).

Rejection and Dissociation

For Sullivan there is one more extreme type of selective inattention, i.e. 'dissociation', which in Freud's sense is 'repression'. Here the individual denies the entrance of any insecure or confusing event into the consciousness altogether. One pays no heed to the phenomenon when dealing with it, as though one closes one's eyes and takes no notice of surprises, ambiguities or uncertainties that may exist around the situation.

Suppression by Myth Making

In the last chapter, we observed that to the extent that an organisation engages in technological innovation it must cope with ambiguity and anxiety. One way of protecting an organisation from the anxiety of uncertainty is the creation of taboos (Douglas, 1992: 30) and myths, e.g. in the form of corporate mythology (Malinowsky, 1954; Goffman, 1961; Morgan, 1997).

For Malinowski, Goffman, and Morgan, among others, the creation of myths is another variant of repressing or rejecting anxiety and ambiguity. Malinowski (1954) argues that myths are cultural responses to situations provoking anxiety and dread. They serve principally to establish a sociological charter and order of ideas entirely different from the real or scientific relation of cause and effect. Myths represent humanity's interest in and need to supplement the rational control of uncertainties in phenomena (Malinowski, 1954: 144).

Goffman (1961: 217) also observes a myth making tendency in patients associated with the stigmatising label of insanity when they were confronted with uncertain and dangerous situations such as playing cards or social interaction with outsiders.

In organisational contexts, Morgan (1997) points to the myths about corporate heroes (Morgan, 1997: 129), myths of organisational rationality, and myths of corporate origins. Morgan (1997: 141) argues that one of the most important myths of modern society is the myth of rationality. The myth of rationality provides corporations with a comprehensive frame of reference or structures of belief through which they suppress the ambiguous, fuzzy, treacherous, and anxious aspects of certain patterns of action to render them clear, credible, normal, and orderly. Corporate myths, like cultural myths, help corporate community to avoid the wrangling that would arise if they were to recognise the uncertainty inherent in certain situations. Corporate myths are selective views of corporate life and no one may feel the need to reconfirm them.

It can be seen that, there are many ways to deny uncertainty and foster mythology in order to legitimate actions and persuade others to see what we want them to see and achieve social cohesion and order (Lupton, 1999a). This could also help to avoid the shame and embarrassment of acknowledging a lack of control. The messy, uncertain and unruly character of uncertain phenomena can be 'white boxed' (Wynne, 1988).

For Mary Douglas (1966), it is 'taboo' that functions so as to repress a broader or more radical recognition of uncertainty, one that extends beyond the accepted cultural frameworks. Douglas (1966) suggests that cultures have a variety of methods to suppress uncertainty around phenomena. The following approaches are ways by which cultural contexts permit the formulation of hypothesis to explain situations that could fall outside an acceptable frame of discourse:

- by classifying a phenomenon into one category only and maintain it within the category, thus reducing the potential for uncertainty;

- by physically controlling it and removing it;

- by strengthening and affirming the classification system that renders a phenomenon as anomalous;

- by using rituals, as in poetry and mythology to enrich meaning or call attention to other level of existence.

To sum up, selective inattention, repression, dissociation, taboo creation and myth-making help individuals and organisations to deal with uncertainty, but these conservative (and at times counterproductive) ways of operating have the potential to generate crises in situations of nonlinear change and higher instability, at which point the actors can no longer mask the denials, myths, and repressions and in consequence are faced with more information than they can handle.

3.5.3 Handling Uncertainty by Reframing, Reconfiguration, and Reorganisation

Here I shall attempt to relate the process of handling uncertainty to the role of 'sense-making', 'pattern forming' (Gestalt) and 'family resemblance'. Some of these terms are far from new and have a broad range of partly related and partly unrelated meanings. But some of their meanings are selected and are aligned with the definition of Knightian uncertainty in this thesis.

Sense-Making

Karl Weick (1995, 2001, 2005) has developed a new theory for handling uncertainty through an analysis of 'sense-making' in organisations. Sense-making, from Weick's view, has to do with tackling ambiguity, turning it into a situation that can be communicated and comprehended explicitly in words. It involves an ongoing retrospective development of

'plausible images' that justify and rationalise what people are doing (Weick et al., 2005). As a springboard into action, sense-making helps people deal with disruptive conditions, and construe what is happening by formulating plausible images and explaining them using reason. Reason here derives from acceptable justifications, expectations, traditions inherited from predecessors, institutional constraints, and organisational premises (Weick et al., 2005). The confusing 'new whole' is in fact a hidden conjunction of old ideas that needs to be explored and recombined.

Such detection and combination of plausible explanations using reason inevitably involves selective (in)attention to the abundance of information inherent in the confusing situation. But any selective interpretation of confusing phenomena is better than nothing. Drawing on Goffman (1974: 30) who says that 'we tolerate the unexplained but not the inexplicable', Weick (2002: 31) claims:

> What is unsettling when people face the inexplicable is that they tend to treat any old explanation as better than nothing. There is something healthy about that tendency because it provides a kernel around which people can organise a story. The initial story may be a stretch. But it makes some sense of the senseless.

Armed with this type of sense-making, plausible explanations should be 'forcibly carved out of the undifferentiated flux of raw experience and conceptually fixed' (Weick and Sutcliffe, 2005) such that unfamiliar situations become more familiar. In other words, in this process of taming the flux one strives to frame and reframe the incomprehensible phenomena as long as one is able to find clear and plausible stories. However, Weick argues that the new whole is not essentially new given that it has already occurred but may not yet be named. The new whole needs new interpretation or a new label to become meaningful and communicable (Weick, 2002, 2005).

Therefore, in situations of professional practice, in order to simplify an ambiguous phenomenon practitioners needs to draft and redraft a story on the basis of given 'reasons' so

that it becomes more communicable and meaningful. What is evident is the existence of a repertoire of conventional orthodoxies and theories by which practitioners can exclude and construe those stories that seem more sensible, plausible and meaningful. So, choices are made on the basis of bits of information currently available and deemed reasonable. Other implausible and unreasonable information might be discarded because it cannot be communicated, thereby propositions which were neither reasonable nor comprehensible are held to have no meaning. They might be dismissed.

Everything that resists plausible explanation and reason or does not conform to one's given theories can be put aside. Only the similarities are retained and reflected upon, and in this way a general idea of a given class of objects is formed in consciousness. This makes an unformed or ill-defined phenomenon gradually take shape and ready for further interpretations; action gets routinised, flux gets tamed, objects get enacted and ambiguity is turned into 'actionable knowledge'.

Gestalt Theories

Having shown that the perceptual or conceptual whole is more than sum of its parts Gestalt psychologists argue that dealing with uncertainty demands radical changes that are far from additive recombinations of old ideas. Having begun with studies of subjective perception, Gestalt psychologists have extended their findings to objective conceptualisation as well (e.g. Wertheimer, 1959). For them the emergence of new ideas to deal with uncertainty involves unique personal knowledge and insight. It needs an organic and dynamic approach rather than a mechanistic, law-like, and logical approach. Therefore, Gestalt psychologists, and chiefly Wertheimer (1959), argue that tackling uncertainty demands unique personal attitudes in pattern formation and unique perception in new conceptualisation.

Wertheimer (1959) argues that solving problematic situations demands a unique approach in thinking to find a causal Gestalt relation between 'experienced fact' and 'internal response'.

In this approach, formation of a Gestalt pattern for uncertain and confusing situations demands re-modification of the old whole, reframing the rules of the game, and disintegration of the situation by changing order of things.

Similar to sense-making, Gestalt forming involves rejecting some information and selecting other information and reorganising, reframing, or re-configuring the remaining information. During this reorientation some parts of the old experience *change* in their meaning and new frame or organisation is more than the sum of its parts (Kohler, 1948, Wertheimer, 1959).

As an illustrative example, two organisation theorists recently have developed a new meaning for strategy (Kim and Mauborgne, 2004). While many strategy authors (Porter, 1985) foster a rational process for achieving 'competitive advantage', Kim and Mauborgne advocate an approach in which competition becomes irrelevant. It seems as if they have found a Gestalt pattern through which the framework has changed from fighting over existing customers to creating demand for existing non-customers.

Gestalt writers emphasise the significance of the dynamic and active contribution of people through conceptual structuring of perceived and experienced uncertainty. For them 'insight', in other words 'a direct personal inner sight' or 'spontaneous self-reflection', which springs from sincerity, courage, and desire, pushes one so as to reframe and transform a conflicting and vague situation. This direct experience seems to counter scientific deduction or law-like methods. But it also implies that there is nothing further to be explained about the emergence of the cognitive means which form insight or reflection. Gestalt psychologists define insight in terms of 'sudden reorganisation of perceptual fields' (Schön, 1963). What is more emphasised in Gestalt theory is the inadequacy of the logical or law-like re-combinations of pre-existing ideas suggested by rational/scientific methods of inquiry. However, although Gestalt writers point to the need for inner insight or personal reflection, the notion of insight itself remains unexplained and inscrutable (Schön, 1963; Koestler, 1967).

Family Resemblance

The notion of 'family resemblance' is an influential idea in Wittgenstein's philosophy. It is introduced to clarify how we think about the sense and meaning of certain words. Wittgenstein uses the analogy of 'family resemblance' to show how a concept is extended beyond to cover more than one phenomenon. Wittgenstein (1953: 65-69) with his notion of the 'family resemblance of phenomena' tells us:

> Instead of producing something common to all that we call language, I am saying that these phenomena have no one thing in common which makes us use the same word for all, but that they are related to one another in many different ways. And it is because of this relationship, or these relationships, that we call them all 'language'…Consider for example the proceedings that we call 'games'. I mean board-games, card-games, ball-games, Olympic games, and so on. What is common to them all? Don't say: 'There must be something common, or they would not be called 'games' – but look and see whether there is anything common to all. For if you look at them you will not see something that is common to all, but *similarities*, *relationships*, and a whole series of them at that. To repeat: don't think, but look!…Look for example at board-games, with their multifarious relationships. Now pass to card-games; here you find many correspondences with the first group, but many common features drop out, and others appear…When we pass next to ball-games, much that is common is retained, but much is lost. Are they all 'amusing'? Compare chess with noughts and crosses. Or is there always winning and losing, or competition between players? Think of patience. In ball games there is winning and losing; but when a child throws his ball at the wall and catches it again, this feature has disappeared. Look at the parts played by skill and luck; and at the difference between skill in chess and skill in tennis…And we can go through the many, many other groups of games in the same way; can see how similarities crop up and disappear…And the result of this examination is: we see a *complicated network of similarities* overlapping and criss-crossing: sometimes overall similarities…I can think of no better expression to characterise these similarities than 'family resemblances'; for the various resemblances between members of a family: build, features, color of eyes, gait, temperament, etc. etc. overlap and cries-cross in the same way. And I shall say: 'games' form a family…But if someone wished to say: 'there is something common to all these constructions − namely the disjunction of all their common properties' I should reply: Now you are only playing with words…the *extension of the concept is not closed by a frontier*. And this is how we do use the word 'game [emphasis added].

Viewed as such, 'family resemblance' has to do with a non-rational inference, with an inquiry process for finding 'symbolic relations' (Schön, 1963: 48) or 'symbolic forms' (Cassirer, 1953) between one's old theories and a new ambiguous phenomenon. One may find family resemblance in the relation between already formed concepts or may use it to discover or formulate new hypotheses. The resemblance comes from an observation of similarity between theories and concepts already formed and elements of an uncertain or new situation. In short, the theory of family resemblance points to a deeper epistemological view by showing that the next instance of a term or concept may indeed require change in the theory for that concept as well as showing how one may find symbolic relation between one's old theories (concepts, things, images, schemes and categories) and the new phenomena using a resemblance of attributes between them, i.e. interrelation analogous to the overlapping similarities in appearance of the members of a family.

3.5.4 Handling Uncertainty by Consolidation and Specialisation

Knight (2006) argues that in economies people must make decisions based on imperfect knowledge, that most business decisions involve a step into an unknown that is to some degree unmeasurable. Likewise, Keynes (1970) observes that 'human decisions affecting the future, whether personal or political or economic, cannot depend on strict mathematical expectation, since the basis for making such calculations does not exist' (Keynes, 1970: 162).

Knight's definitions of risk and uncertainty are uniquely tied to the actors' specific personal attributes when they come to read an indefinite 'situation in question' and construct the means and ends to convert it into a definite one. These definitions are based on his threefold classification of unknown outcomes (Knight, 2006: 224-25): (1) *a priori* probabilities, which are derived deductively, as in throwing a dice; (2) statistical probabilities, which are generated by empirical evaluation of relative frequencies, as in life insurance; and (3) estimates, in which 'there is no valid basis of any kind for classifying instances' for a situation in question, as in innovation (Knight, 2006: 225) and usually can be handled by both

deductive and inductive reasoning. Knight identified risk with categories 1 and 2 and uncertainty with the third. Therefore his attempts were inclined toward converting and reducing uncertainty in the future to categories 1 and 2. In this sense, Knight's comments about the formulation of hypotheses regarding uncertainty in the future have to do with the way such processes work.

Knight argues that, in general, the future situation in relation to which we act depends upon the behavior of an indefinitely large number of factors and no real effort can be made to take account of them all (Knight, 2006: 211). Therefore, it is only in very special cases that *a priori* probabilities, quantitative study, or scientific deduction can be used. Knight suggests that we must reason 'deductively' as far as possible but where the information is too much or too complex to handle, deductive reasoning becomes unmanageable and errors creep in (Knight, 2006: 8). In these indefinite and uncertain situations 'inductive reasoning' must be applied to find a universal, a whole, or gestalt from the particular.

Developing a proposition about uncertainty in the future, therefore, has two components: (i) developing deductive logic using scientific means and rational methods, and (ii) inductive reasoning using personal insight and opinion based on past experience. For Knight 'deductive means' mainly rest on scientific analysis and 'objective probability', while inductive reasoning usually springs from one's personal intuition, opinion, belief or 'subjective probability'. These two types of probability are in fact two interrelated guesses for developing valid propositions about the uncertainty in future.

How does 'objective probability' work? Knight argues that uncertainty is less present in groups than in single cases, hence we need to classify cases that are similar in their modes of behavior. In order to classify objective probabilities, Knight has a doctrine – to find a working number of properties or *modes of resemblance* between things because, generally speaking, things manifest constant modes of behavior (Knight, 2006: 204), and 'the world is

made up of things which under the same circumstances always behave in the same way' (Knight, 2006: 205):

> It must be possible not merely to assume that the *same* thing will always behave in the same way, but that the *same kind* of thing will do the same, and that there is in fact a finite, practically manageable number of kinds of things.

Knight's theory for reducing uncertainty by objective probability involves probabilistic reasoning when he treats hypotheses about the future as relatively law-like recombinations of old instances or the synthetic bundling together of similar kinds of things. But law-like recombination in Knight's argument is not based on *a priori* reasoning, rather that of statistical probability. Knight emphasises that *a priori* methods are inapplicable and hypotheses could be developed by an empirical method of applying statistics to actual instances. Statistical groupings of instances combine and classify on the basis of modes of resemblance, similarity, proportion of distribution, and frequency of association. Knight calls this type of grouping using statistical probability as 'consolidation'. In some ways, Knight's consolidation is similar to Wittgenstein's 'family resemblance' and theories of 'framing' but his underlying principle for grouping and consolidation centers on empirical analysis and systematic methods carried out by technical specialists.

Thus, what distinguishes Knight from those probabilistic methods is his emphasis on the inductive reasoning or intuitive judgment unique to specialists. Knight argues that although it is possible to reduce uncertainty by the expedient of grouping or consolidating instances based on deductive reasoning, this *does not necessarily mean that it will be done*. So unconscious induction or intuitive judgment is the complementing basis of classification of instances to reach a valid probability judgment (Knight, 2006: 229). In other words, any difference in human attitudes toward uncertainty must be understood and taken into account because there is a difference among individuals in their subjective feelings about making a prediction about an indefinite future. Accordingly, individuals differ in consolidating and

grouping of instances given their individual preferences and the different ways they use their intuition, insight, faith, cues, hunches, and in short 'subjective probability'. Put differently, a difference in confidence or belief that one's guess is valid and appropriate could change the opinions upon which conduct is based (Knight, 2006: 232). As Knight (2006: 236-237) argues:

> Any coincidence that strikes attention is likely to be elevated into a law of nature, giving rise to a belief in an erring 'sign'. Even a mere 'hunch' or 'some things tell me' with no real or imaginary basis in the mind of the person himself, may readily be accepted as valid ground for action and treated as an unquestionable verity…it is clearly the subjective uncertainty which is decisive in such a case, what the man believes that chances to be, whether his degree of confidence is based upon an objective probability in the situation itself or in an estimate of his own powers of prediction.

Therefore non-objective and objective types of probability calculations are involved at the same time and the degree of perceived uncertainty is a product of two interpenetrating probability ratios. Inductive reasoning, which informs our subjective probability, juxtaposed with statistical probability or scientific deduction but the greater part seems to rest upon the former (Knight, 2006: 237). So it is important to note the difference in people's feelings and the difference in their position in relation to vagueness and ambiguity. As a result, Knight's second fundamental principle centres on the selection of 'special humans' who could bear the burden of tackling situations of confusion, indeterminacy, and uncertainty. This is what he terms 'specialisation' which points to a selection of responsible people (e.g. entrepreneurs) who feel confident when they come to questions of classifying and framing vague situations, who could tolerate the complexity and puzzlement of consolidation, who could handle uncertainty without being saddled with it. Knight, however, does not provide further details about the different types of mentality to consider when choosing special humans and how in practice such people distinguish between the three above-mentioned situations of uncertainty.

A comment on framing

There is one factor inherent in all framing theories – the relation between an individual's competence at framing in an encounter with unprecedented events and the level of anxiety he or she is able to tolerate. Although Knight emphasizes specialisation, and the fact that grouping and classifying areas of experience demands special capabilities, I argue that Sullivan's notion of anxiety is more illuminating and, in fact, fundamental to the function of 'framing'. Sullivan (1965) investigated the progress in mental development from perception through concept formation to mature learning in an in-depth study of schizophrenics for whom this maturing did not take place. Sullivan's study is based on multiple 'interpersonal experiences' and refers to a process prior to individuals' capability to record and remember patterns, symbolic forms and relations, concepts and frames about their experience.

Sullivan (1965) reports that normal development might not take place if uncontrolled anxiety is present, even part of the time – that the satisfactory interpersonal processes that were significant for reducing anxiety were implicit feelings of tenderness and love between 'the child' and the 'mothering one'. In other words, the capacity to tackle uncertainty, to work with irrelevances, to impose a frame on vague phenomena, to classify instances, to find modes of resemblance, symbolic forms and Gestalt patterns, heavily depends on amount of anxiety one can tolerate. This capacity will develop only if there are adequate interpersonal relationships which not only reinforce the self-system (for the reduction of anxiety) but also build upon learning capacity. This can be extended to one's competence in accumulating knowledge, in utilising intuition, in finding family resemblance and symbolic relation and in using insight. So openness to tackling chaos, and confusion and to developing new correlations and patterns is openness to invention if and only if the degree of anxiety is within one's tolerable bounds.

3.5.5 Handling Uncertainty by Reflection and Inquiry

John Dewey (1933, 1938) attempted to overcome the dualisms of thought and action, decision and deed, research and practice, science and commonsense. The focus of Dewey's stance against these dualisms was his theory of 'reflective thought' or 'inquiry'.

Dewey (1938) asserted that the word 'thought' itself should be regarded as a synonym of 'inquiry', hence its meaning should be determined by what we find out about 'inquiry' rather than 'thought for logic'. Dewey believed that logic is the theory of reflective thought, thereby the meaning of logic could be discovered only by turning inquiry back on itself, that is, by inquiring into inquiry (Schön, 1992). For Dewey, active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and, further, the conclusions to which it tends, constitutes inquiry or reflective thinking (Dewey, 1933).

Inquiry, as Dewey argues, is the combination of 'mental reasoning and action in the world in a process that is transactional, open-ended, and inherently social' (Schön, 1994b). Inquiry proceeds 'from doubt to the resolution of doubt', 'from indeterminacy to determinate conditions', 'from uncertainty to less uncertainty'. The inquirer must not stand outside the problematic situation like a spectator; he or she is in it and in transaction with it. Inquiry also does not merely remove doubt by recurrence to a prior adaptive integration or a law-like recombination of old certainties, but by instituting new environing conditions that occasion new problems, with the result that there is no such thing as a final settlement (Schön, 1992). Therefore, construction of a problem, or what Schön terms 'problem-setting' amid situations of uncertainty and complexity is an attainment for an inquirer. Problem settings determine what facts an inquirer has selected for attention, and the ways of setting problems for problematic situations are subject to variation from society to society, person to person, time to time, and context to context.

Dewey's idea about inquiry was later taken up by Schön who likewise attempted to integrate thought and action, theory and practice, but also in examining the variety of ways in which practitioners set up the reality of problematic situations. Therefore, in the spirit of Dewey's recognition of reflective practitioners as inquirers, Schön explores how, for example, researcher thinks of research especially educational research, as inquiry-enhancing (Schön, 1992). Schön proceeds to describe complex components of reflective practice: including 'knowing-in-action', 'reflection-on-action', and 'reflective conversation with the situation'.

By 'knowing-in-action' Schön means the knowing built into and revealed by one's performance of everyday routines of action. This is not inquiry, in Dewey's use of the term, because the situation of action is not inherently confusing or problematic; the smooth flow of action is not usually interrupted by surprise or by the unexpected. People display knowing-in-action in the exercise of physical skills like walking, bicycle riding, typing, and driving. Knowing-in-action is sometimes labeled 'intuition', 'instinct', or 'tacit knowledge' in Polanyi's sense (Polanyi, 1966). Yet we can learn to observe, reflect on, and describe our knowing-in-action, and we can test such descriptions, for example, by writing out instructions for performance and observing what happens when other people try to follow them. By knowing-in-action we continually manage and modify our behavior in response to changing conditions, as when driving a car. Knowing-in-action draws on pre-structures that guide our seeing, thinking, and doing in familiar situations.

What we already know what to do includes a remarkable ability to take note of surprise and respond to it – to be puzzled, uncertain, or doubtful, if only momentarily, and to respond smoothly through immediate experiments (Schön, 1992). This view is consonant with Weick's sense-making theory. Yet it is different in the sense that reflection in Schön's view includes the inquirer's nonverbal role in the midst of action. Thus 'reflection-in-action' does not refer to that type of reflection which involves what Arendt (1971) calls a 'stop-and-think',

a 'pause' during which we think back on what we have done, reasoning about it explicitly and verbally. This type of reflection is what Schön terms reflection-*on*-action.

Reflection-in-action, in Schön's sense, takes place in the midst of action and it does not need to employ the medium of words. Practitioners think of what they are doing while doing it, without the use of words. Nevertheless, some reflection-in-action could be verbal, like the improvisations that make up a good conversation, falling somewhere between the boredom of repetitive routine and the insanity of utter unpredictability (Schön, 1992). In any event, reflection-in-action is centrally important to practitioners in their encounter with stressful situations of indeterminacy, uncertainty, and conflict when they try to make immediate sense of unexpected situations and convert them into ones they can handle.

The term 'conversation with the situation' refers to a type of reflection-in-action as understood from Dewey's transactional perspective. The term conversation is, in this usage, metaphorical. It does not refer to a literal conversation about the situation but to an inquirer's conversation – like reciprocal transaction with the materials at hand (Schön, 1992). Such a conversation need not be accompanied by explicit self-awareness, though it may be, or it may come to be when it is subjected to retrospective reflection. Here, the inquirer, in transaction with the materials of a situation, encounters a surprise in the form of 'back-talk' that momentarily interrupts action, evoking uncertainty, confusion and at times fear or anxiety. The inquirer goes on to transform the situation in a way that resolves uncertainty, at least for the moment. The inquirer is in the situation, influenced by his self-system of appreciation of it at the same time that he shapes and reshapes it by his thinking and doing – in Dewey's sense, instituting new environing conditions that occasion the setting of new problems.

The terms 'reflection on knowing' and 'reflection on reflection-in-action' are consonant with Hannah Arendt's 'stop-and-think', where thought is turned back on itself, either on the knowing-in-action revealed by a pattern of behavior or on the reflection-in-action that reshapes understanding in the midst of action. Reflection on knowing and reflection-in-action

are processes of getting in touch with the understandings practitioners form spontaneously in the midst of action (Schön, 1985, 1992).

The term 'reflective conversation with the situation' is Dewey's inquiry, mediated by conscious reflection on the situation and, at the same time, on one's way of thinking, and then acting on it. As conversation with the situation is a version of reflection-in-action, so is 'reflective conversation with the situation' a version of reflection on reflection-in-action. It is a version undertaken in the situation of action itself. Reflective conversation with the situation may occur in all situations of uncertainty, in the mode of practice, in the mode of problem setting and proposing solutions, or in hybrid forms that combine all. In the mode of problem setting, for example, reflective practitioners interactively *name* the things to which they attend and *frame* the context by which they will attend to problematic situations (Schön, 1983: 40).

3.5.6 Handling Uncertainty by Fantasy and Foolishness

Simon (1955) argued that human memory is fallible and lacking the computational and cognitive resources to predict and evaluate all future outcomes and their probabilities with sufficient precision, which challenged the dominant economics models which assumed that people are rational actors and can choose the best action according to their relatively stable preferences. For Simon a more realistic approach to rationality should take into account such limitations, for most people are only partly rational, and partly emotional or irrational. Instead of choosing the best or optimal strategy according to the rational model, actors usually use a 'satisficing strategy' in which emotions/irrationality play a crucial role.

This view underpinned March's argument (1978), that 'rational choice' in fact involves two guesses, a guess about 'uncertainty in future consequences' and a guess about 'uncertainty in future preferences'. March also believed that what we do or do not do is based on irrational as

well as rational elements, hence our choice oscillates between the sensible and stupid foolishness.

March attempted to develop a theory for foolishness (i.e. 'technology of foolishness'), assuming that radical and novel ideas about the future usually come to mind when people dally with foolish things. Of course, March argues that the theory of stupidity should be juxtaposed with contemporary cultural ideas of intelligence that had also been developed so as to improve our guesses about an uncertain future. March (1988, 2006), therefore, decries three major building blocks of commonsense thinking deeply embedded in contemporary Western culture. These building blocks include 'cultural ideas of intelligence and theories of choice' (March, 1988: 254). First, he questions the idea of a *preexistence of purposes* that makes us define a set of clear ends or objectives before acting. These pre-existing purposes which have become translated into 'values', 'utility' and 'needs' are presumed to be antecedents to the behaviour. March argues that these commonsense beliefs are in fact 'normative theories of choice' which begin with an assumption of a pre-existent preference that is supposed to shape and inform our action and define possible outcomes of a choice. Second, he tackles the idea of *necessity of consistency* by which we link our purposes, preferences, and actions. Necessity of consistency is in fact a prerequisite for normative models of choice. In organisations it helps hierarchy, coordination and control, and for individuals it provides a set of values that generates consistent preference ordering. Third, March deals with the idea of *primacy of rationality* which makes commonsense thinking decide appropriate regardless of intuition and faith. Primacy of rationality justifies individual and organisational action in terms of an analysis of pre-existent means and ends. It marginalises intuition and faith as possible sources of values. In his words, 'analysis and justification of action lie within the context of reason' (March, 1988: 255).

March argues that these assumptions are thrust upon the modern image of intelligent humanity which has made us unconcerned with unexpected changes of goals over time,

ambiguity of objectives, inconsistency of ends, and uncertainty in values. We are more concerned with making good decisions within pre-existing structures and within a set of consistent and stable values. We do not often ask how we can invent good, interesting, and new goals and values, for these prescriptive theories of choice are dedicated to the development of 'technologies of decision' based on reason (March, 1978), thereby excluding irrational, stupid, yet interesting side of humanity.

In technologies of reason goals are given beforehand and choices are regarded as ready-made and complete, ready to fit the situation in question. Therefore, in normative theories of choice we apply something pre-existing to a new situation. By contrast, in the technology of foolishness individuals and organisations must 'construct' new ways of doing things for which they have neither pre-existing plausible goals nor good reasons. March's metaphor in doing this is 'children's playfulness', and he argues that like children we sometimes need to act before we think. Instead of trying to adapt the model of modern intelligent humanity to children, we might better adapt the model of children to intelligent humanity (March, 1988: 257).

The antidote is, then, to juxtapose intelligent 'technologies of reason' with a child-like 'technologies of foolishness'. Therefore, playfulness should be juxtaposed with rationality. Play and reason should be functional complementary. March suggests five initiatives: (i) to treat fixed goals as questionable or intellectual hypotheses, (ii) to treat intuition and faith as real values, (iii) to treat inconsistency and hypocrisy in behavior as transitional, (iv) to treat memory as an enemy, and (v) to treat experience as a theory and to accept playfulness in social organisations.

In summary, March (1988, 2006) suggests that 'technologies of reason' that are obsessed with order, control and homogeneity might be destructive and unproductive when they come to the questions of radical uncertainty. Instead he suggests that the juxtaposition of 'fantasy, foolishness and playfulness' with 'rationality' allows individuals and organisations to

develop unusual configurations and organisations that describe interesting people, interesting institutions and interesting societies (March, 1988: 265).

3.5.7 Handling Uncertainty by Dialectic

Lester and Piore (1995, 1999, 2004) speak of two aspects of organisational performance when they come to the question of tackling high degrees of uniqueness and uncertainty – the interpretative and the analytical. They argue that 'interpretation' and 'analysis' are two opposing ways of thinking, yet both must happen simultaneously when practitioners deal with the ambiguities of innovation.

As Lester and Piore (2004) observe in a number of innovation studies, the focus of the 'analytic mindset' is on projects with well-defined beginnings and unambiguous ends, so analysis involves reduction, simplification, clarity and closure. Goals and problems are usually set by managers and the appropriate means and ends should be clearly identified and logically linked at the outset, hence ambiguities and uncertainties are eliminated, simplified or dealt with as much as they conform to rational methods of decision-making and problem-solving. Communication, in this view, is the precise exchange of well-defined chunks of information.

In 'interpretation', by contrast, the focus is an on-going process which is open-ended and context-dependent. Interpretive approaches involve the development of new meanings and the discovery of new ideas. Managers stimulate informal discourse and ongoing conversations (e.g. by organising party-like conversations) to find and set new directions, and foster the discovery of new meanings and interesting ideas. Means and ends are usually fuzzy and at times fleeting, subject to varied perceptions and interpretations. Thus ambiguity in selecting and linking the right set of means and ends in advance is something common because communication involves fluidity, playfulness, and indeterminacy (Lester and Piore, 2004). Nevertheless, encouraging such fluid processes helps an interpretive mindset to thrive

in the situations of uncertainty and ambiguity that often characterises innovation in organisations.

These differences are great and at times contradictory as Lester and Piore observe that the analytic mindset is in fact undermining interpretative ways of thinking and doing. Although it seems unlikely for organisations to combine them together, these scholars too argue that both are necessary for product innovation and for tackling situations of uncertainty (Lester and Piore, 1999, 2004). They are so mutually essential that innovation cannot be fully understood without reference to both (Piore and Lester, 2004: 175). Lester and Piore conclude that keeping such a 'dialectic' 'alive and moving' will help organisations to avoid a behavioral world immune from recognising uncertainty, indeterminacy, and value conflict which, in turn, stimulate radically new ideas.

3.6 Conclusion: Towards a Reflective Practice of Managing Risk

Using the idea of reflective practice, I want to reconstruct my discussion on the approaches to risk and uncertainty by arguing that, on the one hand we see an approach favoring the rational process of managing risk and on the other hand we see a deeper epistemological position favoring the reflective practice of handling uncertainty and settling of manageable risks. I group these two approaches with rational and reflective practice of managing risk. This typology is both loose and tight. Loose because some of the theories already discussed overlap both groups and tight in the sense that differences in some theories address two hermetic and disjoint epistemological groupings.

Drawing on the writings of March (1988, 1991, 2006), Schön (1970, 1983, 1994a), Lester and Piore (1999, 2004), Dewey (1933, 1938) and Hainer (1968) I attempt to make the dualism between these two practices more explicit and propose a model for the exercise of a more reflective practice of managing risk.

I argue that both practices are *different facets of the same phenomenon* – which is about how to act in an environment in which uncertainty abounds, when it requires practitioners to make this uncertainty productive and positive.

3.6.1 Rational Practice of Managing Risk

The 'rational practice of managing risk' in its traditional sense usually begins with a generalised concept, clear idea, or 'frame of discourse' about risk, the risky subject, and management of risk that is tacitly accepted or explicitly expressed as appropriate. Theories about risk usually revolve around maintaining order, unity, normality, stability, security, and control, hence an attempt to clearly define the best means to achieve clear ends. Management of risk, therefore, has mainly to do with the selection and application of unambiguous means to reach unambiguous ends. Problems about 'risk' and 'managing risk' are usually given or are definable prior to the fact. The suggested performance, then, centres on the instrumental use of pre-existing ideas as logical proofs to detect and correct pre-defined risks, a process of *instrumental problem solving*. Problems of choice or decision are solved through the selection, from available means, of the one best suited to conventional ends (Schön, 1983). Discourse or ambiguity about identifying potential risks, the magnitude and degree of riskiness of a phenomenon or fruitfulness of an idea can be settled in an orderly fashion by appeal to some other analytic established rules.

Therefore, problems, purposes, methods, norms and goals do exist and are definable even if tentatively; assumptions are stated; 'reason' is implied; the likely outcomes in an uncertain situation are presumed to be determined from the initial choice of assumptions. With a mechanistic, deterministic hold on the past, the uncertainties in the future are usually treated as a hidden combination of old certainties. The rational projection of the past into an infinite future is a realistic activity. Prediction is possible even temporarily or within limits and future events have a certain probability which may be uncertain but usually are subject to measurement and applied methods; so anyone competent in quantification, methodical

application, and logic will obtain the same result when interpreting the risk in a stated situation. Such a body of technique and theory functions as short-cut for thinking, as value-neutral and reproducible science independent of context, culture, emotion, and bias. The best risk management solutions are the ones in which actors are given blue-prints for thinking through which they can exercise a literal application of pre-existing norms and expectations to any situation in question.

In the face of an unfamiliar or uncertain situation only rational and familiar expectations are identified and spelled out. Hence non-rational inference, feeling, intuition, 'something tells me', and prankishness is excluded from consideration and whatever causes confusion and ambiguity and can generate disorder is dismissed and avoided. According to one version of risk management theory, recognition of uncertainty is taboo and a sign of irrationality. Thus, according to 'what are acceptable norms in an established frame of discourse' uncertainty may be repressed, relegated, reduced or selectively attended as far as certain reasonable and satisfactory proposals about risk can be formulated. Propositions about risk are believed to mean what norms or the consensus say they mean. Proposals must be expressed explicitly and put into communicable and unambiguous language. Many failures in communication are seen as being semantic in origin as is the case in scientific methods and probabilistic reasoning. Failure to transmit an understanding of risk and the technologies of applying reason to manage risk usually suggest a failure in methods of diffusion and the need to explore what technique-users have perceived. For some theories (e.g. traditional stage-gate risk management and cognitive-scientific theories) there is only one meaning for a formula on managing risk which is monotonic and value-neutral free from actors' subjective involvement – intuition, hunch, faith, insight, and other nonlinear influences. Rituals or techniques for applying reason should be practiced by actors until the difference between expectation (realisation) and members' performance (implementation) becomes small in successive trials. Unbiased or rational actors are those who clearly identify and objectively rank whatever risks exist, successfully identify the various possible means available for

confronting them, and comprehensively map the relevant chain of consequences likely to result from any choice, and select the course of action likely to achieve the best possible goals at minimum cost and time (preferably all prior to the fact).

3.6.2 Reflective Practice of Managing Risk

In contrast, the 'reflective practice of managing risk' usually begins with subjective experience as central, hence one must get some experience before becoming able to generalise or theorise (Hainer, 1968; Schön, 1983; March, 1991). This practice usually involves making sense of an uncertain, unique, or problematic situation that initially makes no sense. By and large, it revolves around self-reflection, inquiry, on-the-spot experiment, toiling with irrelevancies, coping with anxiety, and framing or reorganising the problematic situations and converting them into solvable problems, namely manageable risks and rewards. This practice demands more reflection on 'problem setting' than 'problem solving' – the process by which one defines the decision to be made, the ends to be achieved, the means which may be chosen. The underlying belief, however, is that 'although risk formulation or problem setting is a necessary condition for exercising instrumental risk management or problem solving, it is not itself an instrumental or technical problem' (Schön, 1983: 40).

Problems, norms and goals, must be constructed from the materials of the problematic situation which appears to be puzzling, anxiety-driven, and obscure. The reflective practitioners need to select what they will treat as the demands of the situation. They deliberately, sometimes unconsciously, set the boundaries of their attention to a situation in question. The coherence that they impose upon the situation, therefore, is unique and uniquely tied to what for them appears as an 'analogy', 'generative metaphor', 'symbolic relation', 'Gestalt pattern', or 'family resemblance' between A and B. This uniqueness in perception, too, affects to what directions they take in order to transform a problematic situation. As Dewey (1938) argued, in the face of an unfamiliar and uncertain situation, the

inquirer cannot stand outside the problematic situation like a spectator; he or she is in it and in a unique emotional involvement with it.

Means and ends with regard to nature and management of risk are not usually clear at the outset and may arise out of a unique individual or social process of perception, of Gestalt pattern forming, of finding family resemblance, of seeking hidden metaphors, of playfulness, of foolishness and fantasy, and of new interpretations which might not be explicitly conscious.

Such perceptions cannot be precisely and comprehensively defined, only described. Descriptions unconsciously are simplified versions of experience and may not be understandable or communicable to others except when the symbols, concepts, and patterns others use essentially resemble ours. According to a softer version of this group, uncertainty can be simplified as far as plausible images can be created to put them into communicable words (e.g. sense-making). But in its extreme version, experience could be nonverbal, incommunicable, and tacit (e.g. reflection-in-action). Put simply, in the face of ambiguous situations, reflective practitioners know more than they can put into words. They reflect on their tacit knowledge-in-action and on the kind of improvisation learned in experience. Hence, the communication of experience in its complete context usually is not possible. But partial and fluid communication is possible if one generates a desire to find something of interest in the verbal or nonverbal message. If pattern forming, interpretations, and symbolising have been well done, and if the audience has had an approximately similar experience, then a sort of resonance will be established between an inquirer and the audience (Hainer, 1968). As a result, failure in communication is expected until there is shared experience.

When reflective practitioners are involved in 'risk management' practice, assumptions about an inherently uncertain activity such as innovation cannot be stated. Implications are emergent and can be discovered. *A priori* logic cannot be implied. Cause and effect

relationships, implying temporal symbolic relations, cannot be justified until the situation indicates its presence within one's acceptable ambiguity. Therefore, guesses about future consequences and preferences using *a priori* probability usually do not have a valid meaning because new variables and information constantly appear. Temporal prediction is not usually possible and anyone, for example, predicting a comprehensive list of risks in an innovation project with certainty is engaged in misrepresentation. Conclusions are not fully determined on the basis of implication. Nor can conclusions be necessarily drawn when assumptions are presumed to be identified. Propositions in an uncertain situation do not necessarily have one meaning or any meaning, and different people will derive different interpretations (Piore and Lester, 2004).

Handling ill-defined and uncertain phenomena usually points to finding new patterns using similarity between one's repertoire of theories, symbols, metaphors, images, schemes and the new situation. Ambiguity may not be fully removed but it might institute new conditions that occasion an iterative process of setting and solving manageable problems, with the result that there is no such thing as a final best formulation of risk. Hence, a reflective practice of risk thrives on ambiguity and uncertainty. Experience is inconsistent and consistency can be assured only through repetition of experience. Stability or consistency in 'framing', 'pattern forming' or 'family resemblance' may be possible when ambiguity in the situation is within acceptable limits. When anxiety is within tolerable bounds a practitioner can build a set of symbols which provides the means for interpreting signs, signals, and concepts which refer to both 'feelings' and 'implied logic' in the situation. This is similar to Knight's notion of juxtaposing subjective feeling (or subjective probability) with scientific deduction (or objective probability). So practitioners must get a feel for what they are to do before they start doing (Hainer, 1968) – analogous to childlikeness, in March's sense. Such a view is consonant with Weick's argument that we often find the initial meaning of events by drawing inferences from how we feel (Weick, 2002). Since many of us feel frightened and out of

control, then this must 'mean' that whatever we face is something we need to flee from or fight.

There are two more important points to consider when engaging in a reflective practice of managing risk. First it is important 'to sometimes treat memory as an enemy' and to consider that what is good at a particular historical moment is not always good at another time. Second, it is important to acknowledge that what is good for one part of an institution is not always good for another part or for the larger social system of which it is a part (March, 1991). The first point suggests that rules of the past, as well as propositions about the future are not necessarily valid or meaningful. Only the 'here-and-now' or 'ever-present present' is valid and has meaning (Hainer, 1968). No pre-existing means and ends from past may be taken as literally applicable to a here-and-now situation. Nor will experience of a situation prove literally applicable to the next here-and-now that will happen in the future. Hence, for the reflective practitioner any given problem, model, and method is, therefore, a questionable hypothesis and cannot be literally applicable.

But understandings and thoughts drawn from other situations, may suggest 'generative metaphors', 'symbolic relations', 'projective models', 'family resemblance', 'Gestalts' and 'similar patterns', which help one to frame a vague here-and-now and permit action within it. One's theories will need to be tested against the next here-and-now. So, in a reflective practice of risk one cannot, therefore, speak of probability or a literal application of theories to the next instance. In brief, a reflective practice of risk is broader than a rational practice of risk. While most risk management methods imply boundaries, controls and *a priori* rules of relevance, a reflective practice of risk implies openness to uncertainty, no *a priori* relevance, and confusion about what is and what is not relevant as well as an ambiguity about ordering.

Accepting this argument, we can see those approaches to risk management and handling of uncertainty which are less intimately tied to other approaches, less crucial to reflective practice of risk, less broadly defined, less productive for handling stressful situations of

uncertainty and, of course, more analytic and conservative in their use of older ideas and techniques. Scientific methods, quantitative reasoning, system accident theories, selective inattention, myth and taboo making, and repression are examples of this kind. There are, however, approaches to risk management and handling of uncertainty whose ideas are most intimately tied to other approaches, more crucial to the whole body of theories and the reflective practice of risk, more broadly described, more related to actual situations of uncertainty and exploration, more radical in their metaphorical use of old ideas as projective models, more fundamental, interpretive and context-dependent. Coping with anxiety, framing and reframing, 'back talk' inquiry and on-the-spot reflection and experiment, engaging in dialectic, Knightian subjective probability, March's model of foolishness and dallying with irrelevancies to find generative metaphors, and to some extent mindfulness, are examples and elements of the reflective practice of risk.

Between these two extremes are sociocultural theories of risk and governmental theories. Although they offer broader definitions of risk they are more focused on technologies of reason, ordering, conservatism and, at times, analytical methods of risk assessment. Risk society and actor-network theorists (ANT) help us to describe actual situations of uncertainty but they do not propose ways practitioners can reflectively handle them. Risk society and ANT theorists give fleeting attention to the formulation of a reflective practice approach or 'actionable knowledge', but they call a critical attention to phenomena of uncertainty. And this sets the stage for such an attempt.

3.7 Summary

It can be argued, in particular according to Bernstein, that the idea of risk and risk management has been gradually developed during the past centuries century to help humanity's so called sacred affairs as the god's gardener to discover the agenda of the rational gods, and if necessary use it in opposition to received authority. The commonsense

and dominant definitions of risk, therefore, revolve around the ways by which practitioners can handle uncertainty using risk management models as an analytic tool for intervention.

However, as we have seen, there are a number of difficulties with this view. Many rational accounts have become increasingly sensitive to the phenomena of uncertainty and it has become commonplace for them to speak of uncertainty in which problems do not lend themselves to application of clear-cut techniques (Smith, 2002). At least in the field of product development, many writers appear to feel a requirement for new ways of dealing with the ambiguity of innovation. Nevertheless, their inquiry still represents a search for predictive mechanisms, instrumentalist theories of choice, techniques of control, and technologies of reason. In other words, it is difficult to get rid of this tacit attachment to technocratic approaches to risk management and product innovation because first, it is strongly tied to their conservative identity and second, uncertainty undermines the entire analytical system to which these people/organisations are dearly attached. Therefore, throwing off this habit would be disruptive, a threat to identity and stability.

At a psychological and organisational level, this tacit attachment to traditional standardised risk management methods can be seen as a defensive reaction, functioning as a guardian against the stressful nature of uncertainty. Many risk management models, in a sense, are an equivalent of Freud's 'defense mechanism' (Freud, 1967). They offer tools to avoid the anxiety of uncertainty and the burden of serious reflective practice and thinking. They provide rhetoric and rituals by which organisations regulate unfamiliar and problematic situations by repressing them or reducing them into narrow tolerable forms. In psychological terms, it is a conscious or preconscious homeostatic tendency to stick with old models, forms and stable situations that would otherwise threaten organisational identity. In Sullivan's sense, it is the anti-anxiety system by which organisations put aside sources of threat and anxiety. Organisations are strongly inclined to suggest rational stratagems by which

organisations can reduce an uncertain situation to one they can exploit through unambiguous recipes and routines they can apply analytically.

There are, as I have mentioned above, extensive discussions of the thought and activities required for 'exploration' vs. 'exploitation' in innovation, or 'interpretation' vs. 'analysis' in the early stages of product innovation. This ambivalence, shared by many organisations, to both espouse and resist rational models of managing risk and product innovation, reflects the great difficulty of theorising and handling uncertainty in problematic situations or theorising practice appropriately in situations of ambiguity. As Schön (1967) observes, organisations do not tend to operate well or deploy the language of invention effectively under conditions of uncertainty but are, rather, beautifully equipped with rational techniques to handle risk as part of a restricted language and practice of investment.

In this thesis, 'risk management' is defined broadly enough to extend beyond such narrow definitions of risk and its management to include the broader and actual practices of 'handling uncertainty' – as practitioners require and exercise the competence to recognise and resolve ill-defined, ambiguous, and multifaceted phenomena in a reflective manner. It was for this reason that this chapter, as a precondition for the formulation of a reflective practice of risk management, reviewed seven 'approaches to handling of uncertainty' as well as the critiques of narrower views of risk and its management.

The content of theories of handling uncertainty, by and large, represents an inquiry into one of the fundamental dimensions of human action: theorising experience and practice, framing and reframing on the basis of Gestalts and family resemblance between things, coping with anxiety, on-the-spot inquiry, reflection and experimentation, dialectic, foolishness, and fantasy. Instead of treating problems as simple means/ends calculations, or as something

given, these accounts focus on the unstable and ill-defined situations in which new problems (and their associated 'risks') must be constructed and settled iteratively.

Drawing on their insights this chapter argues for the existence of two contrasting yet complementary practices of managing risk in organisations: the traditional views of risk management (i.e. rational/scientific approaches to risk) and a more reflective approach to handling risk and uncertainty in practice. Reflective practice, thrives in problematic situations where practitioners attempt to institute new environmental conditions that lead to the construction of new manageable risk, rewards, problems, visions, and horizons, acknowledging that there are no such things as finality, an ideal state and the like. In contrast, traditional risk management practices are more inclined toward producing rational recipes, norms and routines for regulating or rationalising uncertainty.

As discussed above, there is an established modernist quest to interpret events increasingly in terms of narrowly-defined risk and risk management terms. However, broader social/cultural/political views and critiques of risk and its management, as well as approaches to handling of uncertainty, incorporate another dimension: the processes involved in *converting* real-life practical contexts of Knightian uncertainty into situations amenable to rational quantitative calculation and analysis – the traditional province of risk management. These address the wide variety of intellectual, psychological, and sociopolitical factors involved in the formulation of 'manageable risks'. Because an accurate and valuable account of the reflective practice of risk in organisations implies explicit recognition of working in fuzzy conditions, ambiguity, instability, complexity, conflict, and anxiety, the traditional views of risk management appear restricted, and to be directly challenged where they attempt to impose their rationalistic blinkers on the overall process of handling uncertainty.

Consequently, I believe, there is a crucial need for systematising and formulating a conceptual framework that enables practitioners to reflect on how they actually grapple with uncertainty, and what they actually do in transforming unmanageable realities into problems with a relatively ordered character – what I call converting uncertainty into packages of manageable problems. It is this process, of converting a stressful and threatening 'language of uncertainty' into a 'language of manageable risk', that is further developed in chapter five

Chapter 4 Approach and Methods: A Narrative Reconstruction of Critical Events

To present a case is to tell a story in the sense first enunciated by Aristotle: the imitation of an action, with a recognisable beginning, middle, and end, and with recognisable character, plot, and setting. (Schön, 1991: 344)

4.1   Introduction

This chapter introduces the approach adopted to the collection and analysis of data on risk management in practice. This is, however, no traditional account. The material is not presented as a traditional 'case study', at least not in any conventional sense (Yin, 2003). The chapter offers a more 'proximate' account of 'critical events' (Badham and Garrety, 2003), an account that has affinities with Flanagan's critical incident technique (Flanagan, 1954). Moreover, it involved the re-analysis, selection and re-description of material from research undertaken by others (Couchman and Fulop, 2002, 2004, 2005, 2007). This re-analysis was, however, undertaken in close collaboration with the authors, and involved not only the collection, systematisation and re-interpretation of data but also extensive interviews with one of the authors as a source of basic information, assistance and data gathering in its own right. The method had three aims. Firstly, it sought to confirm, illustrate, elaborate and develop a conceptual framework derived from the literature on innovation and risk management. Secondly, it aimed to uncover and present in an informative manner (i.e. 'tell a good story of') the contrast between the (formal, front-stage) 'manifest' and (informal, back-stage) 'underlying' story (Schön, 1991: 346) of risk management in practice. Thirdly, in legitimating and illustrating the conceptual framework developed in the thesis, it aims to provide an informative and persuasive account of the contrast between practitioner's 'theories-in-use' and their 'espoused theories' (Argyris and Schön, 1974) in the practice of risk management. Capturing the processes involved in this 'translation' dynamic is a major goal of this thesis. This was undertaken through a re-examination of the accounts that research managers gave to interviewers about the formal risk management methods they recognised and were expected to follow and the 'real' problems that beset them in practice. While further participant observation or ethnographic research could usefully be undertaken

to deepen and test out these accounts, the in-depth interview material was sufficient for the purposes of this thesis, i.e. to document and present narratives of critical events that illustrate, elaborate and extend the conceptual framework developed in the thesis.

The main strategic objective of this thesis is, however, to develop a conceptual framework for handling situations of uncertainty as they occur in the early stages of product innovation, i.e. a framework for converting problematic situations into manageable problems. A 'conceptual framework', as it is understood here, is a system of constructs or concepts in which the concepts are related to each other by propositions. The whole framework is bounded by a theorist's assumptions (Bacharach, 1989; Sutton and Staw, 1995). Concepts describe the research phenomena while propositions take the explanatory role in the body of the framework. The conceptual framework developed in this thesis is different from the kind employed in traditional rationalistic approaches to risk management. The focus here is on the development of a systematised set of concepts, guideposts, or heuristics – what Argyris (1999) calls 'actionable knowledge' – but from a broader epistemology of practice than that employed in traditional scientific/rational paradigms. It is based on providing conceptual support for reflective practice, incorporating insights gathered from sociological and social psychological literature into how risk, uncertainty and innovation are handled in practice (Schön, 1983). It should be noted that I do not wish to over-draw the boundary but to point to the limitations of a traditional rationalistic view, from the standpoint of rationality itself. The following diagram (figure 4.1 below) shows how this conceptual framework was developed and enriched by research data in the course of the production of this thesis.
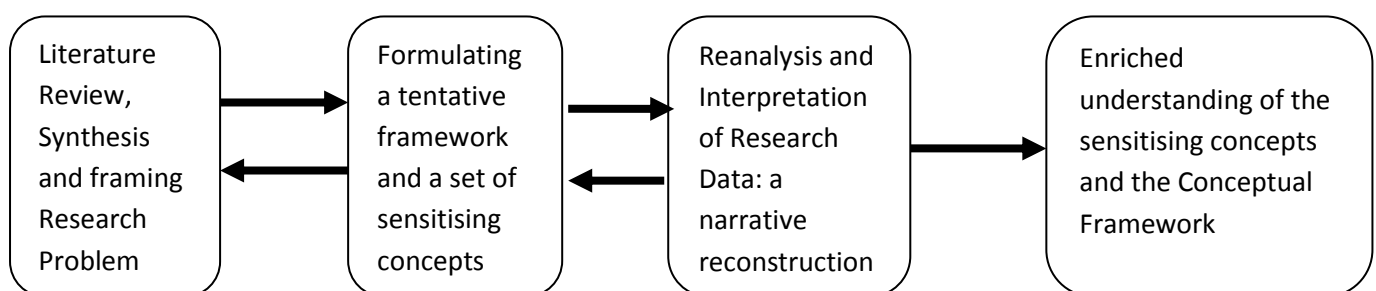
Figure 4.1 The Development of a Conceptual Framework

In elaborating on how the empirical material achieved the purpose of framework confirmation, illustration, and development, this chapter describes the background to the empirical study, its approaches and methods, as well as the rationale of selecting this study and its methodological basis for use in this thesis. This elaboration (Fig. 4.1) includes the interactions that occurred between (i) the literature review, synthesis, and framing of the research problem, (ii) the formulation of a tentative conceptual framework and a set of sensitising concepts to study the research problem, (iii) the study itself, and its context, and how the author engaged with existing data and collected data, and (iv) the reanalysis and reinterpretation of the data using the method of exploring critical incidents through the narrative reconstruction of critical events (and its use in providing an enriched understanding and elaboration of the initial conceptual framework or set of 'sensitising' concepts). The description outlines the benefits as well as costs of focusing on 'critical events', and the efforts taken to overcome the weaknesses.

4.2.1 Framing the Research Problem and Formulating a Tentative Framework

My initial interest in risk, uncertainty and innovation, as well as my knowledge and experience in developing new products led to the identification of a research problem: the high rate of failure in product innovation and an apparent insufficient exploration of the messy and nonlinear process of product innovation; can contemporary risk management models handle the inherent uncertainties effectively? The shortcomings discovered during the initial literature review revealed a theoretical gap in both the sociopolitical and technical dimensions of the practice of risk management in innovation (i.e. especially at the early fuzzy front-end of the process) often seen as nebulous, indeterminate, dicey yet crucial for the development outcome. The question of 'Why do the uncertainties of innovation appear to defy rational risk management models' had been left somewhat unnoticed and unexamined.

I also wanted to create an effective approach or a broader 'method of inquiry' to solve this problem. I was convinced according to my review on Schön that a narrow proceduralised

methodology in a traditional sense would not be able to address the issues raised in my review of the early stages of innovation. Accordingly my focus went beyond instrumental views of risk and innovation, shifting more towards social psychological dimensions. This led to further refinement of the research question into: How do some practitioners and organisations intuitively handle the indeterminate nature of innovation in its early stages that usually defies rational techniques and procedures, namely risk management models? Also how might the tacit dimensions in their practice be adequately uncovered, illustrated, and 'improved'? What are the processes implicit in their patterns of action? And how an approach and a conceptual framework can be developed such that their tacit theories-in-use become accessible? The concept of theories-in-use points to 'the theory of action which is implicit in the performance of (a given) pattern of activity' (Argyris and Schön, 1974) (see 1.3.5).

As a starting point I set out to identify a set of sensitising concepts (Strauss and Corbin, 1998) about how some practitioners cope reasonably well with situations of uncertainty and convert them into something manageable, namely manageable risks.

I found no studies that looked at organisational risk management from the new perspective. Nor had general theories of risk management practice been applied to understanding how manageable risks are constructed and settled in the early stage of innovation. Consequently, 'converting unmanageable uncertainty into manageable risks' was defined as an organisational phenomenon to be studied and as a research question.

In order to develop a conceptual framework that could help me to understand, explore, and elaborate this organisational phenomenon, I also needed to develop an understanding of the complex early stages of innovation (the fuzzy front-end) as an appropriate context within which to study, describe, and explain both the framework and the phenomenon. In the spirit of Schön and his notion of problem setting (Schön, 1979) I noticed, that the main task in the early stage of innovation has more to do with the problematic process of project-setting, problem-formulation, and settlement of risk and rewards to a project where practitioners

under conditions of uncertainty juggle variables, reconcile conflicting values, and manoeuvre around constraints to package a set of well-formed and manageable proposals, policies, projects, and problems (Schön, 1988). I focused on the sociopolitical and psychological dimensions of this process.

From this point on, the task of packaging manageable problems and converting uncertainty at the fuzzy front-end was used as the basis for developing a conceptual framework (i.e. conversion practice) for improving the reflective practice of handling uncertainty and managing risk during innovation.

An understanding of the fuzzy front-end of innovation process as an ill-defined, uncertain, problematic situation was developed. Under such conditions practitioners continuously frame and reframe the context in which they operated, set a direction for action, formulate the problems they wanted to solve, name the themes, and organise means and expressed the desirable ends. Drawing on Schön (1967, 1992) and Dewey (1938) the idea of 'conversion' was, then, used as an appropriate metaphor for *seeing* the practical activities at the early phases of product innovation *as* a an iterative and creative social psychological process of packaging, framing, and transforming a problematic situation into a well-defined problem.

Building on Schön's conceptualisation of reflective practice, four concepts or constructs that might have a direct or indirect influence on this conversion practice were identified and described. As a precondition for developing a conceptual framework the relation between these concepts and handling uncertainty was explored and described. The concepts as summerised below, were presented more in the form of a schematic 'map' rather than an inclusive description, and were intended as underlying *themes and propositions* to be further analysed and explored through subsequent empirical investigation.

Reflection and its role in handling uncertainty: At the heart of attempts to handle uncertainty in a systematic manner is a process of reflection on knowing-in-action, i.e. practitioners coping with uncertainty in practice will be addressing and resolving actual and

possible uncertainties as part of their actions and decisions – although this may be done implicitly as tacit awareness in knowing-in-action (Schön, 1983). Reflection-in-action involves standing back, within action, and reflecting on the governing ideas and assumptions, which are then to be quickly addressed and resolved in the action process (Schön, 1983, 1987). Reflection-on-action involves a more distanced, retrospective look at the assumptions and issues, and may also involve reflection on reflection-in-action, both in terms of the validity of decisions made and the adequacy of the process (Arendt, 1971; Dewey, 1933, 1938).

Coping with anxiety: While uncertainty is ever-present in human activity, it is a continuing source of worry and anxiety (Dewey, 1930). As individuals, groups and organisations, we seek to relieve ourselves of this anxiety by, in some way, 'controlling' experienced uncertainties (Sullivan, 1965). In many cases, however, the fear and anxiety generated by uncertainty pushes practitioners and organisations into a 'managerial command and control' mindset more appropriate for simple rather than complex situations. A common response is to practice what Sullivan (1965) describes as 'selective inattention', i.e. to ignore, avoid or repress evidence or awareness of uncertainty. As argued by many, from Knight's classic writings on uncertainty in economic life to Stacey's application of chaos theory to strategic leadership, an ability to cope with the anxiety of uncertainty, and respond creatively, is a key leadership capability, or mindset or behavioural repertoire.

Framing and reframing: In the face of uncertainty and complexity, actors are inevitably selective in the information that they pay attention to, the criteria and values that they consider and apply, and the bases upon which they make their judgements. The processes through which such selection occurs are variously studied by analysts of metaphor (Cassirer, 1953; Schön, 1963), language (Wittgenstein, 1953), scientific paradigms (Kuhn, 1996) and Gestalt psychology (Wertheimer, 1961), to name a few. When practitioners frame the problems they in fact bound the phenomena on which they will focus. By imposing frames, they determine a strategy for attention and setting a direction by which practitioners can try to

change a problematic situation. They consciously (or sometimes preconsciously) set the values and assumptions which will shape their practice (Schön, 1982).

The process of metaphor: As I observed in 'framing', there is one critically important process – the process of metaphor. Faced with phenomena that are problematic or unique, practitioners nevertheless draw on their familiar repertoire of theories, images, techniques, and tools which they treat as exemplars, analogies, and metaphors for interpreting the phenomena and framing their understandings.

From this point on, I had a set of 'sensitising concepts' that stimulated my thinking towards possible properties, dynamics, and dimensions that might have been in existing research data but which remained partially discovered or undiscovered. I wanted to also refine, deepen and illustrate both the sensitising concepts and my initial tentative framework in an empirical study. These 'sensitising concepts' were, therefore, taken as a basis from which to choose representative empirical studies that would be useful to elucidate and illustrate the likely elements pertinent to conversion practice (converting uncertainty into packages of manageable problems) which in turn helped me to further clarify and see the sensitising concepts in fresh lights.

4.3 Engaging with the Data

As I had developed an initial framework, the next task was to search for an appropriate empirical study, to find organisations that practice risk management in their product development process. The search for a suitable study was associated with finding an associate supervisor with a rich experience in related research projects. The previous data had been collected on the role of risk and risk management across organisations – three government-funded Cooperative Research Centres (CRCs). As part of a broader study of the CRCs as a medium for facilitating cross-sector R&D collaboration in Australia, two researchers had previously investigated the perception and management of risk.

4.3.1 The Study's Context

In this section I provide a general overview of the study's context and the empirical study selected from the Australian Cooperative Research Centres Programme, the nation's largest cross-sector R&D collaboration. The present definition of a CRC (see figure 4.2) according to CRC association website is:

> a company formed through a collaboration of businesses and researchers. This includes private sector organisations (both large and small enterprises), industry associations, universities and government research agencies such as the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and other end users. A selection round for new CRCs is usually held every two years. It is a competitive process with applications selected on the basis of merit against a set of clear guidelines. Successful applicants are required to establish and register a CRC company. The company enters into a formal agreement with the Commonwealth for up to seven years. Under this agreement, the Commonwealth agrees to provide a certain level of funding each year to the CRC. The CRC agrees to undertake certain activities and identifies the contributions (including cash and in-kind) that will be made by its participants.
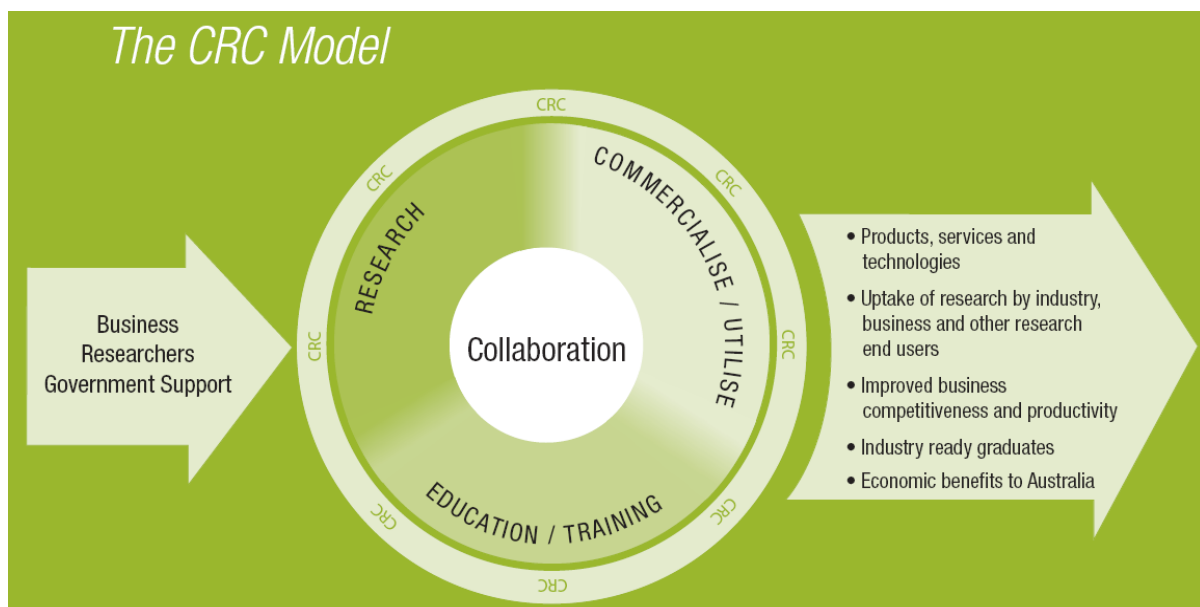

Fig 4.2 The CRC Model (source: the CRC association website)

Commencing in 1991 the CRC programme seeks to foster innovation by promoting long-term strategic links and collaborations between researchers and end users. The CRC programme

aims to link researchers within industry and government with a focus on research applications, turning Australia's scientific innovations into commercial successes – new products, services and technologies. The close interaction between researchers and end users is a defining characteristic of the CRC programme. Moreover, it seeks to foster technology transfer between the public and private sectors, and fiscal pressures which impel public sector research organisations and universities to expand their revenue base through engagement with industry (Couchman and Fulop, 2007).

 The Australian government funds CRCs for up to seven years. Since the commencement of the programme, there have been ten CRC selection rounds, resulting in the establishment and funding of 168 CRCs over the life of the programme. In 2007-2008 there were 58 CRCs, 25 in their first term, 16 in their second term and 17 in their third term. Nine CRCs reached the end of their funding term in June 2008, hence 49 CRCs are still receiving funding in 2008-2009. The first selection round resulted in 20 CRCs and the last round in 2006 resulted in 3 new CRCs, 7 new from existing centres and 4 extensions. In the 2006 selection round, funding provided to new CRCs, or to those developing from existing CRCs, ranged from $21 million to $37.69 million. The total investment by the Australian government is of the order of $3 billion, with almost $9 billion leveraged from participants – $2.9 billion from universities, $2.3 billion from industry; $1.6 billion from government end-users; and $1.1 billion from CSIRO (Commonwealth Scientific and Industrial Research Organisation). A recent study by Allen Consulting Group (2005) revealed that scientific research in the CRC programme is delivering a substantial payoff to the national economy. Their report shows that Australia is $1.1 billion better off, or $0.06 wealthier for every $1 invested by the Australian Government in CRC research, according to the first investigation ever to quantify the net benefits of a major national R&D program. Since the start of the programme, CRCs have also maintained over 2600 patents in Australia and over 3400 patents overseas. CRCs have operated across six sectors: Manufacturing technology, information and communication

technology (ICT), mining & energy, agriculture & rural based manufacturing, environment, and medical science & technology sectors. The current 49 CRCs are shown in the following table:

Table 4.1 A List of Currently Operating CRCs

Sector	Cooperative Research Centres
Manufacturing	CRCs for Advanced Automotive Technology, Advanced Composite Structures , Casting Technology, Construction Innovation, Polymers Rail: **One empirical study selected from here**
ICT	CRCs for Smart Services, Spatial Information, Capital Markets, Interaction Design, Integrated Engineering Asset Management
Mining and Energy	CRCs for Integrated Hydrometallurgy Solutions, Mining, Sustainable Resource Processing, Greenhouse Gas Technologies
Agricultural & Rural Based Manufacturing	CRCs for Australian Seafood, Sheep Industry Innovation, Cotton Catchment Communities, Innovative Dairy Products, Beef Genetic Technologies, Sugar Industry Innovation through Biotechnology, Molecular Plant Breeding, National Plant Bio-security Forestry, Australian Poultry Industries, Australian Bio-security, Emerging Infectious Disease, Future Farm Industries, Innovative Grain Food Products, Pork Industry
Environment	CRCs for Antarctic Climate & Ecosystems, Invasive Animals, Australian Weed Management, Contamination Assessment and Remediation of the Environment, Sustainable Tourism, Bushfire, Environmental Biotechnology, Tropical Savannas Management, Desert Knowledge, Water, Irrigation Futures
Medical Science & Technology	CRCs for Aboriginal Health, Asthma and Airways, Biomedical Imaging Development, Biomarker Translation, Vision, Oral Health Science, Cancer Therapeutics, and Cochlear Implant: **Two empirical studies selected from here**

Under the impetus of government policies, actors (practitioners) and organisations with different interests and cultures form R&D collaborations with the aim of developing new products and services. In doing so, they inevitably initiate a fuzzy front-end stage of product innovation which might take several years of R&D before making the decision for full-scale development of a commercialisable product. While there is a serious issue to consider about whether the early stages of innovation are characterised by genuine innovation or incremental adaptation of established practices, frames and routines, the institutional complexity and strategic commitment of the CRC to develop significantly new 'early stage' innovations makes it a valuable study in the uncertainty of the early 'fuzzy' phase of innovation.

In order to avoid a narrow technological focus, three CRCs were selected as suitable sites for the reconstruction of critical events to further elucidate and illustrate the theoretical results as

previously discussed. These were: (i) A CRC in manufacturing technology (CRC 'X'), (ii) A CRC in medical science and technology (CRC 'Y') (iii) a CRC in medical science and technology with a focus on health and safety ('CRC 'Z'). These CRCs have anonymised because of ethical and confidentiality reasons. These three CRCs were selected because they provided access to a wide range of product innovation activities, from idea generation to development and commercialisation. The data in these cases helped also to address sociopolitical and psychological factors in varied technical and organisational settings as a basis for illustrating the 'sensitising concepts', the handling of uncertainty, and the 'conversion practice'. Each CRC was made up of collaborating partners from industry, university, public sector and government research agencies.

Practitioners and managers at different levels in their organisations, from different sectors, agree to work together towards common goals. In the words of a CRC practitioner:

> The CRC's is actually a separate entity, the fact that a lot of them [researchers] sit in the universities is only because of cheaper accommodation or it's easier for the researchers to sit in their own office and do it but in actual fact CRC's is not a child of the university and it's not a child of industry, it's a separate entity that has input from both sectors and that's why it was created, to be the bridge between those two entities because there was such a gulf where you have the capabilities and the research and even the ideas in the universities but the capability of producing those ideas into a commercial product or process or to develop it further in an applied situation for industry sat out here, so you know where was the bridge, the CRC was that bridge but that's, a lot of times, CRC's is only seen as a research organisation therefore it belongs in the universities...it's been a case where the government entity has said, we would like this kind of research undertaken and here is some extra funding to do it and when the results have come back, it had nothing to do with the research that was requested and when they queried it the researchers who did the research, their reply was, well you really didn't need that research, this was the research you really needed and that comes down to the researchers believing they own the CRC and therefore they can run the agenda and that's when it becomes very dangerous, that CRC is in a lot of problems because of that.

4.3.2 Data Collection

The analysis in this thesis is based on qualitative research data accumulated from two main sources: primary data from previous participant observation and in-depth interviews with CRC managers, and secondary data from CRC websites and documents. The main data for this thesis was collected and analysed over a 10 month-period starting in Nov. 2007.

This approach was necessitated by the practical problems involved in gaining access over an extended period of time to the fuzzy front-end of innovation within R&D active organisations.

I drew on transcripts from 11 in-depth interviews conducted by the original interviewers from 2003-2004 and these ranged from 60 to 120 minutes in duration. At the time of interviewing (conducted by chief investigators), about two or three years after beginning of each CRC, managers were faced simultaneously with unexpected failures and unintended consequences as well as happy accidents. Minor changes in the early stages produced major organizational conflicts among contending groups in each CRC. While in annual reports top management and government were proud of the CRCs' accomplishment, they were also vexed by the conflicts, which had become a feature of everyday practice. The interviewees were R&D managers and CRC board members. All interviews had been taped for qualitative analysis. The guideline for the interviews consisted of a set of open-ended questions with probe points focusing on the management issues associated with ensuring that a CRC met the objectives of its partners and that R&D projects were completed successfully. There was also flexibility in the questioning of each interviewee (i.e. to probe responses and explore the themes raised). Working with the transcripts enabled me to further explore and illustrate the particular interests in detail and to corroborate the conceptual framework I had already developed from literature and other resources. This data source was complemented by notes arising from participants observation conducted during the previous research.

A comprehensive documentary analysis was the second main source of the data collection. A

broad range of public and organisational documents was analysed. These included: the Australian Department of Innovation; CRC annual reports, newsletters and media releases; consulting agencies reports; academic publications and conference papers; CRCs websites, and other public documents such as review of the National Innovation System (CRC review report, 2008).

4.3.3 Data Reanalysis and Interpretation Using Critical Incidents/events

In this section I explain how I went through the data and used a form of exploration and exposition that draws on the 'critical incident technique' (Flanagan, 1954), which is based on 'critical events' (Badham and Garrety, 2003). Drawing on Badham and Garrety's narrative reconstruction of critical events, I provided a conceptual re-examination of the existing data and presented it as a set of 'critical events'. I explored the interweaving of the micro and macro, the technical and the sociopolitical, through a more detailed exploration of the messy picture of product innovation and the meaning of specific incidents than is normally found in traditional processual 'case studies' (e.g. Dawson, 2003).

I approached the empirical data as a secondary data analyst: exploring and examining what had been done; when it was done; who had been involved and where, based on critical incident technique and my pre-defined sensitising concepts. I imported all transcripts, quotes, developed case studies, etc. into one central database for cross-case comparison. In particular, I used Microsoft Word to organise and categorise the transcripts. For each CRC case I sorted the data to capture the gist of what was going on in that centre (e.g. to identify various theories-in-use by CRC actors when they were dealing with indeterminacy, uniqueness, and value conflicts and uncertainty). I looked for any story, quote, scene or event that might best represent each of the sensitising concepts and illustrate their interaction within the tentative conceptual framework.

As argued by advocates of 'dialogic ethnography' (Foley, 2002) and 'reflective action research' (Badham and Sense, 2006), all fieldwork is an exercise in dialogue, collaboration and emergent learning. Researchers involved in the 'action' of fieldwork (Badham and Sense, 2006), often find it difficult to distance themselves from the data (and the informants), and are frequently lacking in the conceptual resources and time necessary to transform their 'data' into significant contributions to theoretical knowledge. In the case of the data drawn upon in CRC case studies, not only have the chief investigators not had the opportunity to fully explore the theoretical implications of their data for handling uncertainty and managing risk in practice, but the data was collected and documented in a way that made it difficult, even inaccessible, for exploring such theoretical implications. As a result, three additional phases of data collection and analysis were required to supplement the original primary data set. Firstly, the background material and primary data were not stored in one place, easily accessible or put into a coherent frame. The first empirical task was, therefore, a basic collection and ordering process. Secondly, the data was collected and reported in the form of general transcripts, and was unsuitable for use to tell 'stories' or 'narratives'. This required the extraction of transcript data, a series of interviews with one of the investigators to obtain supplementary data, linking this data into documentation on project contexts, and the collection of additional primary context data, by obtaining additional documents and further interviews with the chief investigator. Thirdly, the stories and narratives were compiled in basic outline, and used as the basis for a structured interview/co-drafting process with the chief investigator to add additional data as well as base level interpretive judgments. This process of dialogue within a research team has so far received inadequate investigation as part of dialogic ethnography, and is an important and inadequately researched process for helping address the increasingly large amount of project based data collected but often inadequately interpreted in grant-based empirical research. In an important sense, therefore, the thesis involves a significant and proactive degree of data collection and analysis. In addition, as an important part of the reflexivity advocated by dialogic ethnography, the thesis

research uncovered not only the presence of contrasting narratives recording 'theories-in-use' and 'espoused theories', but also the bias and frame of the researchers towards collecting and employing just such a set of data. An additional empirical contribution of the thesis, therefore, has been to encourage reflection on this bias as well as use of the data, and reveal how often tacit, undiscussable and controversial data can be captured in interviews, when there is sufficient familiarity between the interviewees and the investigators to ensure greater openness, and the investigators have an interest in just such data. As Madison (2006: 323) put it in his work on dialogic ethnography, 'in the dialogic performative of fieldwork, all that happens there will fill a caravan. You cannot ride alone!'

Analysing these secondary data and case studies over time first gave me a picture of what changes actually had taken place in the orientation of the CRC programme since its commencement in 1991. I then sought greater understanding of the social and technical dynamics as a reviewer of in-depth interviews and four qualitative studies. Using previous data, analyses, and insights allowed for a broader and essential comparative analysis over time. It facilitated a comparison with other resources collected over a long period of time (reported by the Australian Government and consulting agencies) and allowed multiple sets of data to be combined and investigated. I also took this opportunity to include and combine other issues and their evolution over time so as to further illustrate and develop my initial sensitising concepts and the framework. These resulted in a more diverse study than would have been feasible had I directly conducted one or more conventional case studies.

The Critical Incident Technique (CIT)

By and large, the general view of 'critical incident' has a number of affinities with what Flanagan (1954: 327) has defined as:

> Any observable human activity that is sufficiently complete in itself to permit inferences and predictions to be made about the person performing the act. To be critical, an incident must occur in a

situation where the purpose or intent of the act seems fairly clear to the observer and where its consequences are sufficiently definite to leave little doubt concerning its effects.

This technique is a set of open-ended retrospective methods used for collecting direct observations of human behaviour (i.e. interviewees) that have critical significance. This technique can be used in a wide variety of academic disciplines but is widely used in organisational studies as a research tool for the identification and analysis of organisational problems (Czarniawska, 2004).

Critical events can be gathered in various ways, but typically respondents are asked to tell a 'story' about an experience or 'clusters of changes' they have had (Czarniawska, 2004). Hence, instead of answering direct questions informants are encouraged to focus on 'specific incidents', 'unique challenges' 'problematic events' or 'changes with strong influence' and share their experience in narratives. Interviewers then analyse the observations to summarise the experiences of many respondents or many experiences of the same respondent. These observations are then kept track of as critical events (Sztompka, 1999) or critical incidents (Flanagan, 1954), which are then used to re-examine and solve problems of practice so as to develop broad social psychological theories.

Given the purposes of this thesis, my approach to 'incidents', differs from that of Flanagan in two minor respects. In his review of the dichotomy of 'social statics' and 'social dynamics', Sztompka (1999) questions the view of society as an object and change in any society (group, community, organisation, and nation-state) as a passage from one 'discrete stable state' to another – what Lewin (1947) describes in his 'ice cube' model of change as 'unfreezing', 'movement', and 'refreezing'. In its critique of stable state views of change Sztompka (very similar to Schön's (1971) beyond the stable state) questions such views of change as 'rigid quasi-object' and 'fragmented or discrete incidents'. Sztompka argues that change in a

society should be conceived as cluster of 'processes', 'interlinked networks of interests', or a 'stream of interconnected events'.

From Sztompka's perspective, then, instead of viewing an incident as an untypical, rare type of activity or as having a discrete object-like existence, the smallest unit of analysis appears to be an 'event'. Sztompka's perspective, while it has strong parallels with CIT, differs in the sense that it does not look at events as 'really critical' for the change. Events are, rather, selected 'snapshots' or 'episodes' for interpretation and analysis and 'critically' important for academic studies on organisations (Badham and Garrety, 2003). There is no *a priori* determination or forcing the respondent into a given framework of what will be important to focus. 'Events' in this sense resemble an evolving play script that might be in chronological ordered, detailed, and complete, with the intentions of respondents for understanding and reflecting on a unified whole (Czarniawska, 2004).

Using such a viewpoint we can interrogate data and capture more of the nonlinear, process-like nature of events not as 'fragmented incidents' but as 'samples' more or less representing and illustrative of what goes on in the management of each CRC as a whole. My particular focus, therefore, is on the dynamic, tacit, and indeterminate qualities of professional practice in the process of innovation, i.e. perceiving a holistic social reality in messy and unexpected change and motion – what Sztompka defines as a 'processual perspective' on which, Pettigrew argues (1997: 340):

> If the process is our stream of analysis, the terrain around the stream which shapes the flow of events and is in turn shaped by them is a necessary part of the process of investigation. However, the interactionist field of analysis occurs not just in a nested context but alongside other processes. Metaphorically we are studying some feature of organisational life not as if it represents one stream in one terrain, but more like a river basin where there may be several streams all flowing into one another, dependent on one another for their life force and shaping and being shaped by varieties of terrain each

constraining and enabling in different intensities and ways. This quality of the interactionist field moves us into the form of holistic explanation which is the apotheosis of the processual analysis.

I relate this to the 'critical event' approach. Critical events can occur in the course of a number of major product innovation projects. So I focused in particular on the details surrounding the events. The specific events explored are those surrounding discussion and action in relation to the risks of not handling 'confidentiality', the dangers of projects being too 'research' rather than 'commercially' oriented, decision making processes regarding the commencement of a new project, project formation and management, managing relationships, tackling value conflict and indeterminacy in R&D projects, etc. I used these events to outline, illustrate, and provide a narrative reconstruction of micro and macro dynamics surrounding the use of metaphors, use of frames and framing, coping with anxiety, and undertaking reflection.

Why a narrative approach? As some anthropologists and organization ethnographers believe, verbal story-like explanations are the best approach to inquire about one's lived experience of particular events, for such narrative descriptions can relive moments of the past when any direct access to past is impossible (Bruner, 1986; Mattingly and Lawlor, 2000, p. 5). A rich narrative depiction is, therefore, not only about something but does something. It provides an inside perspective on what a practitioner can do or has been able to do intuitively yet has remained unexplored. Seen from this view, narrative discourse helps researchers to explore reasoning styles (including encounters with ambiguities, anxieties, conflicts, and the like) and understand the multifaceted and usually tacit meanings that surround a complex and contentious organizational phenomenon such as product innovation (Clark and Wheelright, 1992; Lester and Piore, 2004; Schilling, 2005; Schön, 1967, 1983)

There are a range of analytic frameworks to create, collect, and study narrative data. Several traditions have focused on stories as a prime source of data in organizational analysis (Mattingly and Lawor, 2000; Webster and Mertova, 2006): (i) the psychological tradition

which often uses 'critical incident technique' to collect direct observations of human behavior in such a way as to facilitate practical problem solving and developing broad psychological principles (e.g., Flanagan, 1954) (ii) the linguistic tradition for which everyday organizational life depends upon actual story-like communication patterns, a body of linguistically mediated interactions that demand narrative analysis (e.g., Czarniawska, 2004); (iii) the phenomenological and interpretive tradition that examines and emphasizes the ambiguity of sense-making and guesswork as to what is happening in the flow of experience, how these are represented in different stories about the same situation, and the different logics for plotting an ongoing event (e.g., Boje, 2001); (iv) and the cognitive and constructivist tradition which examines the underlying structure of a manifest story as a natural bridge to uncovering strategies of selective reasoning and the governing assumptions, insights, and values that guide action in a particular situation (i.e. exploring one's theories-in-use) (e.g., Schön, 1991, p. 346).

In the analysis of the narrative data in this thesis, the narrative approach is in a specific direction. I tend to uncover and present in an informative manner (i.e., 'tell a good story of'), the contrast between the (formal, front-stage) 'manifest' and (informal, back-stage) 'underlying' story of product innovation in practice.

Using narrative discourse to reconstruct and present a case is, therefore, not surprising because practitioners are asked, after all, to reflect on their practice and present critical experiences and events. Moreover, people, from different sociocultural backgrounds, are naturally storytellers and it is not unusual for organizational researchers to come across many organizational stories even if they are not specifically intended to elicit and analyze narrative data (Boje, 2001; Gabriel, 2000; Mcquillan, 2000). However, not everything one says in an interview is a narrative. Narratives need to reveal how people act, how their action shape events, how events and actors act upon someone shaping a range of possibilities and initiating change in actors and their web of relationship. A narrative does not need to have a complex

plot but it does need to have a beginning, middle, and end so that it unfolds in time and provide a meaningful whole rather than mere sequence of events (Ricoeur, 1984). With our particular concern with practice, the use of narrative discourse to reconstruct and present a case is an essential component of asking practitioners to reflect on their practice and present critical experiences and events. A practitioner's pattern of action, for example, becomes more comprehensible and meaningful for researchers when it is viewed as part of a bigger context.

4.3.4 Narrative Reconstruction of Critical Events in the CRC Programme

Many scholars (Hepburn and Murdoch, 1956; Burrell and Hauerwas, 1977; Mattignly, 1991; Schön, 1991) argue that we tell stories to entertain, to say who we are, to gossip, to evidence our arguments, to reveal the way ideas look in action, and above all to reflect on our past experiences that are at times puzzling, distressing or problematic in order to make sense what has happened.

Organisational theories, though, have been somewhat late in taking an interest in analysing narratives or stories shared in or about organisations by their members, and it is only recently that the importance of stories in organisational and management studies has begun to be recognised (Denning, 2007). This emerging discipline, which for some is a linguistic turn, attempts to recount events in the form of stories within the context of organisations (Czarniawska, 2004). Narrative analysts usually work with open-ended interviews.

'Manifest Stories' and 'Underlying Stories' in the CRC Programme

To make sense of situations using stories, I used the distinction, which Schön makes in discussing case histories of practice, between 'manifest stories' and 'underlying stories' (Schön 1991: 346). Schön argues that the former, 'manifest stories' , are those accounts of a practice episode that actors share explicitly, while the latter, 'underlying stories', are the often unconscious or only partially conscious representations they hold in their minds or feelings in order to make sense of reality. The underlying stories are understood and constructed by

examining the past action through the data of a manifest story, by asking why the manifest story includes some features and ignores others, what accounts for its thrust and direction, why it is understood in terms of certain categories and not others, what makes actors surprised, excited, or distressed; how actors look at things, see and interpret something as something else; what causes them to set problems in this way, etc. In this way, the exploration of these story making processes may catch a deeper level of meaning and understanding than the narratives that the protagonists explicitly support, revealing features that they have been inattentive to or have only partially grasped.

In the previously-collected interviews, managers were asked to share their private (mostly unofficial) stories about their experience in decision making, risk management, changes, clusters of difficulties, setting and solving problems, and managing and organising new projects and then they were asked to analyse their experiences in order to seek out and investigate the tacit values, assumptions and variables that guide their practice – what Argyris, and Schön, term 'theories-in-use'. Using narrative discourse to present a case is not surprising because practitioners are asked, after all, to reflect on their practice and present critical experiences and events. To present an event or critical incident in the sense first expressed by Aristotle in his *Poetics* (Aristotle, 2004) is to tell a narrative which is an imitation of action with a recognisable beginning, middle, and end, which also includes recognisable characters, plot, and settings (Schön, 1991).

For the previous researchers the primary interest was concerned with the perception and management of risk among CRC managers. Clearly, these researchers privileged some categories of description and excluded others, paid attention to some phenomena and gave fleeting attention to others. They usually adopted a personalised approach, including more of the emotive and reflective transaction (give-and-take) between themselves and the interviewees, between reflective actors and the issue at hand, and sought to communicate more of the lived conflicts, political games, tensions, ambiguities, risks, and uncertainties of complex R&D collaborations. Such an approach often includes both the researcher and the

researched as one of the many shifting and evolving facets of innovation projects. It seeks to reflect on the protagonists' underlying theories, techniques, and tactics in a 'collaborative form of inquiry' that generates a sense of immediacy and interest and captures deeper levels of the dynamics and processes that are often ignored or overlooked in formal and technical/rational discourse. The focus adopted by the interviewers within this collaborative inquiry elicited reflections on the ways of thinking, reality describing, knowing, and tackling problematic phenomena tacit in the actors' patter of action. Their interviews indicated that they intended, at least in part, to help actors learn to conduct this sort of reflection and inquiry for themselves as well as for the wellbeing of the CRCs. Having abandoned the expert role of observer/intervener, they sought to enter into the experience of practice.

This approach is close in spirit to what psychiatrist Leonard Duhl terms an 'existential use of the self' in collaborative studies (Schön, 1991: 356) which, in turn, helps researchers to better capture some underground aspects of the unsteady, indeterminate, uncertain, non-rational, and more importantly sociopolitical character of innovation and R&D projects at their early stages. By and large, the data (in the format of in-depth face-to-face interviews) can be interpreted as stories which facilitate a consideration of those tacit beliefs, constructs, assumptions, values, and deeply held images that have guided action. As Polanyi (1966) and Schön (1983, 1987) argue, much of the practical knowledge is tacit and actors may not be able to surface their theories-in-use propositionally or may offer sanitised 'espoused theories' that do not fully represent the values or assumptions that influence their practice. But they can share their experience, and depending on the level of mutual trust, respect, and intimacy (Gabriel, 2000), they might reveal *what has really happened* or what they have been doing *by telling stories* (Mattignly, 1991).

Embedded in these interviews is an attempt to provide a powerful consideration of the ordinarily tacit constructs – values, assumption, metaphors, dramas and jokes, stress and anxiety, strategies, images, tools, and games surrounding CRCs that not only have informed and influenced actors' theories-in-use but also the direction of projects. Their narratives

reveal that storytelling and exchanging dramas, jokes, and tales is common between interviewees and interviewers. However, this type of discourse was just one form of talk, and more importantly, an informal interaction that serves to distinguish between formal speech, memoires, reports, and briefs and the messy, political, complex, and chaotic reality that characterises professional practice, hence this type of discourse is critically significant for developing and testing my conceptual framework. The interviewers asked CRC managers to tell them how they had come to understand a particular project, a promising product, a problematic situation, a problem, or a risk. The work of 'telling a story' happens extensively in the interviews when both interviewees and interviewers reflect on a series of decisions, debates, demands, and the different ways that the project as a whole has been or could have been designed and developed. In the following excerpt, for example, we see how uncertainty in the shape of happy accidents or unanticipated discoveries, usually not covered in formal reports, may generate both tension and opportunity that eventually reshape the course of development:

> Interviewer: Coming back to projects you've got up and running, how do you manage them once they're going?

> Interviewee: It's a very milestone approach, so as I mentioned we've put a *Charter* together describing what the project is and submit that to the Board. That Charter contains basically a table which says by such and such and date we'll have done such and such and reporting is essentially to what extent you've achieved those milestones during the year.

> Interviewer: What happens if there's slippage?

> Interviewee: You look at arrears and you do what you can about it. There often is.

> Interviewer: Do you have rules for pulling the plug?

> Interviewee: I wouldn't say we have rules, but we have pulled the plug because irrespective of how much you put in, up to a point in time, you just have to say, you've got a certain amount of resources for the future and [ask] what's the best use of them. So, if another project has a higher likelihood of either being successful or being more rewarding, in other words, the likelihood of it succeeding and the

value if it does succeed, another project has got a higher combination of those things, then we'll go with it [rather] than the one that we've been going with. You do that *reluctantly* because obviously *it has a morale downside* if you stop things where the people involved which to go on but we have done it from time to time.

Interviewer: So, it's really a judgement of opportunity costs?

Interviewee: Yeah, that's right.

Interviewer: It's quite fascinating this whole thing of managing a portfolio of R&D projects, isn't it, as there is so much uncertainty; what happens if something really yummy comes out of I think an environment or one of your staff comes up with an idea but your resources are all utilised, what do you do?

Interviewee: Well, like I said, you evaluate the yummy one against the other ones.

Interviewer: But you can only do that annually?

Interviewee: *Oh no. We do it formally annually* so all projects are up for grabs annually, Maybe they are all up for grabs but with, on several occasions started other projects mid stream when something has come up and we've just, like I said re-evaluate.

Such narrative reflections encourage both the interviewee and the interviewer to see professional practice as unfolding, unpredictable, and discontinuous, hence a need for reflective response to surprises and unanticipated issues which are dimply apparent in the initial formal planning and assessment. It seems as if CRC projects become significantly different entities when represented through these interviews rather than the formal governance model or reports represented by Government or on-line documents that offer after-the-fact conclusions with no detail description of the chaotic events that led up to a specific result (what sometimes is called 'yummy'). In this sense, government reports or academic documents, as represented on public websites, mostly suggest a sanitised view that is almost invariable from one CRC to one another – successful stories, collaborations, best practices, achievements, awards, and the like. Moreover government has imposed a governance model on all CRC (CRC Guidelines, Nov. 2008: 12):

All CRCs (whether incorporated or unincorporated) must employ a governance model which demonstrates good practice in its design and, after establishment, good practice in its execution. CRCs must demonstrate why their proposed governance arrangements are the most suitable to deliver the proposed results.

To assist in developing a sound governance model, the following eight good governance principles are recommended to all CRC projects:

Table: 4.2 Eight Good Governance Principles in CRCs

Principle 1: Lay solid foundations for management and oversight	Fundamental to any corporate governance structure is establishing the roles of the board and senior executives.
Principle 2: Structure the CRC Board to add value	There should be a balance of skills, experience and independence on the board appropriate to the nature and extent of CRC operations.
Principle 3: Promote ethical and responsible decision-making	There is a basic need for integrity among those who can influence a CRC's strategy and (financial) performance, together with responsible and ethical decision-making which takes into account not only legal obligations but also the interests of stakeholders.
Principle 4: Safeguard integrity in financial reporting	Meeting the information needs of the CRCs, as well as the CRC programme's stakeholders, is also paramount in terms of accountability and attracting investment and participation from end-users. Presenting a CRC's financial and non-financial position requires processes that safeguard, both internally and externally, the integrity of CRC reporting.
Principle 5: Make timely and balanced disclosure	CRC reporting must provide a timely and balanced picture of all material matters.
Principle 6: Respect the rights of shareholders/participants	The rights of CRC owners, that is shareholders/participants, need to be clearly recognised and upheld.
Principle 7: Recognise and manage risk	Every business decision has an element of uncertainty and carries a risk that can be managed through effective oversight and internal control
Principle 8: Remunerate fairly and responsibly	Rewards are also needed to attract the skills required to achieve the performance expected by shareholders.

These principles, which are rather like successful ends, achievements, or accomplishments, intend to make innovation into a plannable, goal-oriented, orderly, and risk-reducing activity, as I argued in the second Chapter. Intuitive judgement, reflective inquiry, internal feeling, games of secrecy and hiding, and other complex sociopolitical processes often tends to remain overlooked or hidden. Likely technical setbacks, unintended consequences, happy accidents, political stratagems, anxiety and confusion in practitioners, and value conflict among actors tends to be masked by a neat, rational, and prescriptive model, typical of retrospective presentation of science and technology.

One striking difference between these interviews and official reports is the very different way problematic, uncertain, and unique situations in projects are given a sense of coherence when rendered through a formal project appraisal or annual reports compared to when they are revealed in storytelling. More often than not, formal reports are 'white-boxed' (Wynne, 1988) and make little or no reference to the unruly nature of technological innovation or sociopolitical dynamics that usually occur behind-the-scenes and which, in turn, shape and influence the direction of a project or the design of an artefact.

The following examples explain the difference between a CRC project revealed through informal interviews and that same project depicted through formal reports, policies, guidelines, and documents. The first example concerns the early stage of a CRC formation, i.e. designing a coherent proposal, policy, or plan for joint partnership amongst government, industry, and university researchers. One CRC manager in the project appraisal annual report describes the early stage of the project as follows:

> The first twelve months of operation has seen the establishment of a market driven strategic framework for the Centre and the implementation of a new corporate structure, operating procedures, programs and resources allocations for the seven year life of the Centre [second round]. In doing so, we have constructively built on the experience and successes of our predecessors [first round]. The transition between corporate entities and the implementation of new strategic research programs was achieved efficiently due to the dedication and enthusiasm of the company participants, the executive

management committee and all staff. The Members of the Company have elected a six member Board for this CRC X, including the Chair and CEO. Two Board sub-committees have been formed covering the areas of IP/Commercialisation and Audit/Risk, in compliance with ASX [Australian Stock Exchange] corporate best practice guidelines. The Board has also adopted policies on the role and duties of directors, including the management of conflicts of interest. The Board has approved policies for attracting new postgraduate researchers in an ever more competitive environment and for the implementation of 'best practice'.

As described above, the rationale for the establishment of a 'market driven strategic framework' is indicated which stimulated the implementation of a new corporate structure and policies, commercialisation programs, and the allocation of resources for the next seven years. But when the same project manager was asked to share his unofficial view (in the format of a story) about the purposes and challenges of imposing such a framework, the problems this initiative rendered shifted and broadened significantly. In his narrative about the imposition of a coherent framework on an initially vague and unstructured situation, he commented:

It's fair to say, that we have been to hell and back. Just to give you a bit of background, the first round ran very well, not many partners. Coming into the second round, having restructured everything, personalities came into play and it was to do with movement, it was like a break-up of a marriage, you know. Two of the principals who worked very closely, one left Queensland to go to Melbourne...In the early days there was opposition from within [this CRC] family for doing that, it forced us to split the CRC or at the very least of course [move] the headquarters and the epicentre from Queensland to Victoria. This reached the stage where we had [the two state premiers]; they had a debate about our CRC on [a famous Australian TV program]. There were lead articles in [Australian newspapers]. We had fights everywhere. In the early stages we were trying to get the proposal together. We had one [meeting] at Melbourne University where we had about 30 people around the table. I just had to go around the table, and ascertain support for going forward from each of them. [a major public research agency] were awkward, some of the industry partners were awkward. The Queensland state government and Federal government representatives weren't talking to anybody. So, in the end I just said, right, I've had it [let's have a] jug of wine. So, I took off with two or three other people and after about the second bottle of a nice red we got a phone call on the mobile from them, come back...[the

major public research agency] had moved, so we went ahead but there were enormous tensions. So, we set this up, with very very strong intentions. So, we now got to the stage of a very high degree of cohesion, collaboration, and very smooth operations. So, the question is how? Well, first of all by recognising the basis [of cooperation]. The basis is all the discussion of all the others. So, attempting to understand each others' agendas and points of view, rather than, you know, you're juggling nine or ten. Having the right people and the right processes in place and having people who are willing to do a lot of work for the Centre [is critical]. So, a lot falls to the Chair and the CEO. So, there is a lot of discussion outside the Board between meetings.

This view is supported in the words of another insider (a scientist engineer) in the same CRC. Clearly, one rationale behind sharing these stories is that the protagonists prided themselves on being able to create dramatic effects, to play politics, to recognise the complexity of juggling conflicting ideas, to implement a decentralised decision making, and more importantly seizing and recognising opportunities in an uncertain, upsetting, and tricky situation which at first glance looked like a complete disaster or failure. What they most wanted to achieve was to simply invite contending groups and conflicting voices to rethink a government-funded project in a more constructive way.

The other, and somewhat underlying, picture I paint for this backstage event and similar types of narratives in CRCs is of a tension between two ways of construing technological innovation, one which is closely linked to fluidity, chaos, non-rational artistic activity, and sociopolitical dynamics (revealed through reflective storytelling) but which carries little legitimacy within the world of product innovation, the second which is predominantly technocratic in its formulation of organisational tasks but has the status of 'rational work' for which management attention and organisational resources can be allocated. In other words, it seems as if there are two quite distinct ways of approaching R&D problems and product innovation in CRCs, approaches that appear to co-exist yet not in a cooperative manner.

Van Maanen (1980) observes this in his investigation of the personal impact of police shootings. He argues that the aftermath of a shooting as a version of an organisational critical incident is a messy matter. Based on one's position and commitment to the organisation and

its role in the larger society, actors attempt to report somewhat sanitised accounts that protect their sense of self as shaped by the relationships they have with the organisation. These formal accounts are worked out in line with mutually held background understandings of what constitutes proper conduct and are only partial indicators of 'what really happened'.

The example below also shows the difference between what is depicted in one of this CRC's annual reports with regard to the first governmental principle ('to lay solid foundations for management and oversight by the Board') and what is expressed in an interview. In the CRC Annual Report (2006-2007: 76) we read:

> The CEO is accountable to the Board for the management of the Company within the policy and authority levels prescribed by the Board. Those authority levels are reviewed and approved by the Board not less than annually. The CEO's specific responsibilities include ensuring research, development and commercialisation activities are in accordance with the Company's legal obligations such as its Constitution, its contract with Members and the Commonwealth CRC Programme Grant, the contract [this CRC] has with the Commonwealth Government. The CRC Board also monitors that the Company is conducting its affairs within the law. The CEO is also obliged to keep the Board informed in relation to the progress of all significant research and commercialisation proposals and any other major developments in relation thereto and to approve the remuneration of personnel. The Board is responsible for overall Company reporting, statutory accounting, legal compliance, auditing and insurance. Their responsibilities also include the monitoring of financial performance and planning by management against the financial control guidelines determined by the Board.

When we look at one insider's story we hear:

> Interviewer: What about [managing] the relationship between the different partners, is that a role for the Board?

> Interviewee: Well, I think the way that it's happening is that, the CEO consults the Chair quite a lot and the Chair guides the CEO probably. The Chair doesn't realise he guides the CEO but I think the Chair does guide the CEO in his approach often which helps the relationships between Board members and the CEO, maybe.

Interviewer: So, if you were thinking of the qualities that a CEO of a CRC should have, what do you think would be good?

Interviewee: In our case...he's got to be well respected as a scientist, both nationally and internationally, and *he's got to be a political animal* because he's got to manage all this disparate group of people which is no easy task and...*he's got to be firm to be able to stand up to people like me, who want everything and can't understand why we're not given it*. In other words, you've got [to be] a bit of a superman I suppose, it is a difficult job to be a CEO of a CRC because to be a CEO of a joint venture is difficult but I think [our] CEO does it quite well... he doesn't tell me these things...but I think he's got some criticism by the, review panel saying, that's he's too supportive of [an industry partner, i.e. his host company] which is not good, is it?

These vivid descriptions of the behind-the-scene politics and chaotic commencement of novel projects reveals the significant discrepancy that exists between the accounts given when formal evidence, reports etc. are requested from practitioners by official boards and the more reflective accounts given in response to requests by researchers to tell their stories. Not unsurprisingly, one striking difference is that the personal narratives focus far more on the sociopolitical dimensions of product innovation, how social actors address conflict and complexity, and the attempts they make to shape and reshape situations. While in formal accounts the emphasis is on clear-cut policies, structures, programs, framework, in short the instrumental adjustment of means to ends, the more personalised reflective narratives highlight confusion and uneasiness, anxiety and ambiguity, value conflict and differing perspectives, power and politics, and the artistic, informal and ongoing conversations, and non-rational activities of actors as they strive to make sense of, frame and reframe inherently problematic situations.

The examples given in this chapter, and the next, reveal what can be uncovered when actors are involved in more informal narrative or storytelling. As Mattingly (1991) argues, narratives are emotional and impassionate accounts by which we surface the motives, personal intricate manoeuvring, feelings, assumptions, intentions, and, on occasion, deeper layers of 'underlying stories' which are usually masked by conventional habits in formal

discourse. Narratives, depending on the nature of the trust and intimacy between the storytellers and the audience, can disclose the often unvoiced dynamics of action, providing their own invaluable chronological structure that may differ strongly from the formal accounts that are acceptable in official work contexts (Mattingly, 1991; Czarniawska, 2004). Clearly, all narratives are social constructions, and therefore need to be treated with care and a healthy dose of scepticism. Aristotle (2004), for example, sees the organisation of story events through a plot as turning a mere sequence of events into a unified whole governed by a moral dear to the narrator. It is, therefore, important to be sensitive to what Carr (1986) describes as the 'bee buzzing in the bonnet' of even the most lay 'historian'. In this thesis, the stories that are being extracted are those of practitioners attempting to make sense of how they handle the uncertainties of innovation that are not adequately captured by formal risk management language and rhetoric.

As suggested by the literature review and documented in the field data, prescribed guidelines, sanitised accounts, and pre-defined means and ends appear to be imperfect, ill-defined, inconsistent, or incompatible with what is actually experienced by participants in the course of innovation, particularly in its conflict-ridden and troublesome early stages.

Collecting narratives, as documented in this thesis, do not require prompting interviewees to provide a complex social psychological account of their experience. They only need to be asked to provide a quick narrated sequence of events as they experienced them. The type of open-ended, chatty, less-controlled discourse exemplified in the interviews provides a natural bridge to serious and critical reflections on the theories-in-use that inform and influence everyday practice and provide an important balance to, indeed relief from, the traditional rational espoused theories or the official stance of actors speaking the traditional language of risk management.

4.4 Summary

The purpose of this thesis is to provide a conceptual framework to support reflective practice. This framework is enriched and illustrated by field data, and was further elaborated and developed in interaction with this data. As documented in this chapter, the data was drawn from three studies of innovation projects within the Australian Cooperative Research Centres (CRCs) programme. The main focus of this chapter has been to justify and explain the nature of this data and how it has been used in this thesis. A more detailed discussion of the field data is provided in the next chapter as part of a more detailed elaboration and illustration of the 'colonisation and conversion' framework.

Chapter 5 Colonisation and Conversion: Risk Settlement and Risk Management at the Fuzzy Front-end of Innovation

[Recognition of] Uncertainty which is at the heart of technical innovation is taboo. Uncertainty is frightening [and] a corporation cannot operate in uncertainty, but it is beautifully equipped to handle risk. Accordingly, the innovative work of a corporation consists in converting uncertainty to risk (Schön, 1967: 25).

By uncertainty I don't simply mean a probability of less than one. I don't simply mean that you are not sure of exactly what will happen. I mean 'being in a situation that doesn't make sense.'...when you have more information about it that you can handle....you don't know what to do with it...you need to get rid of it, and the vehicle for getting rid of it is to have a theory....to know what to pay attention and what to ignore. Dewey's treatment of the problematic situations will help to understand the issue of uncertainty. In such situations the construction of a 'problem' is an attainment (Schön, 1995: 238).

When planners or managers convert an uncertain situation into a solvable problem, they engage in a kind of inquiry which cannot be subsumed under a model of technical problem-solving. They construct not only the means to be deployed but the ends-in-view to be achieved. In such problem-setting, ends and means are reciprocally determined. And often, in the unstable world of practice, where methods and theories developed in one context are unsuited to another, practitioners function as researchers, inventing the techniques and models appropriate to the situation at hand (Schön, 1985:15).

It is only on a non-rational basis that one can make the leap from the virtually infinite combinations of possible variables to some finite set (Schön, 1971: 215).

5.1 Introduction

Having provided an overview of innovation, risk, and uncertainty theories and having reviewed the approach and methods for this thesis, I am now in a position to outline and illustrate a conceptual framework in an attempt to answer the question with which I began this study: How do reflective practitioners actually handle messy, nonlinear and jagged paths of product innovation that defy orderly, standard, and rational solutions? How do they convert such problematic situations into packages of manageable problems – packages in which they colonise and frame ambiguities with manageable risks and rewards? Finally, how, on the basis of this understanding, can we broaden the discourse on risk management beyond the colonisation of the future through risk management rationalisation, and, in essence, support a more open and reflective approach to improving how practitioners handle uncertainty?

In a sense, the notion of converting uncertainty in problematic situations into packages of manageable problems swims against the prevailing tide of rationalistic risk management.

Reflection on this 'conversion' practice has little currency among scholars and authors schooled in the traditional uncritically rational field of risk management in innovation (Lupton, 1999a). Moreover, while Schön's basic ideas on reflective practice are relatively widely disseminated, and clearly relevant for exploring the practice of handling uncertainty, no conceptual framework exists within the risk management literature based on Schön's ideas and the interdisciplinary approach that he brings to exploring and improving practice. If, as Schön argues, following Dewey, uncertainty is dealt with by converting, framing and transforming a problematic situation into a set of manageable problems, it becomes clear that the practices of handling uncertainty and constructing manageable risks are closely intertwined, and exist as a complex field of practice amenable to systematic and purposeful reflection and improvement.

It is the argument of this chapter, and the thesis, that the handling of uncertainty involves actively and selectively settling on relevant facts, issues, conditions and circumstances in *creating* a manageable package of risks subject to calculation and analysis. It is, in a sense, the first stage of colonising uncertainty through an initial complex socio-technical and social psychological process. From this perspective, the traditional approaches to managing risk in organisation are a secondary set of stabilised and calibrated forms made possible by a *prior 'primary' practice*, one that converts the complexity and anxiety of 'uncertainty' into a colonised and bounded set of 'manageable risks and rewards'. Both the first 'settlement' stage that provides a selective perception of problems and uncertainties ('problem setting'), and the subsequent 'management' stage of ranking, calculation, assessing, and resolving ('problem solving'), have a key role in the colonisation of uncertainty. Both of these primary and secondary phases of 'colonisation' need to be addressed in any comprehensive study of the techniques, models, rules, rituals, practices, games, and expectations of organisations as they seek to handle risk and uncertainty in their interaction with their environment.

The first stage of the 'conversion practice' is a kind of creative social psychological inquiry that is close in spirit to John Dewey's (1938) 'transforming the indeterminate into the

determinate', William James' (1953) 'bringing the irregular and unclassified phenomena within the classified and regular fold', and Hermann Hesse's (1969) 'making the indigestible digestible for the mind'.

Insofar as this practice is left unacknowledged and unnoticed, risk management neglects a crucial yet overarching component of colonisation – how uncertainty is actually understood and handled. It 'brackets out' from consideration the intellectual and sociopolitical factors involved in settlement of manageable risks: how risk is constructed and how restrictive risk management practices are stabilised, colonised, and normalised in the first place.

I seek to address this weakness by focusing on a particular area of risk management practice: practitioners handling the uncertainty and anxiety of addressing issues of 'risk' at the fuzzy front-end of innovation. This focus was adopted for two main reasons.

Firstly, as acknowledged by a number of commentators (Wynne, 2001; Hoffmann, 2002), social analyses of risk have often focused on the social consequences of already developed products and processes (MacKenzie and Wajcman 1985, 1996, 1999). This excludes more reflective questions about the dynamics, governing assumptions, values, and visions which shape front-end of product innovation commitments as well as associated risk management methods. Thus the forces shaping these commitments remain as protected as ever from wider scrutiny or what risk society authors term 'organised irresponsibility'. Secondly, as argued earlier (see 2.8), according to a well-established body of literature (e.g. Wheelwright and Clark, 1992) there exists a direct link between senior management's ('strategic') ability to influence risky outcomes and their involvement at the early stages of the innovation process.

These two reasons add up to a forceful argument for a detailed, social constructionist and practice-oriented focus on the handling of uncertainty and managing risk at the fuzzy front-end of innovation.

This chapter presents the conceptual framework developed to address this area of focus, illustrated and elaborated through the use of narratives of critical events from the Australian CRC Programme – as summarised in the previous chapter. This chapter begins with a conceptual outline of the nature of what is termed 'risk settlement' and 'risk management' at the fuzzy front-end of product innovation. I then illustrate this framework through the practices introduced in the previous chapter. The chapter concludes with a more extensive discussion of the conceptual framework, a framework that is specifically designed to grasp how practitioners within organisations handle uncertainty by constructing and settling on what are then perceived to be a set of 'manageable' risks

5.2 Conversion Practice: Risk Settlement and Risk Management

The chapter addresses two key research questions. Firstly, how we can conceptualise the nature and relationship of how uncertainty is handled, transformed into identifiable and manageable risks, and how these risks are then managed. This is addressed by drawing on Gidden's view of risk management (Giddens, 1999) as a project aiming at the 'colonisation of the future', yet this model is developed and used in a very specific manner. It is used as a metaphor to explore the earlier stages of handling radical uncertainties as an initial 'settlement' process, followed by a subsequent process of 'management' once the basic terrain has been established, defined and occupied. Secondly, how are we to understand this earlier 'settlement' process? What 'practices' are required to convert uncertainty into manageable risk? How do these practices or activities lead to the settlement of manageable risks and rewards during product innovation?

In elaborating on conversion as a new tool for the colonisation of uncertainty (and its contrast with the more restricted view of the province of managing risk as being merely the later stages of 'risk management' – what might be loosely, but rather ambiguously, characterised as 'colonisation by rationalisation', it is important to emphasise and make clear that this

framework is developed in direct opposition to the view of risk management as a rational process or a universal tool to colonise the future.

If we continue to elaborate the metaphor, this traditional view of risk management or 'colonisation-by-rationalisation' contains three main elements: the *selection* of the territory to be colonised, *exploring* the territory and *occupying* the territory. The first selection phase, in the terms of traditional risk management, presumes or identifies a 'territory' in a manner that is assumed to be objective and the governing assumptions and purposes as well as the character and boundaries of the territory are not subject to critical reflection. The second exploration phase involves the traditional risk management analytical processes of identifying and ranking risks as part of an assumed objective, systematic and rational analysis of the 'territory'. The third occupying phase is characterised by the traditional risk management process of defining and implementing solutions, involving plans for the mitigation, transfer, and monitoring of risks.

Such a 'colonisation through rationalisation' has been generally adopted by many of the organisations and practitioners involved in the business of investment, growth, and of course product innovation (Smith and Merritt, 2003; PMBOK, 2004). Whatever differences may be among policy designers, practitioners, engineers, financial analysts, and product managers, they have come to regard themselves as risk managers, in the sense described above. Indeed, as Power (2004) argues, institutions at many levels increasingly define their character as an organisation of risk management. Traditional views of managing risk in product innovation are part of this more general phenomenon. These views usually assume that corporations know, or can easily voice, the risks involved in developing a new product, the risks in the market, the risks of allocating financial resources for a full-scale development, the risks in projected income statements, the risks of timing, the risks of future deliveries, interpreting threats and opportunities mostly in the 'language of investment'. Risk management solutions act as instruments to identify, measure, and rank the possibilities, and monitor future

uncertainties. In sum, the task is to find appropriate risk management solutions well-suited, in the face of constraints, to target and tackle familiar and expected issues, coordinating corporate action and administrating risk management plans through an orderly process of implementation.

It is the argument presented here that this model of risk management as 'colonisation by rationalisation' is only good for 'solving' well-formed problems of risk within an intellectual terrain that has already been intellectually 'set'. It fails to systematically recognise the non-rational character of the 'language of invention', and fails to reflect upon and improve the effectiveness of artistic work undertaken in the prior stage of 'problem setting' or 'risk settling' crucial in situations of higher uncertainty and instability (Ackoff, 1979; Beck, 1999).

Drawing on a broader definition of colonisation, I outline the first, and primary, stage of the handling of uncertainty as a process of 'risk settlement', that establishes the basic conceptual territory, its conditions and boundaries – the terrain that subsequent discussions of risk management will occupy. It might even be argued that this phase is an ontological process, a creative form of world-making (Schön. 1987; Goodman, 1978). It creates the risk maps that others, even the first settlers, take as the risk territory. The creativity exercised during this process involves actors' improvisation, reflection, tacit knowledge, insight, craft, or hunches. It involves real-time intuitive artistry in the existential here-and-now (Schön, 1967, 1971), non-rational inference (Schön, 1963, 1967), coping with anxiety and undertaking on-the-spot reflection and experiment (Schön, 1983, 1987), and the use of generative metaphors.

In the general discussion of risk management, it is this first 'risk settlement' stage that 'sets up' the conditions that enable and allow for subsequent stages of more traditionally defined 'risk management' as a technical/rational process of risk identification, rating, and resolution. These subsequent processes work on packages of manageable problems that are the result of prior settlements, created through a reflective process of psychological, cultural, and political construction. From the broader cultural, political and critical perspectives on risk, such

processes include elements like the role of social stigma and blame in defining what is taken to be 'good', 'bad', 'impure', 'taboo', 'normal', 'abnormal' (Douglas, 1966; Lupton, 1999), the political structures of 'organised irresponsibility' that bracket out certain factors from consideration (Beck, 1999), and the discursive practices and disciplinary regimes that define and control institutional 'danger' (Lupton, 1999).

In this chapter, all such elements are integrated into a conceptual framework of the colonisation of uncertainty as a conversion practice that elaborates and extends Schön's work on practice, uncertainty and the institutional shaping of innovation. In accordance with *Schön's view on exemplars and rules of thumb in informing professional practice, this conceptual framework is **not** presented as a closed formalistic theoretical system but a set of more open, illustrative, metaphorical and sensitising heuristics.*

In developing and illustrating this framework, a central aim of this chapter is to elaborate, explore and illustrate four practices of what is conceptualised as a 'colonisation as conversion' process. These are constituted by the micro and macro dynamics that surround: the deployment of metaphors (Cassirer, 1946; Schön, 1963, 1979), the use of frames and framing (Goffman, 1974; Schön, 1987, 1994), coping with anxiety (Sullivan, 1965; Schön, 1967), and undertaking reflection (Dewey, 1933; Schön, 1983, 1987).

Like all attempts at colonisation, however, the quest for control is, in part, always an illusion – and radical and shifting uncertainties do not just stop after the initial 'settlement' process is over. The practice of uncertainty handling continues throughout the whole risk management process. This said, however, the earlier stage of 'settlement', defines the problems and boundaries which make the later application of more traditional, probabilistic, technically/rational methods and practices possible. It does not mean that the problems have been solved, or that the boundaries have been correctly drawn or do not need to be redrawn.

The colonisation of uncertainty is, in Nietzsche's words, a 'dance on the feet of chance' (Kaufmann, 1976); but it is a duet not a solo. In the field of risk management, it is an

ongoing interactive process of both 'settlement' and 'management', not one or the other. The problem with traditional technical/rational approaches lies not in their techniques but in their lack of understanding of context, and their restriction of knowledge to a narrow technical domain. The purpose of this chapter is to help open up for reflection and scrutiny the less traditionally 'rational' components of risk management in practice – as an aid to informing that practice itself

In such a 'colonisation as conversion' process there are two central issues. The first has to do with handling Knightian uncertainty, from what people in organisations say and do in uncertain, ill-defined, and problematic situations, how they acknowledge and handle such difficult situations, whether their practice involves setting up manageable problems and the settlement of risk and rewards. This train of thought argues for a greater awareness of risk settlement at the front-end of innovation. This leads to the obvious question: what type of framework should we use as a guide for informing practice and reflection in this area?

The second issue has to do with the elaboration of a set of 'conversion' practices or activities as a framework for conceptualising this inevitably messy process. It explores nothing less than the question of *how and through what practices* some practitioners come to transform a problematic situation into one where they can exercise risk management. The concern here is to offer a conceptualisation of the process by which such settlements are made, the practices and the sorts of elements pertinent to them. The framework outlined here regards this as a process of risk settlement, in which the colonisation of uncertainty occurs through a process of conversion, the conversion of uncertainty into manageable risks. It is intended to provide an intellectual framework capable of supporting practical reflection on both issues, and assist in opening up discussion and debate on the complexities of 'problem setting' and the uncertainties that characterise the 'language of invention'.

5.3 Risk Settlement at the Fuzzy Front-end of CRC projects

Using CRC events, I attempt here to illustrate and elaborate on my framework by expounding and deploying it through narratives of how practitioners saw themselves as handling uncertainty and risk in the early stages of product innovation in the Australian CRC Programme. Drawing on these narratives, I shall then single out and describe the underlying practices and activities entered into by the practitioners. These involve the key issues of their quality of inquiry and self-reflection; the use of frames for formulating and reformulating problems; metaphorical insights and inferences; and the ability to tolerate anxiety that handling puzzling phenomena creates.

At the fuzzy front-end of innovation there are multiple levels of ambiguity, complexity, and instability. While many people attempt to manage such problematic situations through a traditional risk management framework, we shall see that these situations defy such technical/rational terms and tactics. In fact, they are addressed, often tacitly, often clumsily and frequently ad-hoc in a more informal personal and subjective manner where social and political criteria are the key parts of the process and the judgement criteria. I first illustrate this in three stories, before then proceeding to elaborate on a more systematic analysis of the 'risk settlement' conceptual framework. I use interspersing italics in the quotes I am using for emphasis as I draw on them when linking theory to the empirical data.

A story about the gambling nature of the fuzzy front-end

In an interview, interviewer asks an interviewee to reflect on the very early stages of a major project at which she and her colleagues seemed to be searching for an appropriate set of research projects in a particular medical products field. She says that for the 30 years the industry had been searching for ideal product. The search for an ideal design had been the number one priority in the industry, yet no feasible solution was in sight. This CRC then decided to gamble and combine two other technological frames for possible solutions,

necessitating the need for an original equipment manufacturer as an industry partner. But there was a dilemma. Within the existing budget they needed to choose between two options: either to scan 50 less risky research projects using multiple and alternative perspectives with a variety of suppliers or to focus on 3 high risk but high pay-off projects with only one supplier and to do these projects really well. After many debates and discussions they made a strategic decision to choose a well-known supplier outside the industry and define 3 projects in the hope that later they could talk about other projects. The chosen supplier had a division in the area of medical technology which was of interest to that CRC. The first project ran well for a while until, as the interviewer says: 'their surgical CEO jumped ship and they terminated the agreement with us. So, there is a risk; you're only as good as you are. Our success with the [the first project] was not enough to keep the other [project] going when they lost their CEO. They just couldn't put much money into the R&D'.

An underlying story for this event is that CRC people often step into an indeterminate and unpredictable situation in which they strive to construct a framework for its likely problems, converting uncertainties into a set of hopes and fears, a set of manageable risks and rewards. Once the concept of a project or a product originates in a brainstorming session, people start asking 'what benefits can we deliver through this project and what are the risks or the rewards we may reap?' and when they arrive at a basic product definition, they might begin to explore the particular technologies they need.

Yet many opportunities, dilemmas and their likely solutions are not usually given or even suspected at the outset. There is ambiguity and doubt around which might be the 'right' supplier, 'right' way, or the 'right' technology for their purposes. These ambiguities must be explored, constructed and settled by practitioners when making sense of ill-defined, treacherous and problematic phenomena. Ways of describing dilemmas and setting problems shift and evolve in time.

Social construction of discovery: a new trend in industry

In the same interview, the interviewer asks the interviewee about the demographic trend in the market of the medical product which is growing in the developing Asian countries. The interviewee agrees but acknowledges that the increase in the number of people that are short-sighted is huge, particularly among young boys under 18 and is exacerbated by the use of video and computer screens. The interviewee says:

Interviewee: [it] is very interesting because a lot of work has gone into to trying to understand what is driving this new trend. For instance,...if you look at parentage, there is obviously a genetic factor. It goes up [according to parental background]: [if] you've got no parents [who are short-sighted], [then] there is a certain risk, that risk [increases] if you've got one parent [who is short-sighted], [and] if you've got two parents, it's like three times the initial risk. So obviously you've got to choose your parents well.

Interviewer: That's [so] with all things.

Interviewee: Yeah and as these countries develop, there is [an increasing] focus on [near sightedness]...Today we are much more focused [on this] here than we were a few years ago, so that's got to create a trend. You look at the [use of the] Internet in Australian schools, there is a remarkable increase in the number of children becoming myopic.

Interviewer: Is this a problem, [or are we just] paying more attention [do] you think? [What exactly] are we measuring?

Interviewee: No, I think there is a real change.

Interviewer: Do you?

Interviewee: Yes, because there have been studies done in Taiwan and in schools and they go back and look at the [trend]. It's a real trend and…it's not only genetic. It happens too quickly for it to be just genetic.

Interviewer: Well [if it was genetic] the proportions would be relative stable for several generations.

Interviewee: That's exactly right. They think it's more than just [inheritance]. Parents are important, but [they are] not the only [factor].

Here we observe that, in this CRC, managers discover unanticipated patterns and possibilities which have informed and modified their previous perception of a medical product industry. They attempt to construct a new representation of the situation. As the new representation takes shape, new goals, criteria, threats, and opportunities emerge of which they find some incompatible, requiring the rethinking of their initial plan.

The problem of myopia (short-sightedness) among young Asian boys tended to be defined before the 1990s as a 'genetic or inheritance factor' and is now seen as a problem due to overuse of the internet and computer screens ('we are much more focused [on this] here than we were a few years ago, You look at the [use of the] Internet in Australian schools, there is a remarkable increase in the number of children becoming myopic'). This has triggered a new trend in scientific research, a dilemma, and probably an opportunity in the market. But as it is observed, new descriptions of dilemmas and opportunities tend not to spring from the solutions of the problems earlier set (short-sightedness due to inheritance). Instead they evolve as new features of an unfamiliar situation come into prominence.

Some new products from another domain have created unintended consequences, and these products come to be perceived as risks in their own right that needs to be managed. Detecting the intended as well as unintended consequences of previous moves, this CRC manager becomes aware of an evolving field of criteria, constraints, and concerns, which are to some extent, mutually incompatible (e.g. should the CRC focus be more on ethnicity, or on environment, or on country, or on occupation, or on age, or a combination of all of these factors?). She has to set new problems, invent new alternatives for action and formulate the likelihood of newly emerged risks and rewards. On the basis of this restructuring she resets and reorganises another frame for developing new products. The new frame takes account of the multiple, partly incompatible requirements of which she may become aware only later.

A common underlying story

The above two narratives simply reveal that the essential difficulties in fuzzy front-end have more to do with an ongoing practice of 'problem-formulation' than with 'problem-resolution' (Watzlawick, 1974) more to do with ways in which practitioners explore new threats and opportunities, recognise the inherent uncertainties and translate them into new structures of risks and rewards to be managed than with the selection and exploitation of common technical means for managing common ones. We should notice that each settlement is provisional as new unanticipated problems, variables, criteria, and values always come into prominence (as in the first case). Moreover, these settlements may yield unanticipated consequences that people find the previous choices inadequate. In this way the iterative cycle of 'risk settlement-risk management' is an ongoing game. It becomes, then, critically important to learn how risks and rewards at the fuzzy front-end of innovation are actually settled and to explore what it means to transform ambiguity in the early stage of innovation into bundles of manageable problems.

Such a settlement often depends upon an underlying conversion practice in which practitioners make sense of threats and opportunities and set the direction for managing them. The notion of conversion then becomes a tool or perhaps a generative metaphor for the critical analysis of handling and colonising uncertainty at the front-end of undertaking adventures such as innovation, i.e. translating indeterminate into determinate. My point here is not that practitioners ought to think of the fuzzy front-end as a risk settlement enterprise, but that some of them do already act during this phase in terms of a tacit formulation of risks and rewards, a tacit colonisation of uncertainty into manageable arrangements. So we ought to become critically aware of such dynamics, in order to increase the rigor and precision of our analysis of risk and uncertainty in innovation, particularly in its early stages, with the hope that such practices may be improved.

A story about breaking a stalemate

In the previous chapter (see p. 231), I reviewed the first part of the following story, a story that reveals the contrast between a CRC formal report that explains about the establishment of a market driven strategic framework and the unofficial view of a CRC manager regarding the challenges of imposing such framework in that CRC. When asked how the CRC manager has broken the deadlock he says:

> Well, first of all by recognising the basis [that] all the discussion of all the others [should be taken into account]. So, attempting to understand each other's agendas and points of view [but] you know, you're juggling nine or ten [conflicting viewpoints]. Having the right people and the right processes in place and having people who are willing to do a lot of work for the Centre...The other good thing we've done at Board level, is, recognise that we then, a number of different businesses and a lot of the confusion and tension has been in operating those in a uniform way. So, now we've activated [a new spin-off company]. That's more than a shell company and that is now an operating company and we've got a small Board for that and this firm deals with all the commercial activities. Now, the commercial activities are things like, all IP licensing, commercial contracts and commercial research and development, which we call alliance programs, contract research, consulting, training. So, what we are doing under this company is then have another series of spin-off companies. So, we've got a company for consulting, a company for training, etc., etc. Now, what this does is gives us the structure that we can have proper processes in place to run each of these parts of the business and the shareholders and the stakeholders are then involved in every part of the business if they want.

As we saw before (see p. 231) the early stage of this CRC commenced as a very conflictual, situation. The conflict between actors had resulted in a stalemate. No side had the leverage to get what they really want on any particular issue. In this sense the interviewee was referring to the early stages in the formation of the CRC.

Among the moves necessary to break the existing deadlock, the CRC manager maintains that actors needed to stop being defensive and work on developing a broad mutual structure that reveals important overlapping interests. Initially, the crux of the matter is not whether they

should have a mutual frame that guide actions in concert, or why they should have it, but how to go about doing so.

The beginning of any CRC is characteristically a collection of actors each with their own interests, intentions, and images of a desirable future and the likelihood of undesirable events, and their own interpretation of the facts because each actor structures the information flow differently. So actors dispute over the definition of a new project/product and the use, or initiation of particular policies. They might tend to cooperate yet they are within a framework of potentially conflicting imperatives for action.

Whether conscious of it or not they hold conflicting frames, perspectives, metaphors, and interests and use their respective powers to promote their own interests; hence they might employ different stratagems of selective inattention. Depending on their views, they differ as to what issues are relevant/irrelevant. Even when they focus their attention on the same issues, they may try to give them different interpretations to dismiss the evidence adduced by antagonists. As an unintended consequence, these dynamics initiate a complicated, uncertain, and defensive environment. The situation becomes a gallery of conflicting opinions whose shifts may change the definition of a new project as well as the values and constraints that determine how the new products can or should be developed. New data may yield new perspectives or may aggravate old differences.

It seems that the post and past of this CRC manager make him notice a lack of coherency in what is first unanimously regarded as manageable risks and rewards that the partners can later operate on that basis. As a consequence of the complex and conflictual situation in which they are engaged, this manager seeks to arrive at agreement about the problems they are trying to resolve, the form and fashion of the benefits they are trying to achieve, and the risks they are trying to avoid. Hence, appropriately he strives for reliable communication to inquire about actors' tacit assumptions, values, and governing variables. Involved in a treacherous and political situation he reflects on the meaning behind the signals and messages he receives

from the other members, and probes other actors' interpretations of the situation. He initially strives for a convergence of ideas, at least about the focus of the CRC, even though the members, at any given time, hold different views about the reason for participation in the CRC.

The convergence of conflicting ideas can be a very painful step with enormous tensions. A working consensus is required despite the conditions of uncertainty and complexity ('juggling nine or ten conflicting ideas'), so he attempts to make clear what the concerns are and what it would mean to resolve them. In this process, the CRC manager's intentions evolve. However, the main problem for him is still a coherent organisation that must be given to an ill-defined situation in the form of a project proposal, how to impose a discipline, order, or normative template upon such a situation.

From whatever sources he, along with his colleagues, draw initial order they are treating its imposition as an experiment whose results will be only dimly apparent at the outset ('attempting to understand each other's agendas and points of view'). In the reminder of this stage, his initial attention still centres on the problem of coordinating people's agendas and points of view and giving them a cohesive structure. For example, he discovers that some of future confusions and tensions would be resolved if he, and his colleagues, initiate a joint commercial spin-off, encouraging all involved parties. But he is aware that this would also create unique problems due to royalties, dividend, etc. His recent finding, nonetheless, creates a new, sharp consensus across all parties, as voiced with surprising harmony at one of their emergency meetings. Indeed, such a strong positive signal to all parties about their likely abilities has encouraged them to reinvent themselves and re-engage with the program. Although the devil is in the details, one of the great debates about the future of the CRC is now over. They no longer need to argue about one of the main issues – the likely profits – and they can cast aside discussions about the structure of the commercial relationships.

As the process goes on, the CRC manager together with other CRC members intuitively combine and recombine a set of themes, purposes and goals as the basis for further coherence. They look for criteria and directions for shaping and further reshaping a workable proposal. In other words, they attempt to impose workable frames on the situation and to package a set of manageable problems. A frame or coherence does not exist prior to their association but must be imposed upon the situation by an order of their own. They must also take responsibility for the order they impose which otherwise would collapse. The frame implicitly shows the sense of a manager able to guide and shape the debates. So this CRC manager, engages in a disciplined pursuit of the implications of his chosen frame or structure by which he strives to shape and bring consistency to a situation otherwise unstable and in flux. For example, he puts together processes through which parties can become involved in every part of the venture if they want. At the same time he incrementally increases his chances of arriving at a deeper and broader coherence in the programme as it gains pace. His moves inevitably produce some unanticipated effects ('fighting everywhere') which he sees either as flaw ('break-up of a scientific relationship') or happy accidents that suggest new opportunities. Each move has implications building on later moves. Each triggers new problems to be described, new risks to be managed, and new opportunities to be exploited.

Through the intended and unintended consequences of these moves the situation changes, creating a new set of valid bases for further action, negotiation, reflection, and experimentation. As he reflects on the ideas, threats and opportunities as they emerge after the previous frame, he evaluates each negotiated order by its quality and direction to which it leads. In other words, he moves in the situation, holding back from those actions which would commit him irrevocably and dogmatically to one perspective/frame or another, seeks to learn from the situation in the process, listening to what the situation has to teach as he probes it ('The other good thing we've done at Board level, is, recognise that we then, a number of different businesses and a lot of the confusion and tension has been in operating those in a uniform way. So, we've activated a spin-off company'). This evaluation rests on his perception of the potential for

coherence, which he can realise through further inquiry, on-the-spot experimentation, and intervention.

As this CRC manager together with other CRC board members try to impose and institutionalise each negotiated frame upon the situations, they determine the features to which they will attend, the directions in which they will attempt to divert problematic situations, the goals they will strive to achieve, and the risks they will detect. So manageable risks are settled when CRC partners select and set the boundaries of their attention; and make an effort to impose upon a fuzzy situation a workable coherence which allows them to say what are the new purposes to be achieved and what are the new threats to this achievement. The settlement of risks and rewards is a process in which, interactively, actors reflect on the dangers and opportunities, and explore new issues from which they will select a few to attend to, and frame the context in which they will attend to them. Even when an arrangement for managing risks has been constructed and settled, it may escape the categories of applied risk management techniques because the process may encounter another unique, puzzling and problematic situations or happy accidents which require leaps of decision making.

Such complexities are often not resolvable solely by applied science, i.e. proceduralised means, or mechanisms of quantification. Indeed, seemingly intractable conflicts and controversies result in higher degrees of anxiety and uncertainty which become, in their own right, concerns and variables in the early stages of a venture. The question then arises as to how these protagonists actually do more than they can say when they convert problematic situations into resolvable problems and how it is possible by a *conversion practice* to achieve the framing, coordination and integration of conflicting perspectives for the settlement of risks and rewards. What is the nature or structure of this practice?

5.4 Practices of Conversion

Each of the above stories emphasises different features of the underlying theme and helps make that theme explicit. These include practitioners' abilities to create dramatic effects and play political games while coping with stress and anxiety, to recognise and reflect on the complexity of juggling conflicting ideas, to use previous exemplars to implement a decentralised decision making, to reshape an upsetting and tricky situation which at first glance looked like a disaster, to recognise the political structure of 'unintended consequences' and exploration of the new variables governing the new phenomenon.

However, all of these stories have a number of features in common that can be described as a set of overlapping and interrelated 'practices' in conversion – converting problematic situations into manageable problems. These practices are integrated into a conceptual framework of converting uncertainty based on the work of Schön. The specific concern will be to elaborate, explore and illustrate four dimensions of this conversion practice. These are constituted by the micro and macro dynamics that surround: the process of metaphor (Cassirer, 1946; Schön, 1963, 1978, the use of framing (Goffman, 1974; Schön, 1987, 1994a), coping with anxiety and defensiveness (Sullivan, 1965; Schön, 1967), and undertaking reflection (Dewey, 1933; Schön, 1983, 1987).

To one degree or another, the conversion of uncertainty characterises the initial stages of product innovation in many corporations (Schön, 1967). In each company it may take a different form but to a large extent retains its essential characteristic. These practices are not discrete activities, sequentially following one another, but aspects of an iterative process whose overlapping components are intertwined.

Drawing on the notions of underlying story and critical event, I shall pursue this line of enquiry by revisiting several examples and consider in these cases the practitioners' engagement in the conversion of uncertainty. I systematise a structure for the four intertwined

elements in the practice of conversion – coping with anxiety, framing, metaphor, and reflection.

5.4.1 Coping with Anxiety

In chapter 2 and 3, as I argued, there are many sources of anxiety and insecurity for practitioners involved in the business of developing new products. These include: the sense of vulnerability for being in indeterminate and unstable situations; threat to the sense of self; a terror of failure; games of secrecy and hiding; the use of pecking order and scapegoat mechanism in the event of failure; threats to credibility and the potential for embarrassment; poor communication; a conflict of values and cognitive dissonance; mistrust, games of mystery and mastery; the incongruity between actors' espoused theories (what they say) and theories-in-use (what they actually do); decision making on the basis of inadequate information or being faced with too much competing information than can be handled.

Practitioners strive to maintain their established sense of self and avoid insecurity and anxiety at all costs even at times by seeming confident, because uncontrollable sources of anxiety may result in a loss of credibility and confidence which make it difficult and stressful for them to perform. It may result in camouflage of responsible actors in order to avoid decision making, mutual deception, defensive reasoning, and bypassing perceived threats and covering up the bypasses, all of which oppose an effective and reflective practice of innovation. More importantly, uncontrollable anxiety limits practitioners' competence in effective decision-making, in efficiently being able to read the complex phenomena, in the framing of ambiguous events, and in setting and solving problems in situations of uncertainty. Anxiety, Sullivan (1965: 44) argues, can almost be said to eliminate foresight. The more anxious one is, the less the capacity for foresight is free to work effectively on the choice of action appropriate to the challenges and complexities that one is experiencing. Accordingly, the development and formation of new frames, generative metaphors, hypotheses, ideas, and concepts may not occur if uncontrolled anxiety is present.

The sense of vulnerability in situations of indeterminacy

The initial condition of a CRC is one in which practitioners and managers confront a demanding yet inconsistent situation. There is a need for focused attention to develop commercialisable projects within a pre-defined grant period. Yet there are both opportunities and dangers, and when the main purpose of R&D becomes commercial it is by no means clear what area of research expertise should be given special attention because one CRC manager states:

> [when] you have a project plan, you have your objective, you have, say, your strategy of how you are going to reach that objective and then some milestones and then some detailed tasks and you have timelines and people outside [sponsors] feel that you should deliver to those timelines. Whereas the academic feeling is well, that's what we wrote then [on paper] and of course, *research, you can't plan research...*[because] research you know, tends to go off in all directions

The phenomenon at hand usually escapes the ordinary categories of predictable risk and reward because neither ends (purposes, goals, etc.) remain fixed or compatible nor can the means (techniques, technologies, know-how, etc) be fully determined at the beginning. As one CRC practitioner puts it:

> I haven't seen any good way of estimating the chances of success of the project, you know, before so I don't know if there is a good way to do it for R&D projects. Perhaps there is, you can have ratings for this, this, and this and end up with a number at the end, and I don't know how good these estimates are.

Ends and means are confused and often conflicting and there is no unanimously set of problems to solve, or an agreed set of risks and rewards to manage. The situation, therefore, presents itself as a unique gamble and as a dubious game of success and failure. As one CRC manager comments:

> [you've] always got the risk that you've backed the wrong horse, you then do the work and it doesn't work and then you've got to start all over again and do something else and you know it can well be a market risk, you know, developing a product, getting it to market and then finding out people don't really like it, it's not working.

So CRC actors find themselves in a fearful, treacherous, and troublesome situation which they cannot readily convert to a manageable arrangement.

Conflict of values and interests

Moreover, it is difficult to make a resource controller committed to a project, when the fear of failure is high. As one CRC manager puts it:

> [if] somebody is paying $5,000 they want results...they want value for their $5,000...they want $50,000 for their $5,000 worth and if you tell them...that $50,000 won't buy you much research, they don't even want to know about it...they think $50,000 is a huge amount of money, even [Ford] would think that because it comes out of some poor sod's budget, [when] everybody's budget was pared down to the minimum and here's a huge external lump of $50,000 and what are we getting for it.

Actors need to gain and retain resources controllers' commitment, while seeing as necessary to appear confident and maintaining their own credibility. When a sponsors' commitment is retained, all parties inevitably feel a greater sense of responsibility. The project becomes a drama of success and failure for all actors. The drive for success or failure makes the drama as a sort of win/lose game, with the sponsors usually as the judge and jury of what is good and bad. One CRC manager says:

> [when] you pull in a sponsor, it became a major project for us, and a much more major, a larger project than it was before they were involved.

Under such circumstances, all actors strive to achieve their objectives as they conservatively interpret the problems. Sponsors look for a winnable game in which the risk of failure is low:

> [we] find [sponsors] a bit averse to putting money into projects that aren't really at their final feasibility study [stage] or [at the] end of a feasibility [study]. So, they really would prefer to invest a much larger amount of money when the development has happened, rather than a relatively minor amount of money when development is needed.

Researchers try to gain the sponsors' and CRC top managers' commitment while maintaining their own academic career and credibility; CRC top managers at times keep the burden of

failure and uncertainty on the shoulders of CRC researchers. One CRC senior manager explains the difficulties for justifying purely scientific research but crucial for finding a technical know-how:

> If I had to actually rationally justify doing those projects, I would have had a really difficult time doing it because all it looked like was I was going back doing what the people were doing in the seventies or something of that nature, and in the end what it came down to is you actually have to trust, [the researcher] that they do have some sort of intuitive feel that this is worthwhile doing

All of this shows that within the early stages of innovation process there are competing values, contradictory concerns, and conflicting interests which generate anxiety and tension among contending groups. As one manager in a CRC observed:

> there's [always a] tension between what researchers want and what companies [sponsors] want, and researchers like to get to the bottom of things, they like to optimise things, they like to fully understand things and that's what makes them good researchers. Companies like to have something solve just enough; Whatever it is that they're producing won't come back and embarrass them;

There is interaction between practitioners' narrowly technical activity and the larger sociopolitical context over which they usually have little control. This can be seen in two interviews:

> Interviewer: How do you manage the business of careers? Like [in the case of] scientists where you progress with publication, [but] on the other hand you are locking up a lot of their time on stuff which, because of its nature, you've got to keep secret.

> Interviewee: Well, that's very very difficult, and I know that's an issue with [a major public research agency] because you can't always publish. You sometimes have problems [with] patenting. Often you have to decide to keep something as know-how, and that is a fine balance. It depends on where people's careers are going, and whether they're committed to a commercial applied career, or whether they do what [is required] to get back into academia. The CRC's are probably not career building for those people that want to [remain] in academia in any way.

Elsewhere:

Interviewee: You can't move up [in your career] entirely on the [industry work], you can't be totally product-focused. You have to publish, [so the CRC has] to develop strategies to give [its researchers] some kind of career by [allowing them] to publish, so it's a balance.

Games of mystery and mastery; Decision making on the basis of inadequate information

As we observe in the following story there is a conflict over the issue of confidentiality and the actors attempt to find a balance and decrease the level of threat. An interviewer asks about the issue of intellectual property, why in a particular CRC there was no protocol or rule to define it clearly. The interviewee responds:

> [right] from the start you're operating from an unclear sort of view of what's known and what's not known. I guess we [researchers in this CRC] could sort of try and describe that in broad terms and then we'd continually run into this problem that since we are directing the projects largely, and we're providing the know-how about [manufacturing methods] to put people on the right path, then...I've found that we've been leading the project teams to discoveries that we've already made right...[but] they'll come along [a major public research agency] and say, you know, this is this great idea and you know, we've already done that, that was something that we've been lead to by our work three years ago; and because they're leading them through the process of learning and knowing what all the surrounding knowledge is in order to do a particular thing, you know they come across stuff and they think it's their own idea, so that causes a problem then because we haven't specified the background [knowledge] comprehensively.

In this CRC, as in others, there is usually a powerful partner who wants to keep information as confidential as possible. But according to the interviewee above, there is close contact and collaboration among competitors in their particular industry, hence from his professional perspective:

> [how] you value information and what you're prepared to talk about or the realisation that something is important. [because] , what you don't know is the most dangerous. So, that's sort of the fundamental problem, so you end up with this balance between making [the project] pre-competitive because then you have to worry about all these IP and confidentiality and background issues versus if it's too pre competitive then, within our company, you know, you can't demonstrate value in a short enough time

frame or convince people that it's worthwhile doing because it's too removed, and it is sort of finding that balance...

By and large, in the initial stage of a CRC there is an uncontrolled anxiety and each actor tries to protect him or herself from future threat and embarrassment. This is noted by one of the interviewees when talking about the early stages of a CRC (i.e. just after it had been established with Government funding and the collaborating organisations had begun to develop a research program):

Fear is highest in the start up years and then drops off as you [begin] to establish a track record for managing it ok.

More often, actors encounter situations in the form of too many yet competing ideas, interests, and information that cannot be easily handled and these situations are also characterised by a mix of risks and rewards, hopes and fears, failures and successes, dangers and opportunities ('right from the start you're operating from an unclear sort of view of what's known and what's not known, what you don't know is the most dangerous'). Clearly, these practitioners deal with multifaceted and incoherent situations in which scientific, academic, commercial, management, political and cultural issues are all mixed up together.

Coping with anxiety by winning people's hearts

Because many people perceive such conditions as frightening, some CRC leaders display behaviour that lessens anxiety and brings about a sense of shared commitment, trust, emotional involvement, and companionship to tackle the terror of uncertainty and failure. Implicit in their approach to handling such anxieties is Schön's (1963) and Hainer's (1968) idea that one must develop a feel and commitment for what one is doing before one knows what one is doing – similar to Knight's subjective feeling, and March's idea of childlikeness and prankishness. These CRC leaders know that they are in a situation where the relevance of past experience and the predictability of future consequences are most in doubt. There is a

need for 'shared commitment' to a point of view beyond what the available evidence would strictly justify (Schön, 1975).

Hence, these CRC leaders attempt to develop interpersonal relations (as a variant of Sullivan's 'good mothering') and nurture this emotional involvement among practitioners. Because they believe:

> [Research] is so impersonal...research scientists are very emotional people and you have to win their hearts, you know, you have to get emotionally involved. I mean you don't have to fall in love with them or anything like, that but you know what I mean, it's got to be a good relationship and if you do that, they begin to enjoy it more, they see the purpose of it all and they get more and more enthusiastic, if you can get it right and it is difficult sometimes, they get more and more enthusiastic and then you get better results.

Managers know that the early stages of establishing a CRC seems to be a tricky 'high-wire act' in which practitioners may fall if they fail to cope with anxiety. Because of this, they admit to uncertainty but they also attempt to develop a feel and a commitment for the treacherous task with which they are dealing and constantly attempt to playfully shape and reshape it. Even so they cannot know at the outset what the right set of proposals will be, nor can be sure that their proposals will work or will be manageable at all. But the choice they make or the 'order' they attempt to iteratively impose upon the shifting situation is one that lends itself to means and opinions in which they have confidence, which helps them to collectively bring about a sense of passion, emotional and intellectual curiosity and commitment.

They, therefore, make an effort to transform problematic situations in a way that resolves conflict, fear, and inconsistency, at least enough for the initiative to proceed from its early stages. They look at the chaos from different perspectives and frame the messes without letting stress and anxiety disrupt their flow of inquiry and experimentation. Inevitably, their inquiry involves deliberate selective management of too many yet conflicting ideas and information (similar to bounded rationality). In the face of overwhelming complexity and

uncertainty such selective management can be productive, provided the actors remain reflective and honest enough to change their choices when they discover these are no longer the choices they wish to make or they find them to be unproductive or destructive.

As another example, I discussed earlier about breaking a stalemate in a CRC, the manager wanted to encourage other actors to change their defensive mode of behaviour and dogmatic perception so as to reach a unanimous frame for concerted action. As he tried to promote the actors' collaborative behaviour he became aware of the things that fostered ('strong intentions, high degree of cohesion, collaboration, and very smooth operations') or impeded it ('enormous tensions'). He hypothesised that actors' feeling and commitment ('Having the right people...people who are willing to do a lot of work for the Centre') about the project, about their own performance, about their agendas and points of view, and their relation to the area of research are essential parts of approaching an agreement. So he attempts to convey this important message that he himself is not the sort of managers that wants to play an omnipotent or omniscient role of a judge, exempting themselves and ignore at their peril others' feeling, ideas, level of commitment and contribution to the wellbeing of the project ('we set this up...The basis is all the discussion of all the others'). He attempts to appear to be an enthusiastic and cooperative participant who prefers to listen rather than to lecture. He avoids creating an environment filled with games of mystery and mastery, defensive reasoning, and suppressing subordinates' ideas, fostering instead an environment of nurturing inquiry, emotion, and exchanging valid information.

His reflections suggested that in a particular situation, this may be the last chance for him to imprint this productive frame on such an incoherent and inconsistent web of actors with their very different value systems. Therefore, he decided to run a risky on-the-spot experiment the results of which were only dimly apparent at the outset ('I just said, right, I've had it [let's have a] jug of wine. So, I took off with two or three other people and after about the second bottle of a nice red we got a phone call on the mobile from them, come back'). He decided to both test his own influences during the course of development and to understand and restructure the other actors' perception,

should they really wish him to lead. Under stress he tried to make some intervention to demonstrate his passion to this CRC. His adoption of a strategy of combined apprehension, reflection, experimentation and intervention helped him attain the actors' appreciation and change their conservative perception, at least for a limited time. If this manager after his risky intervention appeared to be a strong dedicated manager, this is because of his personal competencies, quality of inquiry, political abilities, and informal hyper-activism which was his way of getting beneath the 'surface' of organisational life to generate deeper levels of intimacy, commitment, and collaboration. These responses are not a result of the CRC's initial technical or social arrangements. As actors began to gradually get in touch and intuitively reframe their understandings of their manager's role as well as advancing their common understanding of the rocky road ahead, he knew he had taken a crucial step toward shifting the CRC's direction until it rested on a more collaborative and cohesive relation and of course such behaviour created a less frightening and conservative setting; and all CRC partners have to wake up to the fact that CRC programme is not a private club for playing games of secrecy, evasion and unilateral control (a major public research agency were awkward, some of the industry partners were awkward. The Queensland state government and Federal government representatives weren't talking to anybody).

5.4.2 Framing and Reframing

For Schön (1982: 309, 1994a), framing refers to the ways by which practitioners frame 'roles' and 'problems'. When practitioners frame problems they in fact bound the multifaceted phenomenon on which they will focus, determine a strategy for attention, and set a direction toward which they will try to divert the problematic situation. Through framing, practitioners consciously (or sometimes sub-consciously) set the values and assumptions which will shape their practice. Schön (1979), however, argues that framing problems has its own life, hence the process of framing involves an ongoing and iterative

process of frame-awareness, frame-conflict, and frame-restructuring which comes with the ongoing task of problem-setting and solving.

When framing, practitioners may come across situations in which dealing with a pre-packaged problem demands them to think within the context of broader whole to which it belongs, hence they need to reframe the boundaries of their attention and package a new problem. According to my analysis of CRCs, I adopt Schön's notion of framing.

Framing as ongoing problem-setting and problem-solving

In the previous section, we noticed that the innovation activities might stall if people fail to cope with anxiety. I also argued that the purposes and objectives of CRCs are confusing and unclear in the beginning, and there is no clear definition of product concepts to manage likely problems. In other words, CRC actors are initially concerned about what to develop rather than how to develop it, thereby they come against financial, social, organisational, governmental, and technical issues upon which an R&D project may be developed or a line of enquiry may pursued. When, having initiated an R&D project they encounter such additional problems as the constraints on budgets, their career ladder, commercialisation policies, security issues, power plays and political games, and the like.

They are in a problematic situation whereby, in Dewey's sense, they might make an effort to institute new conditions that occasion new manageable problems. But setting problems demands that they also uncover nontechnical difficulties (e.g. value conflict among actors) that usually fall outside the scientific approaches to problem solving and the decision making for which most practitioners are trained. Even when a problem has been set, it may escape the technical and scientific categories because it may yet again present itself as puzzling, unique, doubtful and unstable.

It is these sorts of situations that CRC practitioners see as central to their practice. Apparently they see that although the elusive task of 'problem-formation or problem-finding' is a

necessary condition for the routinised and analytical task of 'problem-resolution or problem solving', it is not reducible to the exercise of describable routines for it is not itself a technical problem (Schön, 1982). CRC managers usually point to the overwhelming complexity of the iterative process of problem-definition with which practitioners try to cope. For example, when objectives in a task are not clear or still conflicting, practitioners cannot simply apply specialised knowledge and techniques. Or, when applying a risk management method, risk experts may discover that this fails because the situation has become something other than the one the method is designed for.

In many of these instances, there is ambiguity in what the problems really are, how they can be constructed and settled out of the messy material of the phenomenon, and how a problem may be said to be well or badly set. It is through the process of 'problem setting' that practitioners organise and describe both the ends and the purposes to be achieved, the possible means and methods of achieving them, and mitigate the likely threats to such achievement. One of the main features of the nontechnical process of problem setting has to do with 'framing and reframing' the puzzling phenomena so as to design well-formed policies or proposals. It is a process in which practitioners interactively make sense of the puzzling phenomena and attempt to convert these phenomena into coherent and congruent situation (Schön, 1982: 40). This is not to say that rational and technocratic views do not allow for this but to argue that problem-formation is not a plannable, proceduralised pattern of action; rather it is a nonlinear ad-hoc process in which micro and macro social psychological issues as well as artistic judgements come into play. It demands a creative and political process in which actors draft and redraft the objectives, construct the ways by which they can meet those objectives, establish a new mindset, and set the boundaries of attention to a selected set of issues. This is emphasised by two of the CRC practitioners for whom framing has to do first with perceiving and understanding phenomena (e.g. future events or problematic situations) as a 'complex' or 'web of relationships' and then select and design the desired sub-components as a whole.

Examples of framing and problem-setting in the CRCs

The use of frames and reframing, depending on the dynamics of each CRC, happens frequently. Framing, for example, is used for structuring a project, for defining roles, for formulating a well-defined problem out of a multifaceted phenomenon, or for setting directions, values, visions, strategies and assumptions. This tendency can be seen in the following quotes:

1) *the way you structure the agreement* at the outset is really critical to how your Centre operates *because then people know what they are getting into...*

2) We [in our CRC] *set a vision* for us, it is a combination of three CRC's and all the relevant resources from a major pubic research agency, into a common entity which we called [A].

3) basically rather than having three CRC's that are sub critical, that are overlapping at the margins and competing with [the government], we thought that we would put our whole effort in the proposition of something that we really firmly believe should take the place of what we currently are driving...

4) we [in our CRC] go over what we would like to do over the next year, staff put up projects that they would like to proceed, people outline their ideas for them and then the last half day we go through sort of ranking, rating evaluation process and decide which projects we're are actually going to pursue and then the final thing is we have *a big staff matrix* and we work out which people are going to be, or how much of each person is going to be assigned to each project, so at the end of those few days *we have an agreed program which the people in each of the parties...*that becomes a *Charter...*

5) When we [in our CRC] went into this [collaboration] with firm F, you could have polymer chemists that say...this is a great material and this is a great surface; but if you don't have someone saying 'yeah well that might [be the case], [but] it's never going to work because the eye just doesn't like those kinds of [materials], it needs these kind of properties in order for it to work' [then the collaboration will not be so successful]. When we set up the project, the very first meeting was just that kind of meeting where it was driven fundamentally by what the eye needs, not *by what a chemist thinks is good but by people that understand what the eye needs* . You know, a lot of companies [in our industry] have polymer development driven by what a good polymer chemist thinks, but [they] do not understand what an eye needs...[so] we're always looking for what does differentiate good products, [to find out if]

is there going to be a problem, [or] what does [a particular finding] mean. So, we're critical of the information that we collect, as well as just [collecting the data].

6) We [in our CRC] always say 'OK, *we need a group that is going to chart direction*, *We make it known that this is what we can do and this is what we can't do.* We put together usually *a protocol*, or how we think it will run over a time span and then we generally update that as needed . [You] can't crystal ball-gaze, or gauge it too far down the track. Having somewhere to start, and having the mechanism [for] being able to update the agreement, where you are going to [in each] stage...

7) It is pretty critical to the value I see in setting up the projects, hence it's directly related to the whether I think they've got someone really good that can work on it...

As we see, the problem of 'framing' (e.g. setting and formulating a behavioural world in a CRC, describing the risks and rewards to a project, setting direction, designing a charter, a protocol, , etc.) is to iteratively decide and design where, why and how to draw the line and what to include and what to exclude when there are too many conflicts, signals and options ('We put together usually *a protocol*, or how we think it will run over a time span and then we generally update that as needed'). Framing, in this sense, has to do with the construction of new descriptions of the situations which, very often, elude the instrumental exploitation of science-based means, namely the rational process of risk management. Some managers frame their intermediate or intervening role in terms of a balancing act in designing roles and determining the kinds of manageable problems they will set in the various contexts of their practice. The construction of a role frame (addressing which people for what project, how much of each person, etc) for them, then, becomes a general long-lasting frame (e.g. a staff matrix) under which a set of sub-categories is subsumed. Framing managerial and research roles in the fourth quote, is superordinated to ranking, rating and resolving particular manageable risks and rewards for that CRC project as a whole.

Sometimes practitioners arrive at a new theory about a particular case (as in the fifth quote), so they ought to interactively frame means and ends by reflecting on the appreciations which they have brought to the situation ('we're always looking for what does differentiate good products, [to

find out if] is there going to be a problem, [or] what does [a particular finding] mean. So, we're critical of the information that we collect').

A similar behaviour can be observed as we read the sixth quote. Here practitioners reflect more on 'problem setting' ('we need a group that is going to chart direction') and settlement of risks and rewards rather than 'problem solving', the former a process through which the new findings to be appreciated (this is what we can do) or rejected (this is what we can't do), the decisions to be made, the ends to be achieved, the dangers to be avoided, and the range of means which may be deployed are defined. They must continually find ways for choosing among the variables and values at stake which must be considered afresh in each new situation ([You] can't crystal ball-gaze, or gauge it too far down the track).

Frame-experiments

Implicit in these narratives is the notion that, while these practitioners entertain several values, variables, assumption, and hypotheses, determining which of them should be included or excluded is itself a dilemma. Hence, framing involves an ongoing process of experimentation. As one CRC manager puts it:

> When you look at how the projects are charted, a lot of basic fundamental stuff happens early on in the project and then it tapers down…You sometimes have to branch out and do some more fundamental [science], and if you think the project isn't going anywhere then you can [pull] back [and say] 'OK, how can we pad out the science so that that [the scientific findings] can be the outcome at least?' We publish the science in what we've been doing, and it is [important to manage] that at each level. [You ask] "Where are you at? What's the most important [issue here]? Where are we trying to go? OK, back off if we are not going to go that way, or push forward if we are. And [then] getting the commitment of the group to that [decision], you have to go through and say 'we're doing this scientifically, we [are going to] run this experiment …. [we are] trying to get to this point, this is what we are going to do.'

Drawing on Popper's (1969) notion of 'refutation', Schön (1983) argues that in a 'frame experiment' practitioners produce a situation in which they discriminate among the

competing values, variables and hypotheses. Sometimes it is possible to carry out controlled experiments. In this kind of experiment practitioners selectively control the presence, absence, or variation of several factors while at the same time conducting a competition among them. The values, variables, and hypotheses that most successfully resist refutation are the ones usually accepted tentatively, for another set of variables, values and hypotheses can emerge or might be found which resist refutation more successfully still. For example in the example of short-sightedness, there might be found some other factors, as yet undiscovered, which are present along with computer screens and genetic factors and the absence of which Asian juveniles no longer experience myopia.

There are, however, other kinds of experiments, each of which with its own logic and its own criteria of success and failure. As Schön (1983) observes, and similar to what we see in the previous quote, in the most generic sense, to experiment is to explore, to ask 'what if?', and to act in order to see what follows without having a good reason before action. This type of experiment is very much similar to March's metaphor of 'children's playfulness' (see pp.195-6), as he argues that like children we sometimes need to act before we think in order to learn. It is a kind of probing playful activity by which child gets a *feel* for doing something when exploring the surrounding world. The exploration succeeds when it leads to discovery or the experiencing of something new.

There is still one other experiment in which we take action in order to produce an intended change. Here a deliberate action is undertaken with a desired end in mind. Then we affirm the move when it produces what is intended and negate it when it does not. If the move produces unintended effects or unanticipated consequences, then the test of affirmation is not only to ask 'do I get what I intended?' but also to ask 'do I like and appreciate what I get from this action, taking its consequences as a whole?'. This is a shift from reasoning or deduction to a combination of emotion and deduction.

It is clear that under the complex and fluctuating conditions of innovation, controlled experiments can be carried out only in a very limited and narrow context. Values, variables, and hypotheses change rapidly (see Schön's definition of uncertainty p. 168), and are often interlocked, so separating them is far from possible. Usually the situation is uncertain in the sense that practitioners do not know what the variables actually are. In fact in innovation all these kinds of experiment are mixed up and most of the time an individual's interest, commitment, and emotion are intertwined with scientific reasoning and logic.

Experiment in product innovation, indeed, implies openness to uncertainty, confusion about what is and what is not feasible, and ambiguity about variables, relationships, and their relative importance under unlike circumstances. Such a kind of experimentation is broader than traditional scientific and technical views. It is the merging of 'people's hearts and commitment' and the 'technology' in which heterogeneous actors, webs of relationships, uncertainty and discontinuity, are all employed. So my view of a 'frame experiment' incorporates both social and technical concerns, as we see in this excerpt:

> Interviewer: I'd imagine you come across people within the projects that under-perform at times, how do you deal with that?
>
> Interviewee: Oh yeah. I'll give you an example. I had one person reporting to me three times a day, six months ago, it got bad, he had some other outside difficulties but it was just, and he was very enthusiastic and a dedicated guy but just could not focus on getting a steady course which would make the project go, it would go all over in the place, he would come to me early in the morning and we'd agree on what he was going to do that morning, really small size chunks, he'd go away, we'd talk at lunch time and we'd talk at the end of the day and he'd worked long hours, he got himself into a state where he just couldn't do it. So, I don't have an overall formulae, you try and look at what the problem is and you think what's the solution to this particular problem. They're only three minute meetings, all we had to do was agree on what the topic was, really a precise topic that he was going to do for the next few hours and then he would pursue it and got a little down and now I see him twice a week or something, so, depending on the problem you do something different I suppose.

This manager runs an experiment to frame a role for a researcher who has some difficulties in order to make his potential enthusiasm conform to their CRC values, social arrangement, and technical settings, but the manager ought to remain open to the possibility that the chosen role frame may not work.

On the whole, an actor's relations to problematic situations are a kind of reflective conversation and, in Dewey's (1938) sense, 'transactional'. Actors attempt to shape and reshape the phenomenon they encounter but with a 'reciprocal transaction', their moves, values, theories and appreciations are also influenced and shaped afresh in each unique situation. This reflective and reciprocal transaction involves both a move by which inquirers try to achieve a desired change in the situation and a probe by which they explore it. Actors attempt to understand the phenomena by trying to change it, and consider the resulting change (including unintended effects) *not as a failure but as the essence of learning by reflective transaction*. In the words of a CRC manager:

> You go in there [research] to find something out and to make the results known, and so if you find something out, if it goes this way or that way. In fact, just as a philosophy, I try not to do any experiments where if it goes this way you learn something, if it goes [another] way you haven't learnt anything. So, I mean there's plenty of other experiments to choose from, so you try and [choose] one that you learn something from, no matter which way the results fall.

Hence, out of experiments and transactions with the situation, new satisfying conditions might be achieved out of which new problems are framed and constructed from the appropriate materials. It should be noticed that it is not possible to be sure, at the moment of problem setting that the new problems will be fully manageable, but the frame actors have imposed is the one to which they show hope, satisfaction, emotional involvement, commitment and confidence:

> You can't [always] reach the goal or outcome that you are looking for. We don't so much have it in [the sense] that we've asked our researchers to do something that they've been unable to do ; we've just been lucky in some of these areas. Sometimes we've decided what we are trying to achieve is too

difficult, or the biology is more complicated than we thought, so we have to go back to fundamentals and understand more. But we've never put that [task] down, I suppose that's what you are saying. For instance, in the next generation [of a medical product]….we *hope* to achieve [a particular level of performance] and we understand we've got to go back and do more fundamental research [to achieve that].

Solving resolvable problems

After experiments and problem setting, the work continues with the weighing of the threats and benefits of any chosen frame (whether it is called a protocol, charter, etc.) against the likely risks and rewards of alternative outcomes. Now when a unanimous context is settled, CRC practitioners attempt to define a set of objectives within this larger context such as milestones, budget, timing and the like, associated with the likely risk and rewards. As one CRC manager puts it:

> for each project,... we [define] start and finish dates, hypothesis, or specific objectives, then milestones, specific milestones for the year.

Following framing, problem setting and risk settlement, come instrumental problem solving and risk management, which revolve around the application of scientific methods and calculation techniques (e.g. assigning numbers and probabilities). According to one of interviewees:

> [when] we have this [initial process of setting] our objectives,….our project milestones...the milestone timetables, ... staff... the risks...then [we] start to quantify.

As CRC actors go through the iterations of setting manageable proposals and gaining an appreciation of the outcomes of these settlements, they shift from tentative adoption of a proposal to eventual commitment. This shift enables them to cope with anxiety, achieve coherence, and develop a feeling for collaborative relationship and keep the project in motion.

5.4.3 The Process of Metaphor

I have dealt at some length with framing, but I have not so far asked on what basis ideas, images, exemplars, frames, initial orders or settlements operate so as to convert unmanageable puzzling phenomena into something comprehensible and constructive. What are vehicles for both creative action and restricted thinking? What provides the materials for framing roles and problems in an R&D programme as a whole, for looking at ambiguous situations from several perspectives and converting them into manageable problems? What underlies practitioners' perceptions and descriptions that generate for them a new framework, angle and eventually a settlement that sets the directions for the analysis of risk and reward management?

Constructing a matrix to support dialectic

Drawing on Schön and his notion of 'generative metaphors' (see p. 44), I shall argue that one of the pertinent practices of my conceptual framework is the process of metaphor, as I have previously indicated. Let me consider one example of risk management in a story drawn from the words of a CRC program manager. When asked about the way he formulated risk, his underlying story not only reveals the practice of converting uncertainty into manageable risk but also the politics and the prototypes involved:

> Some risks are dependencies, obviously, you have internal and external externalities or issues, changes within the company. What we try and do in terms of risk analysis...given the resources that we have, [is ask] can we conduct this study completely internally without any input from anyone else? Does it require something else, external things coming in, if so what's the likelihood of there being a problem. So, say, for example, if we need to do a bio safety study on [a metal], right, one of the main risks that we might look at is well, what kind of animal model are we going to use, maybe we are using cats. Are we going to be using cats for the next year? Do we have an agreed supply of cats for the next year? If so, do we have enough space for the cats because biological research is one of the more difficult things? Risk [assessment] then also needs to address how likely is it that the project is going to give us a successful outcome and that's a more difficult thing to...attach from research. I mean researchers wouldn't do it if they didn't believe they were going to be successful but again, you know, I sort of

think, that's where you're actually asking the researcher to make a comment and then the group makes a group comment. So, we, the way we structure it is, is that each program has a two-day review internally, where each project presents along these sorts of guidelines and addresses all these various sorts of issues. We then, *as a program*, *jointly construct a matrix*, so it's all upfront, with everyone...which looks at issues of significance of the research, potential outcomes, risk, so we are getting a very wide opinion on the risk and if there are outliers, we have to explain why they are outliers. So, let's say for example, we've got our twelve project leaders and the average risk factor assessed for a project is seven and we've got one person who says that the risk is one, we need to know why, why do they say it's one. Now, we use this structure, then it feeds into a quarterly report, which comes back which fills this box out and this box out and any changes. We then have a monthly report that we do as well.

As was observed on several occasions, each of the CRC actors' interpretations conveys a selective view of reality and represents a special way of making sense of and seeing events, which not only creates complexity, confusion, and controversy but also paralyses productive action. To avoid such dilemmas and in order to give their potentially complex practice a coherent and constructive arrangement and trace what is threatening/rewarding in such a way as to set the direction for risk and reward it seems that these actors engage in the process of metaphor. The process of metaphor is nothing less than the question of how practitioners come to see things in new and at times creative ways, just as risk settlement in this narrative is described as the joint construction of a 'matrix'. It should be, however, noted that the process of metaphor does not necessarily lead to new and creative ways of thinking. Metaphors can also be constraining (see p.58-62)

In this case, in order to transform a potentially ambiguous and complex situation (due to conflicting ideas and competing information) into a formalised pattern, these actors actually use the metaphor of a matrix to program the roles, and to create a dialectic about the likely risks and rewards. Whether they have a conscious and systematic grasp of a matrix as a 'generative metaphor' in their account, 'risk settlement-as-joint matrix' operates to structure an ill-defined situation and convert it into a well-formed problem which brings about a

constructive dialectic. It, then, lets actors select and interpret crucial events as they perceive them, set other technical and organisational problems and frame roles, and consequently settle the discourse on risks and rewards. Actors entertain the description of a different process (the construction of a matrix) as an alternative description of setting problems, defining roles, and constructing risks and rewards that allows for a good dialectic and purposeful interventions.

In contrast to standardised methods of risk management which can be applied to well-formed problems, these actors put varied things together and construct a negotiated order (in the form of a matrix) in which they can now juggle variables, reconcile conflicting views and values, and attempt to manoeuvre around constraints ('let's say, for example, we've got our twelve project leaders and the average risk factor assessed for a project is seven and we've got one person who says that the risk is one, we need to know why, why do they say it's one'). This is a process in which there are no single correct answers and no moves that have only their intended consequences. With its webs of moves, discovered consequences, and implications, the construction of such a matrix triggers open-ended and ongoing yet constructive conversations.

My second example of such metaphorical processes will be drawn from a different field, that of the risk of information 'leaks'. The following stories are drawn from the opinions of two of the CRC interviewees on the issue of confidentiality.

Transfer of sensitive information as leakage

In one interview the interviewer asks whether a CRC practitioner had experienced a situation where intellectual property has been secretly transferred to competitors, and how his CRC deal with these sorts of issues. He replies:

> There are two issues. One, that we've had to deal with...is we had an employee who left us and went to a competitor a month later, [and] gosh [we] had [developed very] wonderful ideas in that month. One of which, unbeknown to us, he was allowed to file a US patent. Now, unfortunately we have here, on a dated video discussing that project, two and a half years before he filed his patent, so yeah, we are very

aware of *leakage of information* and are very concerned about leakage of information. Hence, my request to you, to sign a confidentiality agreement. We're very concerned about it. As a highly competitive market, we have to look very carefully, at what we do. Our financial reports are separate because if our competitors got a hold of those, they could use them to adjudge how much effort we are putting in various research projects. *Some research projects that we are doing are not in our Annual Report.*

Fireproofing confidentiality: the firewall as a tool for dealing with cultural integrity

A similar question is asked of another CRC manager, who replied:

[we] are negotiating a research contract with a major international company and this is definitely contract research, they'll own the IP and they are very concerned that there should be no mention in our reports as to the nature of the work or the progress of the work as an issue or one of the items under their confidentiality, so we can say that we're doing a research contract in relation to [a particular type of product] with a [firm], let's say that's the company but that's as much as we can say....the world of [this product] is one of competitive advantage comes from small technological improvement. I mean they cooperate up to point. There's a patent suit that everyone uses but then really market share, competitive advantage is really technological advantage. So, you know, small technology changes can make these swings in marketing and so, they're very concerned with leakage to competitors now because we have a partner who is company [in this industry], we've had to be able to show [other] companies who want us to do contract research with them that *there is a rock solid firewall and it stops transfer of information*. So, we haven't had a scenario where there've been a transfer of information inappropriately from one area to another.

At this moment the interviewer gets excited and curious about the analogy or the metaphor which has been used ('rock solid firewall') and asks about how they actually put up a firewall in practice. The interviewee believes that:

Firewalls are the right thing. Partially it's by very carefully going over the issues of confidentiality with all staff. Now, we do that annually plus every new staff member we discuss with them what are the issues. Say, for example, I just did my IP seminar with the staff about three weeks ago, another one because we were concerned about conference presentations. Now we usually do a presentation, before anyone goes to conferences. What we make people aware of is that they might be aware of and I'll use

[one of our divisions: L] as an analogy. We have a number of teams that work, that are integrally integrated with L's R&D team. We are doing particular aspects of the research, which feed into the R&D, so we know L's staging gate times, we know the market-release date, we know some very sensitive information. Our research need to be made aware that *where information is stamped confidential that's what it means*. So, if they're in a conference and somebody asks them how likely is it that your division L will release product X next year, their answer has to be I don't know, I don't work for L.

In everyday discourse, a firewall is the use of fireproof material to prevent the spread of a fire from one part of a building or ship to another or to isolate an engine compartment, as on a plane, automobile, etc. In the computer industry firewalls serve to prevent unauthorised access to a networked computer system. 'Leak' or 'leakage' refers to an unwanted hole or opening through which something escapes or transfers from its proper location.

When this CRC manager says, 'there should be a rock solid firewall that stops transfer of information' he is himself thinking of the confidentiality as a firewall, seeing it as a rock solid firewall, seeing unauthorised transfer of information as 'leakage', and he invites others CRC staff to do likewise. When the CRC staff see issues of confidentiality as such, they come to understand the issue of confidentiality in CRC programs differently. This has to do with how well they understand leakage and the function of firewalls. All of this leads them to restructure their perception and to the construction of a behaviour under which they become able to treat 'information privacy as a firewall', 'keeping confidentiality as a form of CRC normalcy' and 'leakage as a threat to CRC cultural integrity' ('if they're in a conference and somebody asks them how...their answer has to be I don't know'). Clearly, firewall is not an anomaly of language, it is central to the task of accounting for practitioners' perspectives on the behavioural world of the CRC. It is a way of looking by which a new perspective on the CRC world comes into existence. The consequence of using such a metaphor in this CRC is observed in the words of a practitioner when he was asked about his CRC dealt with confidentiality issues:

Everything someone does when they're under employment is owned by the employer irrespective of what happens in the future, so people have signed agreements saying that they understand that anything they do is owned by their employer, despite that we're looking at, in fact have already done some skills whereby some of the staff had some entitlement to a share of royalties, an incentive to everyone...

The business consulting as a guiding model

Drawing on the example of a 'consulting business' (avoiding the disclosure of information) we see how in the following story the same problem (confidentiality) has been formulated differently in another CRC. A practitioner noted that:

[We] live, breath and die on [the premise that] nothing goes into the hands of competitors, and so far we have been remarkably successful [in] keeping information [quarantined].

The interviewer asks about this successful formula. The practitioner speaks about creating a different type of culture:

The whole [thing is], obviously when we've been part of this [intellectual property], litigation lawyers ask us exactly this question, and *it is the culture*. When a new staff member is inducted here, they [are made to] understand the nature of [the required] confidentiality...we may be situated on a university [campus], but we are not like any university community, we are not like any university department that you can find here or at another university. We are a committed group. It is a young group, the risks are well appreciated, [and it is well understood] about how it is important. When we started to work with the [a major public research agency], initially they were astounded that you could do this, but it's simply the way it is [here].

When the interviewee is asked if she thought there could be an analogy between this culture and another sort of business, she replies: 'Yes, I'd imagine so, had I a consulting business'. Running a consulting business for them is not only about making money with the exchange of ideas and information but also avoiding the disclosure of that information as much as possible ('You don't, [and] you can't talk about what's happened'). As a proof of this way of setting the behavioural world of that CRC she states:

Interviewee: If you look behind you at those filing cabinets, [you can see] we file the projects M in a different place to the projects N, to the O and P, [and so on]. So even at that level there is an understanding that there is clear project [compartmentalisation]. We have our research support system where we code companies and products. We don't use the term, we never use the term lotrafilcon; the whole project was called Z3, you know. The project [names] that we use for other companies [follow the same pattern]. We have a Z4 project, which is with another company...We code everything in an attempt to maintain and ensure confidentiality; and [so for a particular company's product] it isn't company B's product, it is 'Sample XYZ'.

Interviewer: OK. Now I think I can see what you are saying. Really it's a way of life?

Interviewee: It is. It's just second nature to us, and we've been doing it for too long to even think of what we do. It's part of how we do things.

Another underlying picture in this story revolves around the governmental notion of 'technologies of self-discipline and self-surveillance' and Douglas' idea of 'risk management as protecting cultural integrity'.

In all of these narratives we see the interaction of CRC staff and a treacherous situation (the issue of confidentiality and interdisciplinary R&D, patents, etc.) that needs to be converted into a productive environment in which people can perform. The CRC managers make a representation of the situation – an analogy, or a symbolic description – which will later be embodied and deployed as a metaphor. Such a representation is made under conditions of conflict, concern and at times distrust[8]. This representation is made within a field of social, cultural and political constraints, objectives, and purposes which are not fully defined at the outset. These issues are not fixed, and new threats and opportunities emerge in the course of managing the confidentiality issue (e.g. 'an employee unexpectedly left and went to a competitor now we

---

[8] As Schön (1971) argues, belief in stable state and peripheral change is a defensive yet tacit tendency against the threat of real change and uncertainty. This can be observed in the belief in old ways of thinking and doing business, and the difficulty of casting them aside. Social systems including corporations resist change in their old ways of thinking through desperate and destructive tactics of which they are largely unaware. Any social system seek to protect itself against the threat of change by strategies of dynamic conservatism including selective inattention, repression, unwillingness to know, selective perception, making myths, dissociation, etc (see p. 106-7).

have a proposal everything someone does when they're under employment is owned by the employer irrespective of what happens in the future'). Indeed, many of the problems emerge through a process of seeing and sense-making, experimenting, intervention, and seeing again. Working across CRC programs the managers see what new risks are, discuss the issues with their own staff and reflect on what has been achieved, thereby thinking of additional modifications and reforms ('our financial reports are separate because if our competitors got a hold of those, they could use them to adjudge how much effort we are putting in various research projects. Some research projects that we are doing are not in our Annual Report').

These examples suggest how the metaphors of 'firewall', 'leakage', 'business consulting culture' and 'matrix' may be developed – with an emphasis on 'taboo', 'self-policing', 'cultural integrity', moral behaviour', and 'governmental normalcy'– in such a way as to reveal a special fit with the structure of any CRC as a whole and its shifting environments and contexts. In all cases, actors have figured out how to make sense of a problematic phenomenon by modelling the unfamiliar on the familiar, treating the new in old-like ways (e.g. treating the CRC as a 'consulting business' in which disclosing information is taboo, immoral, or a kind of abnormality).

Depending on the initial similarity or family resemblance of the two things perceived as similar, the old (matrix, firewall, business consulting) may serve as a generative metaphor, projective model or exemplar. Through reflection on an earlier perception of similarity, actors arrive at a new description of the phenomena. In other words, reflecting on what is perceived, one may *feel* that two things are analogous and therefore become able to describe the resemblance of attributes between their components in a restructured perception of both. The new model for thinking and doing is then a product of reflection on the perceived similarity.

When organisations or practitioners see familiar problems they can use familiar tools and techniques but in the case of unique and puzzling situations they might feel that it has become impossible to articulate the relevant similarities and differences between old experiences and the new phenomenon. Not only is a new description needed but reflection on similarities and

differences is also required. Actors begin to describe and re-describe the new phenomenon in the light of a tacit or explicit reference to old experiences. In so doing, they search for old exemplars, symbolic relations, and metaphors, so as to provide a new yet plausible description of the new situation. These notions then become interpretive tools for the reflective and symbolic analysis of the situation.

On the other hand, metaphors, as I explained before, can become restrictive and protective if we use them as inflexible and rigid tools or theories for interpreting and seeing the new. In an interview a CRC interviewee is asked to reflect on the problems they had with a major public research agency. The interviewee says:

> Well, they seem to have, *they seem to compete with the CRC themselves* in their own right and they'd even tried to set up projects with us, *outside the CRC which we flatly refused to do*...they just have a whole lot of other drivers that...somehow are forcing them to have their own...sort of measures of performance that have to do with...funded projects and *I believe they just see the CRC and the CRC stuff as another way of tapping the government money and haven't really been fully committed making CAST itself work. They've just used it to leverage their own activities* and that's been a problem. Most of the, well, from the Universities, it has been a problem enough with patents, [this public research agency] tended to be more of a problem of they always wanted the right to use the know-how outside of our CRC you know in any way they liked, like without recourse to our Board or anything to approve it... I'd have been a hell of a lot happier if they had done a better job...and being more collaborative themselves about doing the project.

One underlying story I picture for this, is the metaphorical use of old ways as defensive tools or routines to see and make sense of a situation without re-examining the tool according to the demands of the situation. One CRC partner (a major public research agency) treats the new reality (i.e. engagement in the world of the CRC) in the manner of its old experience ('seeing the CRC and the CAST stuff as another way of tapping the government money') without changing or modifying the old itself, which has created destructive effects.

There is a question: why one thing, image, or concept rather than another is used in the process of metaphor?

To answer, I first note that practitioners and the organisations in which they participate have built up a repertoire of theories, images, techniques, tools, understandings, and practices (Schön, 1982). For some CRC managers, this repertoire ranges across academic domains and government-funded, joint R&D programs. This includes research management, licensing and commercialisation, the clinical practice, specific technologies, academic lectureships, venture-capital, spin-off companies, to name but a few. Other CRC managers' repertoires include mechanical engineering, composites, manufacturing, etc. And for others their repertoires include Machiavellian games of maximising monetary rewards by mystery and mastery, secrecy and hiding, evasion and unilateral control.

On the whole, practitioners' repertoires include the whole of their social status, cultural background, educational and work experience, insofar as these are accessible to them for reflection, exploring, sense-making, understanding, selective attention, interpretation, and action. A practitioner's repertoire provides the material from which his or her metaphors are made.

When practitioners confront a situation they perceive to be puzzling and unique, they see it as both similar to and different from their old repertoire yet without at first being able to say similar or different with respect to what attributes. In other words, when actors become aware of the correlations between old and new they have a dim perception of a set of shared relations which may become explicit only later on. The old repertoire functions as a metaphor or exemplar, suggests that they see the unfamiliar as a variation of the familiar, and triggers different perceptions of the new prior to later articulations of it. This process of metaphor enables them to bring the past and the old repertoires to bear on unfamiliar situations, and convert them into manageable problems or familiar settlements. But metaphors can be used either as rigid or elastic tools. In the case of using consulting business as a model for setting the behavioural world in a CRC, for example, one might argue that management consulting firms are often criticised for delivering empty promises, despite high fees, for offering one-size-fits-all strategies and 'pre-packaged' policies that do not satisfy the client's particular

needs. Nonetheless, consulting firms have strict policies and practices regarding the confidentiality of their clients' private information and individual opinions expressed on sensitive issues. They refuse to discuss any aspect of their relationships with a client, including the name of the client. In this sense, this CRC can be seen as a type of consulting firm involved in designing and developing innovative products. So the point here is to become critically aware of the similarities and differences between the old and the new situation, and actors' underlying tools (metaphors, exemplars, symbols, etc.). The artistry of a CRC practitioner or manager, then, hinges on the range and variety of the repertoire of flexible, elastic tools that he or she brings to problematic situations to convert such situations into constructive and manageable arrangements.

Put differently, the settlement of risks and rewards is achieved through the attempt to comprehend and interpret danger and opportunities, and interpreted through the attempt to search for new symbolic relations, family resemblance, Gestalt patterns, projective models and metaphors. As the actors elicit new correlations and interpretations and probe them, they examine their evolving understanding and interpretation, which in turn, alters their experience of the situation.

Each organisation has indeed a 'repertoire of past experience' or 'stock of knowledge' (Schutz, 1967) which has shaped a set of values, assumptions, rituals, norms, and standards. When an organisation makes sense of a unique, unfamiliar, problematic and devious situation, it infers from its past experience. To make sense of uncertainty is to bring the past as a projective model, metaphor or symbol to bear on an unfamiliar and puzzling situation. Nonetheless, as observed above, the use of the past as a rigid tool or concept might produce destructive effects while in other cases old tool is treated as a flexible model to convert the tricky situation into a productive partnership.

Apart from using metaphors in a restrictive or creative manner, practitioners and organisations build up a repertoire to serve their function of employing metaphors, projective

models, symbols and exemplars as they attempt to describe and redescribe different phenomena. Repertoire building varies from context to context, culture to culture, corporation to corporation. And in every attempt to frame and reframe a problematic situation using the analogy between old and new there is a feeling of transition from fear, bewilderment, and anxiety to power, security, excitement and opportunity. Before, actors were aware of a situation that was vague and disturbing, after there was a feeling of having something less troublesome and ambiguous to deal with and of having a valid basis for making deliberate change.

5.4.4 Reflection

Up to now, I have argued that despite their different industry contexts, CRC practitioners are likely to find themselves in a situation of chaos and uncertainty which demands the imposition of order in the shape of workable frames. They should treat the imposition of frames upon such problematic situations as an inquiry process in which they attempt to interpret events and package the uncertainties with manageable problems and policies. The contents of these packages reflect what their theories-in-use are, how they surface and use these to interpret facts and artefacts, and what they select as the hopes and fears or manageable risks or rewards of their activity. From a broader sociocultural and governmental views of risk, actors, drawing on their theories-in-use, set the boundaries of their attention; and the coherence (or discipline, order) that they impose upon an uncertain situation more or less depends on what they selectively taken to be normality or abnormality, danger or opportunity, order or disorder with regard to their overall performance and organisational wellbeing (Douglas, 1992, Lupton, 1999b).

One of the factors governing such creative practice is actors' effectiveness in running a productive inquiry; that is the way they develop a feel or an emotional curiosity about the task with which they are engaged and find their inner voice which provides a valid basis for the tacit personal style in any given context. By this I mean that actors explore their tacit

governing values, assumptions, and strategies which shape their behaviour and guides their action, as well as how they can reflectively test and modify such tacit understanding, knowledge, and frames. According to Schön (1992) it is through the practice of 'reflection-in-action,' 'reflection-on-action' or, on the whole, 'reflective conversation with the situation' (1992) that actors' tacit theories-in-use can be instantiated, developed, and on occasion modified and adequately verbalised. Such reflective inquiry lets actors surface their theories-in-use, modify, and improve them as events require without being restricted by bias, anxiety, or defensiveness (Schön, 1974: 28).

The practice of critical reflection

The ability to take such a reflective stance, and to be conscious of taking it, helps practitioners to see and interpret facts and artefacts in different ways, challenging conventional ways of looking at them. Reflective practitioners in fact lose a little of their sureness and try for a new focus and new perspective by reshuffling and playing with conflicting viewpoints. They try to tolerate the suggestions of others without defensiveness, and they attempt to remain honest enough to learn from what is happening in the existential here-and-now. They toil with irrelevancies while doing immediate experiments to find anew what is appropriate. Such conscious reflections thrive with the asking of basic (and complicated) questions about the context within which one is involved: What are we (as a group of practitioners) trying to do? Is it meaningful? Can we do what we want? Can we learn and start over? Do we collaborate or compete? Can we change? Are we defensive and dogmatic? Are we open to debate without defensiveness? Are we after control? Do we fear uncertainty? Are we under stress and anxiety? Do we appreciate new ideas? Do we have the sensitivity to record events? What are the criteria by which we judge this event? Can we find new ways to look at this phenomenon? Do we like to use metaphors, analogies and symbols? Can we conceptualise and generalise? Can we frame and set problems in vague situations? How can we frame a problem that we are trying to solve? What features do we notice when we recognise this situation? What do critical reflections as such have to do with framing, the

process of metaphor, problem setting, and risk and reward settlement in the CRC programme?

In the CRC examples, actors do not act as though they have no relevant prior experience; they try to focus on the peculiarities of the phenomena at hand. Because of the uncertainty of the situation they cannot behave as though they are looking for cues to conventional or standard solutions. This is because the distinction between the known and the unknown, the measurable and immeasurable benefits and threats is blurred. The situation initially defies clear-cut methods of justifying means to ends because most of the times problems are not given or clearly defined. The situation is complex, unstable, and fuzzy and there is a great deal of difficulty in packaging its uncertainties. It is difficult to construct a set of well-formed problems upon which practitioners can exercise methodical ways and technical means. Actors first attempt to explore the particular features of the ill-defined and messy situation at hand that usually fall beyond systematic or scientific categories. They tend to construct an understanding of the situation from their gradual discoveries and they need to explore and discover the intended as well as unintended effects and implications. Because each actor may differ in his or her way of appreciating and exploiting the situations, they might engage in a social process of inquiry, reflection, and reflective conversation with each other and the situation they are shaping. Let me illustrate these processes with a story.

An interviewee is asked to reflect on the way she manages the relationship across different cultures in a CRC and how she usually make sense of different organisational cultures and build networks with other practitioners from international companies for scanning and screening ideas at the early stages of a project. Firstly she replies:

> I think you go in, *you have to go in with no pre-conceived ideas about things and get a feel for the company culture as you go.*

She continues by recalling a story about how she had gone to a conference and by chance had sat beside a practitioner from a competitor company. They started chatting and she noticed that the person next to her knew about her previous experience:

> There was a chap there who was from a company V who also did [similar research] and made a lot of products and he listened to my [conference] presentation, which was more or less about where we were going to head...[because] we didn't have much [feasible solutions] in those days, and when I sat down, I actually sat down next to him after the presentation and he said are you the senior that did all that work on V1 techniques in blah, blah and I said, yes, and he said, oh I know your papers and I was staggered...I think he already had a view about me just from reading the literature...

Then she explains that a year later she was in Europe travelling with one of her CRC industry partners when he suggested they go and talk to company V about possible collaborative research and she thought that was a good idea. Company V welcomed them and asked about the possibility of training a PhD student in their CRC as a test to explore future R&D collaborations. She reveals about her reflection-in-action:

> *I think in their own mind they already had a good impression of us* but the other thing was *I already knew about the culture and the way they operated from visiting* so that was fairly easy to do.

Then she compares this company V with another firm (which is also one of her CRC partners) with a different culture:

> *[you] had to deal with them in quite different ways and you know*, I often talk about that with the research teams, you know, *you've got to learn how they operate, you have to even rightly talk the way they would like and so on and just be flexible about* while you ease into that and we had one of the CSIRO people who I thought would never come onto this CRC thinking when I first started and in fact he retires in about three years time I think, another reason, *a new dog has to learn new tricks* but he was an expert in a particular area and an opportunity for a project came up with an Italian company which needed him in the project, and I said...we've got this offer of doing a project, would you like to be involved and he said, yes, because it was right in his area and so on *but you realise we're dealing with an industry project, you have to communicate fairly well to keep them up to date and aim for various targets, I'm quite nervous about it and we get started and he's a bit of an intellectual character*

himself who's interested in European culture and so on and within about three months he's got this pattern of the key person in Italy and himself about various things to do in the Italian culture and all this stuff as well as the project and then he produces this report at the end which he actually didn't make it on time but what he did produce was fantastic and they thought it was brilliant, a really good report and it got another area of work after that *but the direction was going to change away from his area of expertise* and he said to me, ok, you won't want me involved and I said, no, no, no, I said you're stuck right where you are because that relationship is going to be almost impossible to duplicate and I want you to still be the project leader for these other people who will be working on this *and I learnt that from [this experience], when you had a good mix of people, you don't jeopardise it because it is so hard to replicate and you know those sort of things work really well but you've got to recognise them, you have to know that they're happening.* I've got one happening with [another project] at the moment, one of my researchers is becoming the golden boy and so straight away I started encouraging direct communications, you don't have to go through me or the project leader, just talk direct, now because he will be a key person running projects in a couple of years time and because *it's all to do with that sort of (a) there's often a personality thing (b) it's a trust thing, you know, and (c) they know you are going to deliver.*

Then she is asked about the way her team deals with organisational reputation:

[It] comes down to individuals, you know in the end it doesn't matter about all these organisational structures, in the end what makes them work, is you get the repeat business, is the individuals and if the organisation is as such that people see that they are supporting individuals and creating the right framework, then they will come to that organisation in preference than going directly to [others], they're trying to get that blend right is really difficult *and I find it hard to talk about how you do this because it's so related, like I couldn't do a course on it, these are the things you do because I know in the end it depends on the person, it depends on how their brain is working and how they anticipate the need of the person when they need to communicate..* and it's this *intuitive sense* about when I need to react and when I don't need to react and can I balance these various activities .

Then the interviewer inquires about the ways she has learnt to reflect-in-action – what she calls 'this intuitive sense'. She says:

Look it's some people, if they're already slightly pre-disposed, then all you have to do is tell them that ok, *what I want you to think about is this aspect about how they might be thinking and then it will work*

but then there are some people who can't, I just, there is cases in CRA where I thought you could and there are certain gung ho personalities that you will never make them fit certain moulds but that's ok, because then you look for where they do fit. I had one guy where I thought it wouldn't work in a sense and then it suddenly matched up with a person in argyle diamonds. I remember that going and then click, oh great, that's gonna work and now I know he is going to go somewhere and be happy and all this sort of stuff and he was getting the right feedback and he was being listened to and that type of thing but I knew he wasn't going to suit other types of projects and some of it is accidental, that's the trouble.

This long quote in fact has an underlying story. In a brief account of her theories-in-use this manager tells us how in her encounter with a new phenomenon she attempts to understand what is going on by developing a feel, sense-making, and at times reflection-in-action ('you have to go in with no pre-conceived ideas about things and get a feel for the company culture as you go'). By surfacing her understanding of this kind of reflection ('it's this intuitive sense about when I need to react and when I don't need to react and can I balance these various activities') which has been at times vague and implicit, she reminds us of Schön's idea that some professionals know more than they can say ('I find it hard to talk about how you do this because it's so related, like I couldn't do a course on it, these are the things you do because I know in the end it depends on the person, it depends on how their brain is working and how they anticipate the need of the person when they need to communicate').

In transaction with any situation, she sometimes encounters surprises in the form of 'back-talk' that momentarily interrupts action, evoking uncertainty and inquiry ('when I sat down, I actually sat down next to him after the presentation... he said, oh I know your papers and I was staggered'). Triggered by surprise, by excitement, by the unexpected, or by the happy accident, she thinks on her feet in the midst of action to describe and redescribe the puzzling phenomena ('I think he already had a view about me just from reading the literature'). She iteratively goes on to transform such situations in a way that resolves doubt, at least for the moment. She does not stand outside the phenomena like a spectator; she is in them and in a social process of transaction (give-and-take) with the situations.

In chapter three, I argued that reflection and reflective thought is not merely a sequence of ideas but a consecutive ordering in such a way that each idea determines the next as its proper outcome, while each in turn leans back on its predecessors. The successive reflections emerge out of one another and support one another. Each move is a step or suggested direction from something to something else, leaving a deposit which may be utilised later ('a year later I was in Europe and I was travelling with a guy [one of our industrial partners] and he said, why don't we go and talk to them about possible collaborative research and I said, oh yeah, that would be really good, so we did that').

Influenced by her appreciation of the phenomena at the same time that she shapes them by her thinking and doing ('I think in their own mind they already had a good impression of us'), she may interpret such phenomena as a problem and set new conditions that occasions resolution and workable interventions that she has confidence at undertaking ('as the first step for collaboration one company wanted to support a PhD student, so we started this student and we did that and he finished successfully').

This practitioner sometimes surfaces and criticises her tacit frames in her encounter with excitement, the unexpected, and surprises ('I already knew about the culture and the way they operated from visiting and so on, so that was fairly easy to do but you're right they are different'), so she tries to restructure her understanding and knowledge about the phenomenon at hand (or knowing-in-action), undertaking inquiry (e.g. 'you had to deal with them in quite different ways and you know, I often talk about that with the research teams, you know, you've got to learn how they operate, you have to even rightly talk the way they would like and so on and just be flexible').

Her inquiry sometimes proceeds from doubt ('I'm quite nervous about it and we get started and he's a bit of an intellectual character himself who's interested in European culture') to the resolution of doubt ('what he did produce was fantastic and they thought it was brilliant'), from indeterminacy to determinate conditions, from uncertainty to reduced uncertainty.

In her encounter with new phenomena and surprises, she loses a little of her previous sureness or her tacit theories-in-use, and is honest enough to learn from what happens by

undertaking reflection-on-action ('I learnt that from CRA, when you had a good mix of people, you don't jeopardise it because it is so hard to replicate') and changing her previous tacit frames and theories-in-use ('it comes down to individuals, you know in the end it doesn't matter about all these organisational structures...it's all to do with that sort of (a) there's often a personality thing (b) it's a trust thing, you know, and (c) they know you are going to deliver').

This interviewee's pattern of activity also reveals her consciousness in taking a reflective stance in the here-and-now (those sort of things work really well but you've got to recognise them, you have to know that they're happening). At times, she tries to educate other practitioners in the improvement of their knowing-in-action ('so straight away I started encouraging direct communications, you don't have to go through me or the project leader, just talk direct').

All this she does through a network of socio-technical arrangements and heterogeneous actors, each involved in a different role, each with his or her own interests, his or her own perspectives, and his or her own access to power and information. Within this network, her reflections and moves yield phenomena to be understood from different perspectives, as she sets new priorities ('doing collaborative research'), as she defines new problems ('defining manageable PhD projects'), and as she settles the new rewards and opportunities to be exploited and the new risks to be avoided ('funding PhD students for our alloy systems'). As a reflective practitioner she in fact evaluates her performance by the quality and direction of the inquiry to which it leads. This evaluation rests on her perception of the potential for addressing risks and rewards which she can realise through further inquiry and intervention. In this way, her reflective inquiry is transactional, open-ended, and inherently social ('Now, we already had the feel and part of the reason why V was happy to involve us was that they were partly funding a PhD student with me, this is interesting').

The practice of such kinds of reflections might be repressed, underrated, or remain unnoticed for the sake of technical/rational views of innovation and risk management. But it seems that when practitioners neither undertake reflection nor reflect on the tacit frames and theories-in-use that guide their actions when setting roles or problems, they do not feel the need to test

their tacit understandings. They do not attend to the ways in which they construct their reality or the ways in which they function whether in a profession or larger social institution. Thus, for example, practitioners may assume without question that in the course of product development they should maximise rewards and minimise risks – according to rational models of decision-making – avoid the trap of blame games, stay away from surfacing uncertainty and negative feelings, selectively interpret scientific evidence to justify the benefits of a product over its inherent bugs and ambiguities, define ends unambiguously and try to adapt means. When such practitioners reflect on their frames and theories-in-use they may also reflect on the possibility of alternative ways of framing the reality of product innovation and risk management. They may become aware of the norms, restrictions, routines, traditions, and values which they admire, and those they have given less priority and those left out of consideration altogether. Such frame reflection leads to awareness of competing frames, conflicting goals, problems, differences, and dilemmas (Schön and Rein, 1994).

On-the-spot Experiment

As we saw in another CRC story, the discovery of a new phenomenon (the leak of information, myopia due to computer screens, treating the CRC in the manner of consulting firm, seeing CRC as another way of tapping government money) leads to new questions, 'How do we account for the effectiveness of our old approach and the new phenomenon?', 'How do we recast the scientific inquiry from 'inheritance' to 'computer over-usage'? How do we set the new projects when one strong sponsor tends not to commit itself? Actors' inquiries turns into testing the structure, discipline or frame they constantly impose upon the variables and problems. They are willing to follow the implications of their frame but they have to remain open to make sense of surprises, shocks and the unexpected as well as the expected as the situations talk back. They must ask themselves: Do we like it? Is it useful? Did we learn anything? Does it work? Is it what we were expecting? Reflecting on the surprising as well as the regular consequences of

their efforts and moves to shape the situations to conform with their last chosen frame, actors refine new questions, design new interventions, and reorganise the means and ends.

Each move creates, in considerable measure, the conditions for reflection and inquiry, and from their reflections, actors design the next move for intervention. Each move to frame a problematic situation is an experiment which may produce some intended as well as unintended consequences, from which actors have to regard some information as relevant and worthwhile and some as redundant. Actors respond to uncertainty and complexity by selective management of large amounts of signals, implications, consequences, and information. They spin out long lines of invention, inquiry and inference and hold in their mind several ways of looking at the phenomena at hand without disrupting their flow of reflections. And actors evaluate their reflections by determining how they appreciate unintended consequences or at least appreciate what they can make of them.

Each reflection reproduces some new understandings as well as new uncertainties. Each new reflection suggests new experiments which generate new interventions, implications, and questions. Reflecting on these experiments may suggest new meanings, new choices, new metaphors and symbolic relations, by which actors construct a more harmonious, better organisation, and a better settlement.

5.5 Summary

This chapter considered several critical events in product innovation across the CRC programme, exploring patterns in how the practitioners involved dealt with situations of uncertainty and anxiety surrounding issues of 'risk' and its 'management'.

In many of these events, the story begins with making sense of a problematic, unfamiliar event and an effort to transform it into a set of manageable problems to which actors may apply familiar theories and techniques. In many cases the problems are complex and interconnected, and solutions only dimly apparent at the outset, if at all. Problems are framed

and constructed from the materials of such problematic situations. Most of the times, the problem is initially set as the classic problem of developing a profitable product with minimal risks and maximum rewards. But as the project goes on additional yet unforeseen problems appear which may be framed as problems of making/developing something amid confusion, instability and pressure (a coordinated decision, a coherent structure, a collaborative arrangement, or a consistent design). Problems are also sometimes framed as a problem of realising/recognising something (why higher rate of myopia in this area/ how to defeat leakage of sensitive information /what this phenomenon means, etc). In all such cases, some actors remain open to the discovery of new variables incongruent with their initial problem setting, in which case they ought to be open to reframing the older problems afresh in each new situation.

These events illustrate the general 'risk settlement' process of converting uncertainty into packages of manageable problems, problems through which practitioners then frame threats and opportunities as manageable risk and rewards. I called this 'colonisation as conversion practice', revealing how the handling of uncertainty in product innovation in the CRC programme can be seen as a variation of a general set of activities and processes that are practiced de-facto as a method of action and inquiry in situations of high anxiety and uncertainty.

It was argued that this 'method of inquiry' involves four sets of sub-activities: 'framing, frame-awareness, frame-restructuring'; 'actors' use of a repertoire of metaphors, analogies, and exemplars'; 'strategies for coping with anxiety, fear, defensiveness'; and a process of 'undertaking reciprocal reflection, inquiry, and transaction with the situation'.

This conceptual framework has been developed on the assumption that it is important to name and give systematic 'voice' to this often tacit and frequently repressed method of inquiry, and to help establish it as a practice with a place of its own in the complex world of professional action – in risk management in innovation and more generally.

Out of the narrated critical events, and the framework that is applied and illustrated through this narration, come a number of themes. A summarised comparative chart follows, outlining:

1) The fuzzy front-end of innovation involves incoherent, distressing and problematic situations such as the conflict of means and ends, instability, uniqueness, value conflicts and overabundance of competing information which cannot usually cannot be reducible to the use of technical prescriptive methods or standard risk management models. It is in fact an apt social 'laboratory' for studying the anxiety of uncertainty experienced by actors and all of the twists, turns, and manoeuvres taken by their 'anti-anxiety system' [sic] in order to avoid or minimise such anxiety.

2) In order to understand, transform, and handle uncertainty and convert it into something manageable some practitioners are intuitively able to iteratively construct and set up manageable problems. In this process, they engage in a colonisation practice whose underlying structure is more or less the same at least for radical product innovation (in R&D projects). When we look at this phenomenon certain kinds of overlapping practices can be distinguished. I singled out four of these under the headings of 'reflection', 'framing and reframing', 'coping with anxiety' and 'the process of metaphor'.

3) The unmanageable reality of radical uncertainty cannot readily be converted into something manageable. Most of the time, problems are not given or clearly defined. New ways of setting problems must be constructed. On many occasions there are many distractions and multiple possibilities that often leave actors setting and solving what come to be seen as the 'wrong' problems. They often deal with more information than can be handled, and have to deal with too many conflicting and competing variables. Most of the possible solutions are dimly apparent at the outset. Sometimes the solutions to one problem will make the others worse. Their usefulness and feasibility need to be tested amid anxiety, agony, ambivalence, and ambiguity.

They experiment in order to explore whether situations conform to their hypotheses, but they also have to remain open to the possibility that it will not. Inevitably, they juggle many conflicting and competing viewpoints in tentatively resolving problems in ill-defined yet stressful situations.
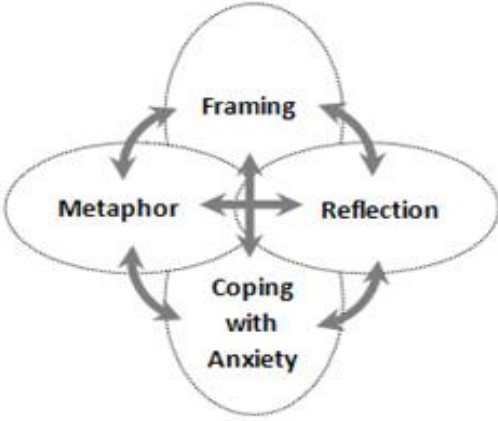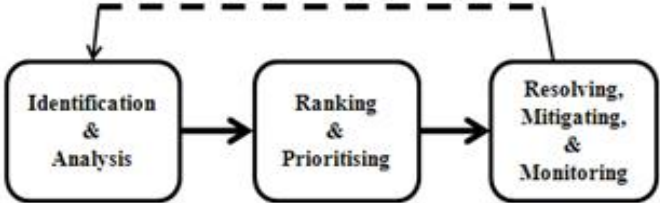
4) In many treacherous and threatening situations something, say phenomenon or object A is seen and treated in the manner of something else, say phenomenon or object B. In the CRC program projects, this is illustrated through interpretations of confidentiality as fireproofing; the staff matrix as a technique for framing roles and problems; a consulting business as a guiding culture, and so forth. In each case, this involves the construction of new images of the situations through the process of metaphor, requiring the actors' revision of the understanding of their position in relation to a problem. Actors' repertoire of techniques, theories, images, and tools provide the material for the process of metaphor use. They engage in an inquiry in which the old is taken as a projective model to provide new representation or images for the problematic aspects of the unfamiliar situation. The new projective model is then a product of reflection on the resemblance of attributes earlier perceived. This uniqueness in perception, too, affects what directions are pursued in order to change the situation. It is in relation to the unique features of the metaphorical grappling with uncertainty that each organisation undertakes the risk settlement differently. And in every successful attempt to set and solve a problem, using different views of 'similarity' of relations between A and B, there is a feeling of transition from fear and anxiety to power and opportunity.

5) Colonising uncertainty at the fuzzy front-end of innovation depends heavily on the quality of actors' inquiries and reflective thinking. Through reflection and inquiry they can become aware of new opportunities and weaknesses, in the light of which they can frame and reframe problems, set and reset the assumptions built into their previous formulation of the risks and rewards. They reflect on their previous

interactions, exploring how their performance may provoke further reflections (reflection on reflection-in-action). These open up ways in which the practitioners may rethink, restructure, or modify their previous theories-in-use.

6) In this reframing process, some essential aspects of colonisation as conversion are: the will of the protagonists to overcome other actor's (and their own) defensiveness and dogmatism, his/her competence and confidence in artistic creativity and performance, and the handling of his/her relations with other actors.

All in all, colonisation as a conversion process is an ongoing development without a final settlement, what I call, following Nietzsche, the 'dance on the feet of chance'. It involves looking at uncertainty through different lenses so as to find or design a set of appropriate lenses for a provisional settlement of risks and rewards. The ability of actors to perform this kind of dance has to do with actors' art in using metaphors to make sense of chaos, their competence in setting and solving manageable problems, their ability to synthesise conflicting frames, their ability to tolerate high levels of anxiety, and their quality of inquiry.

Table 5.1 Practices of Risk Settlement and Risk Management

Risk Settlement: Converting Uncertainty into Manageable Risks	Conventional Risk Management
• Coping with anxiety and developing hunches, intuitions, and feelings	• Controlling through formality and calculation; minimising human subject involvement
• Reflection, inquiry, technology of foolishness	• Implying *a priori* logic, *a priori* rules of relevance; juggling normative theories of choice; preoccupation with technologies of reason
• Seeking metaphors; exploring analogies and family resemblance; building projective models; finding Gestalt patterns and exemplars; finding symbolic relations	• Systematic and instrumental exploitation of available techniques, Technical-scientific deduction and assessment of threats using qualitative and quantitative likelihoods
• Framing unstructured and ill-defined situations; no clear link between means and ends; on-going construction of means and ends; shifting and fluctuating goals, setting packages of manageable problems	• Reduction and selective inattention; decision making within pre-packaged frames, means and ends clearly distinguished and linked by casual relationships; fixed and clear goals; solving manageable problems

Chapter 6 Conclusion

Children growing up today face a future without a Promised Land. If they are to develop a sense of themselves and of their own worth, they have to develop an ethic of change. They will have to accept, as continuing, the changes in technology, institutions and objectives which have outmoded the Technological Program (the idea that human progress would be achieved by harnessing science to create technology for the achievement of human ends). They will have to identify themselves instead as those who trust themselves to the here-and-now, who start from where they are, who experiment, who seek the metaphors for the future inherent in their traditions, who permit freedom to change, seek new visions and become (Schön, 1967: 217-218).

6.1 Thesis Summary

This thesis is structured in three main parts: (i) dealing with the conservative and radical function of metaphors and metaphor use in academic models of innovation in elaborating a 'ribbed balloon' metaphor for exploring and enhancing product innovation-in-practice; (ii) traditional risk management as a universal and influential tool, assumed to map, measure, and monitor future uncertainty objectively, and to program and colonise a utopian future through an orderly process, contrasted with sociopolitical/cultural critiques of this approach, and theories of how uncertainty is dealt in theory and practice; and (iii) the development of a conceptual framework to support a reflective practice that acknowledges rather than avoids or represses the challenges to traditional risk management embedded in the sociopolitical/cultural critiques.

The third section draws on the other two in developing a framework designed to support a reflective practice of risk management in the early 'fuzzy front-end' of the innovation process and help counter the traditional image of risk management as 'colonisation by rationalisation'. It is argued that most risk management recipes are designed to identify and 'resolve' familiar and well-formed problems of risk and that this neglects the primary practice of 'risk-settlement' or 'problem-setting' within which the conditions for the exercise of rational risk management is 'set up'.

To remedy this weakness, I built on Donald Schön's corpus of research and used a narrative reconstruction of critical events in a government-funded R&D programme, to identify, illustrate, and integrate four interrelated practices in risk settlement, systematised them in a conceptual framework, and show how they work in practice. The framework contended that in ill-defined, indeterminate, and intractable situations many practitioners intuitively engage in an iterative practice of formulation and resolution of manageable risks and rewards, converting uncertainty into packages of manageable problems by 'undertaking reflective conversation with the situation', 'coping with anxiety', 'using metaphors', and 'ongoing framing and reframing'. This framework has been developed as a generative metaphor of risk management (as a new model) for handling and colonising uncertainty in contemporary organisations.

6.2 Contributions of the Thesis

In elaborating on risk management in relation to our contemporary ideas of 'progress', the thesis has attempted to locate the more technical and restricted academic discussions of risk management in their broader social context. I have argued that modern social systems faced with uncertainty in the world and seeking to create economic and social development, as well as scientific and technological innovation, have developed a utopian imagery of social progress informed by instrumental metaphors. This idealised imagery legitimises their attempt to colonise selected environmental niches, and to fabricate their future according to rule-following methods, mechanisms, and tool-like metaphors. In so doing, instrumental risk management is a modern institutional fetish (Bernstein, 1997). It allows organisations to predict and analyse uncertainties that govern the behaviour of any chosen niche environment. This view of risk holds that by seeking a close and clear fit between risk management and the environment, social systems are able to dominate the future against the whim of the gods. In this process risk management functions, however, not as an effective guide but as a sanitised, standardised, and systematic method that obscures its own practices in seeking to rigorously

envisage and employ risk management as a rational strategy for mapping, mediating, and mastering future possibilities.

Viewed as such, organisations seek to coordinate their future actions and administer their risk management strategy through an orderly process of justification, evaluation, and implementation (mostly stage-gate metaphors). This supports actors' viewing their identifying, ranking and resolving of risks and rewards as a law-like process that should be settled by reference to technical rules and objective data. Within this view, organisations' pre-defined purposes, principles, and problems are given or can be defined and resolved in an orderly manner through appeal to rational, value-neutral techniques prior to the fact. Mastery of the future, in short, is seen as possible through methodical application of a body of means (namely risk management) to unambiguous ends within a well-defined strategy.

The discourse of risk management (in contrast to a recognition of the complex practice of handling uncertainty) is part cause and part consequence of this broader sociocultural ethos. It was in the light of such a powerful and persuasive tool that late modernity, in Giddens' phrase, has developed an increasing preoccupation with the future, which in turn has generated and legitimised the notion of risk and risk management based on the uncritical rationalist assumption that the future be a territory that is analytically regulated and rationally conquered, colonised and normalised through the systematic application of risk management concepts and methods.

One of the main aims of the thesis has been to assemble and provisionally organise enough material to throw doubt on the pillars of such a commonsense utopian imagery of the colonisation of the future through 'risk management'.

In the introduction, I pointed to the increasing rate of uncertain, unique, and complex problems as they affect professionals, organisations involved in innovation, and modern institutions as a whole. This situation has, I argued, weakened decisively the grip of modern corporations on the levers of risk management as an effective way of controlling their product

development activities. Practitioners and corporate executives are becoming increasingly aware of the zones of ambiguity and anxiety in the practice of risk management in which problems interlock and are ill-defined, means and ends are acknowledged to be fuzzy, and situations usually escape the regular and standard categories of problem-solving most professionals are trained for. In other words, professionals and organisations are badly served by a dominant body of theories and techniques for which given problems are assumed to be handled by systematic exploitation of rational means to achieve unambiguous ends, preferably scientifically-based. Put simply, and as Schön argued long ago, they have trouble handling uncertainty and they are defensively conservative about what actually happens in the existential here-and-now. They ignore and fail to systematically reflect on the complex processes and practices necessary for converting unmanageable uncertainty into something manageable, something that can be constructed as manageable risks and rewards. I extended Schön's (1967: 25) aphorism: 'corporations cannot operate under uncertainty but they are equipped to uncover, analyse, and manage risk', seeking to develop a conceptual framework that could help practitioners creatively construct manageable risks and reflect on this artistic task.

In addition, the thesis explored how the problem of handling uncertainty was handled in a particular field and in a set of inquiries. I explored technological innovation as a mythical motor and momentum of progress, and focused on the fuzzy front-end of innovation as a situation of uncertainty, ambiguity, uniqueness, unpredictability, and anxiety for organisations.

In order to guide this exploration, in chapter 2 I employed Schön's approach to metaphor to explore academic models of innovation as conservative or radical generative metaphors. Little research has been carried out about how models of product innovation are actually put into practice and guide action.

In this chapter I explored the limitations of both the 'funnel' and 'fireworks' metaphors, argued for the reflective use of a 'ribbed balloon' metaphor that – unlike the others – was openly reflective about its metaphorical nature and use.

After reviewing the background academic literatures, I deliberately considered the 'funnel' and the 'fireworks' metaphors, which take polar positions on the relation between theory and practice in innovation. Despite their different positions they hold two assumptions in common. The first is that the process of creativity in organisations can be better captured and coordinated by formulating a model, finding a family resemblance between familiar tools, concepts, and images and the mysterious, indeterminate nature of the innovation.

Both metaphors of funnel and fireworks, albeit in very different forms and to very different degrees, acknowledge that 'technological innovation is disruptive, puzzling, and uncertain', but a 'managerial perspective or roadmap that indicates how and why the innovation journey unfolds is needed' (Van de Ven et al., 2000: 4). While coming from a 'fireworks' perspective, Van de Ven et al. (2000) acknowledge that innovation managers need a process theory that describes and arranges discrete phenomena, sequences, and performances over time and produces some fundamental laws of innovating useful for influencing the course of events. Yet this has proven to be elusive. The second shared assumption is the imperative of a behavioural world in which actors can run a productive organisational inquiry to handle uncertainty and problematic situations and constantly contribute to the organisation's stock of knowledge.

However, it was argued that neither the 'funnel' nor 'fireworks' proponents have been reflective and coherent enough about the dominance of instrumental metaphors in decisions about how to model and manage innovation. Neither side gives much emphasis to the nature of the instrumental metaphor they suggest, the form and fashion of the ensuing problems and restrictions, and its position on the relation between thinking and doing in innovation. They

display a particular selective inattention. Within the first view there is a *gap of attention* to the mismatch between 'funnel rationality' and the emergent problems and non-rational processes. Within the second view there is a *gap of explanation* about firms' failure to notice the mismatch between actors' public discussions and assumptions and their private puzzling action, between actors' espoused theories and their theories-in-use, a gap that is kept undiscussible until multiple 'fires' and an avalanche of bypassed errors make them unavoidably visible and cause a crisis.

In the end, despite their respective contributions, neither approach has enough to say about how managers/practitioners intuitively make decisions under uncertainty and what they actually do in their encounter with problematic situations, value conflict, and discontinuity (as in key decision points).

In contrast to these two camps, and those who remain entrenched within them, my purpose was to follow up and extend Schön's theoretically informed, pragmatic and integrative 'third way' approach toward organisational inquiry, the description of reality, and the organisation of product innovation. I sought to combine the orderly, economic, productive and prescriptive views of the funnel rationality, with the non-linear, critical, and sociopolitical insights and perspectives of the messy fireworks. I wanted to offer a new kind of marriage between the celebrated notions of 'funnel' and 'fireworks'.

Drawing on the strengths and limitations of both metaphors (two competing yet complementary views), the particular focus, therefore, was to show how a multifaceted approach toward innovation might work to inform and design an integrated actionable metaphor. My model of innovation, as a result, was not simply a critique of rational and technical/instrumental views of problem solving in product innovation. By combining both critical and economic/managerial approaches to product innovation as well as considering

sociological studies and psychological investigations of technology I developed a generative, radical, and multifaceted metaphor (the innovation process as an elastic ribbed balloon). This model views product innovation as a non-rational and socio-technical practice, one that not only reveals politics, uncertainty, technical setbacks, and reversals with which actors grapple but also considers rituals, people's defensiveness, and anxiety in its understanding.

In chapter 3, I took stock of available discourse about risk and identified one of the crucial absences in the debates – a systematic exploration and examination of the implications of the problem of handling Knightian uncertainty. I first grouped theories of risk and risk management into narrow technocratic and broader critical/sceptical views of risk. I argued that, at the end of the day, despite their different perspectives on risk management, proponents of both perspectives hold one key assumption in common – to design a frame for the reflective (not knee-jerk reflex type) exercise of rationality under situations of uncertainty, one that has been subjected to systematic critique by broader views of risk society and risk management.

Using the notion of 'handling Knightian uncertainty' as a common yet decisive factor or feature that serves as the foundation for reconstructing and contributing to the available literature useful for reflective practice, I then constructed a body of (seven philosophically/sociologically/psychologically informed) theses about/approaches to uncertainty and used the common rather than the idiosyncratic features of each to fill the pragmatic gap in broader perspectives. Drawing on these insights, I attempted to draw anew a contrast between two contrasting yet (I went on to argue) ultimately complementary positions – rational and reflective practices of risk management – and illustrated the basic themes in each frame of discourse. Corporations, in particular large firms, usually experience difficulty and complexity in handling indeterminate zones of practice during the process of innovation, particularly in its early stages. They are better equipped and are more ready to employ and act upon a 'language of investment' than the 'language of invention'. As a result, in the language of investment, corporations select a market niche, and attempt to program and fabricate its

future according to a utopian image of risk management as a tool able to objectively map, measure, and monitor future uncertainties that govern the behaviour of the chosen niche – more akin to incremental innovation, as calculative risks. By seeking a close and clear fit between risk management methods and the dominant factors that determine the niche behavior, corporations attempt to handle pre-defined risks in an orderly and methodical manner. In this study, I argue that such rational practices of risk management often involve yet ignore a primary process (what I call risk settlement), in which practitioners struggle to convert ill-defined and problematic situations into more packaged and less uncertain processes – packages in which practitioners reframe such ill-defined situations by constructing well-defined and resolvable risks and rewards. The argument here is that such primary process is inevitable, as practitioners should convert uncertainty in problematic situations into a set of seemingly separate problems, helping to shape it and permit action within it, which would otherwise defy orderly and methodical ways. In other words, problematic and indeterminate zones of practice should to be separated into manageable problems so that practitioners accommodate their limited understanding of the phenomenon. They do so in an iterative manner as they progressively set and solve new problems. The decision, therefore, is not whether or not to perform this but whether such activities are recognised in rational practice of risk management or not, or done well or badly. This is not only a feature of corporate innovation practice as actors grapple with the 'language of invention', but is also a key component of transforming this into the 'language of investment. as a precursor to further innovation.

The rationale here was to overcome the somewhat stereotyped split between 'exploiting rational methods of problem solving and risk management' and 'exploring different and diverse ways of setting problems and manageable risks' in the face of uncertainty. My aim was to both distinguish and formulate the preconditions for the exercise of an informed, pragmatic, critical rationality, involving the artistic activities essential for tackling uncertainty and bridging the gap between competing views and contributing to practice.

The next task was to systematise a set of sensitising concepts and put them in a conceptual framework that to a great extent captures how many practitioners reflectively convert the inherent anxiety and uncertainty of the risks involved in uncertain, fuzzy front-end, processes of innovation, into manageable problems or manageable risks. I then raised the question of 'what is the nature of such a conversion practice?' This provided the backdrop to chapters 4 and 5.

The framework developed and illustrated in these chapters builds on Schön's insights in conceptualising the initial handling of uncertainty as a 'conversion practice', translating and transforming unmanageable uncertainty into packages of manageable problems (Schön, 1995). The framework applies and develops Schön's notion of reflective practice in the process of applying it to a specific sphere: risk management in innovation. In developing this framework, the thesis singled out some of the overlapping and intertwined practices pertinent to this conversion practice – 'coping with anxiety, 'framing', 'reflection', and 'the process of metaphor'. These can be described as follows:

- Coping with anxiety *avoiding defensive routines and restrictive mechanisms when dealing with uncertainty.*

- Framing – selectivity and partiality in *shaping the contexts and setting manageable problems out of uncertainty.*

- Reflection – how one swiftly monitors the chaos and disruption as it arises, overcomes rational angst, and avoids reflex, all of which *involving reciprocal conversation and transaction with the situations based on open-ended inquiry, immediate 'back-talk', and experimentations in response to doubt, shock, unexpected, surprises, or happy accident.*

- The process of metaphor – *playful and prankish inference, non-rational weaving, dallying with things based on appreciation of the correlation between one's repertoire of exemplars and the materials of the situation,*

Little research is available on how practitioners within organisations actually handle uncertainty, engage in converting uncertainty into manageable risks and rewards, and undertake the kind of activities identified above. I therefore, presented a prototypical empirical study and a set of critical events based on a study of how practitioners in Cooperative Research Centres (CRC), a government-funded R&D programme, grappled with uncertainty in the innovation process, interpreted threats and opportunities as risks and rewards, and converted, in an ongoing manner, such problematic situations into manageable problems.

This data was previously collected during an inquiry about the critical events in the CRC program by two Australian researchers who arranged a series of in-depth interviews with senior managers to address issues of mistrust, organisational conflicts, fear of uncertainty and anxiety, defensiveness, and resistance to change; and to discover how these managers nurtured the sense of companionship and commitment necessary for creativity under such conditions. They had encouraged managers to discuss the meanings and stories they assigned to problematic and critical events encountered in everyday practice and their actual response to such situations.

In order to show whether the criteria in the conceptual framework were met, however, I had to undertake an inquiry in the data. Because the publicly accessible data and the empirical study presented the results in a layered, partial, and fragmented form, I reconstructed the narratives and provided a formal description of the CRCs from three perspectives. Firstly, as seen from a formal 'front-stage' perspective (the annual reports, public documents, official stance of the organisations, etc.), which show how CRCs according to government policy,

and experienced a linear sanitised development. Secondly, as seen from an inside or 'back-stage' perspective (the accounts of CRC members), I focused on the 'manifest stories' – how practitioners share their episodes of practice and how they engage in a process of reflection on their actions and their previous reflection-in-action in the face of ambiguity and anxiety. Finally, I constructed an 'underlying story' by examining how these practitioners were in fact experiencing uncertainty, and how they attempted to juggle both 'official' and 'unofficial' discourses in handling such uncertainties, interpreting fears and hopes as risks and rewards, and continuously constructing and reconstructing what was regarded as resolvable problems or manageable risks and rewards. I used the pre-developed framework as a set of sensitising concepts to explore, illustrate and ultimately further develop a detailed understanding of how these practitioners' artistic interventions were undertaken in a way that handled uncertainty.

In this manner, I tried to show how the handling of uncertainty in product innovation across the CRC programme can be seen as variations and versions on what I defined as a general process of 'colonisation'. This image was developed, however, in direct opposition to a Giddensian view of 'colonisation by rationalisation'. I argued that the latter, limited, view of colonisation overlooks a primary and overarching artistic activity in which many practitioners iteratively colonise and convert 'uncertainty' into packages of manageable problems, namely manageable risks and rewards. I termed the primary part of this process the 'risk settlement' phase or element in the colonisation process, and argued that risk settlement calls for a kind of inquiry beyond the regular, standardised tools of risk management.

I focused on this type of colonisation of uncertainty in the early stages of product innovation but this was used as a lever for a more general statement about the management of uncertainty in late modernity. My initial aim was to take it as a metaphor or exemplar in other fields increasingly distant from risk management and product development – fields that occupy managerial concerns in late modernity. It is my hypothesis, indeed contention, that the arguments about 'risk settlement-risk management' in corporate innovation hold, in only slightly altered form, for other late modern social systems. Corporations and nations are,

arguably, analogous in the sense that they are sociopolitical organisations confronted with the dilemmas and uncertainties of growth and progress amid discontinuous and unpredictably interconnected socio-technological change.

This broader definition of colonisation (as risk settlement and risk management) draws on Schön's distinction between 'problem-setting' and 'problem-solving', as an ongoing process with two different yet overlapping and intertwined spheres.

There are, however, two possible misinterpretations of this view. The use of these phrases may suggest a sequential process that overlooks the ambiguities and complexities in risk management. Or, that it presumes risk management is an 'inferior' and 'mistaken' view of what happens in handling risk. Either view would be a mistaken understanding of the colonisation as a conversion process. This process is one that is multifaceted, iterative, and chaotic, with settlement and management often overlapping and intertwining, with an interplay between deliberate and emergent processes. Also, following Schön, the framework seeks to integrate risk settlement and management in order to achieve practical outcomes, and to support reflection on and development of the practice. It is *not* undertaken merely to criticise the limitations of a rational/scientific world view or to force-fit it into a new rigid sequential schema. In a rational/scientific world there is always the danger, even likelihood, that any critical reflection will be interpreted this way – a penance paid for the 'sacrilege' of questioning a restricted rational world view. I believe that the problem with technical/rational approaches lies not in their techniques but in their lack of understanding of context, and their restriction of knowledge to a narrow technical domain. The purpose of this thesis, and the framework that it has developed, is to help open up for reflection and scrutiny the less traditionally 'rational' components of risk management in practice – as an aid to informing that practice itself.

All in all, the aim was to contribute some elements of a theory capable of supporting reflective practitioners in their dance on the feet of chance. The aim of identifying four sets

of activities in the colonisation as conversion process is that they act like magnets below a piece of paper, artistically and intuitively yet invisibly arranging and aligning iron filings into new frames and forms of their making. One may use rational recipes, quantitative techniques, and proceduralised methods to help produce outcomes. But an equally, if not more, complex and daunting task is to creatively forge consensus to get conflicting policies and competing ideas constructively and coherently packaged, to wrestle with and transform radical uncertainty into something that can be handled, and to get the resulting packages of policy enacted. The aim of the thesis is to stimulate and support reflection on such issues.

6.3 General Implications and Some Issues in Implementation

I shall now explore several implications of the 'colonisation as process' framework as it affects professions, organisations, and larger social systems. I shall also explore the organisational contexts hindering as well as supporting the recognition and diffusion of such a framework, and the visions of technological change and social progress which may be used to condemn or justify it. In other words, I tend to explore what the idea of colonisation by conversion implies for the nature of corporate innovation, risk management, technological change, and social progress.

Colonisation by rationalisation in the light of a utopian imagery of risk management, product innovation and social progress, as I argued, is still very much alive. It, for example, underlies the dilemmas of prevailing scientific risk discourse and the attempt to put the future at the service of the present, as identified by Giddens (1999) and Wynne (2002), and the problem of technological advancement (and restricted use of risk analysis) as a cognitive map to conquer and colonise the future (Beck, 1999). It is embedded in the tendency of many academic institutions and professional corporations to see themselves as organisations of applied technical/scientific methods (including risk management), reserving the highest status for applied and analytical techniques and theories. In some parts of some businesses, which are relatively stable and predictable, we can use these techniques and theories as good recipes

and routines. But one should not forget that large zones of professional practice increasingly present situations of ambiguity, uncertainty, manufactured risk, novelty and instability which do not lend themselves to technical-scientific rationality.

I hasten to say that the notion of 'colonisation as process' does not suddenly free us from manufactured risks, organised irresponsibility, technological imbroglios, or unexpected shifts. My concern was to show how, following Schön, such a conceptual framework in product innovation *can* be used as a metaphor and, it is hoped, provide a momentum to help transform professions, corporations, and social systems, within a framework of reflective responsibility (Selznick, 1994) – towards a situation where practitioners are able to function as reflective self-reforming agents in their encounter with situations of radical uncertainty.

As 'colonisation as process' includes the iterative form of setting and packaging manageable risks and rewards amid discontinuity and uncertainty, so the practitioners, corporations, and social systems' recognition of uncertainties take an on-going form of setting and solving manageable problems and policies. Reflective practitioners involved in this process recognise that their practical activities may hold conflicting frames, different meanings and interpretations than they initially intended to have, and they give themselves the task of exploring what these are. They recognise a constructive responsibility to make their own tacit frames (inner voice) accessible for testing, inquiry, and modification, which means that they need often to revise anew what they regard as fixed, enduring, rational, and constant. For them, there is readiness, confidence, and competence in exploring new ways of looking at things, theories, and techniques, which are at one and the same time socially, technically and politically constructed and rhetorically intensified. They try to discover the limits of their tacit knowledge and technical expertise through critical inquiry, interrogating subjective experience, open experimentation, and rapid reflection.

Clearly there are serious restrictions on the establishment of a 'colonisation as process' framework in the language of professions, corporations, or modern societies as a whole.

Settlement is very difficult, challenging, and time consuming, and the area of concern must seem of sufficient importance to make the effort worthwhile – in conditions where everyone is already busy and anxious in addressing the complex problems of risk and innovation. It is the argument of this thesis, however, that the establishment of this framework is imperative, possible, and extremely worthwhile.

The essential difficulty lies in the diverse and different views of competence, willingness, and confidence. This is because activities inherent in the conversion practice call for a kind of competence, will, and behavioural world which initially seems strange for traditional views (i.e. colonisation as rationalisation) closely bound to rational imagery of risk, innovation, technological change, and social progress. Practitioners, corporations, and social systems are traditionally expected to appear rational and diplomatic in public, an in private to seek unilateral control in ways that deny uncertainty, to set aside unknown unknowns, and to repress or bypass fear and anxiety and to hide the bypass. They traditionally employ Machiavellian stratagems of selective reasoning, engage in win/lose games of control, secrecy and hiding, and enjoy tactics of mystery and mastery, what Argyris and Schön (1974, 1996) term as Model I in organisational learning. Model I can, however, have serious deleterious consequences in organisations. When practitioners, for example, are encouraged to exaggerate their claim to know in the face of unknown situations or to hide and repress their ignorance, they may fail to perceive a fruitful line of inquiry which could yield new and more effective ways of managing and looking at a particular phenomenon. Top management may misinterpret the ideas a practitioner proposes for research and experimentation, failing to acknowledge and act on management's uncertainty and lack of expertise in a field. The practitioner on the other hand may use vagueness and subterfuge as a vehicle to flout and foil a manager's control over the situation.

To openly admit uncertainty and ambiguity, to make it apparent that one needs to conduct serious reflective experiments, may indicate a lack of power, security and control when the basic world view is based on Model I games of evasion and selective inattention, denial and

dogmatism, mystery and mastery. When a situation is conflicting, complex and confusing, when practitioners' understanding is incoherent, incongruent, and inconsistent, then it is extremely difficult and disturbing to detect real risks and rewards and to correct real errors, discontinuities and disorders. It may trigger a defensive or dogmatic reaction in which actors deny their uncertainty. Therefore, it is not clear what expectations one ought to have or what constitutes an outcome mismatched with expectations.

To put it another way, under Model I 'theories-in-use' usually remain incongruent and inconsistent with 'espoused theories', thereby inhibiting the capacity, will, and competence to explore, to experiment, to enquire and above all to effectively reflect on what is going on right here and right now, as I described in the introductory chapter. Risk management without attention to risk settlement stimulates Model I responses, and these, in turn, tend to reinforce the problematic conditions of a risk society – manufactured risks, organised irresponsibility, boomerang effects, and so on.

The antidote, as I have argued, is a recognition and combination of the nature and value of both risk settlement and risk management. This recognition helps practitioners to be aware of and move towards new competencies: to exercise artistic reflections, to reveal their uncertainties, and to open up new sources of satisfaction, renewal, and recognition whether for themselves or larger social institutions. The recognition of error, discontinuity and disorder – in the form of inconsistency, indeterminacy, or incoherency – with its resulting ambiguity and anxiety, can become a source of inquiry, experimentation, exploration, and appreciation, rather than dogmatism, defensiveness, or denial.

To be able to exercise such competencies one must be willing to function and cope with the matter at hand as a reflective self-reforming active agent. One should cultivate competence in swift reflections; openly stimulate others to reflect on their own experience, inspire them to seek the metaphors behind their conventional wisdom, and encourage them to re-examine the myths they dearly espouse, without making the self the cause of their despair, denial,

defiance, and defensiveness. This is what Argyris and Schön refer to as Model II organisational learning.

For any individual, professional, corporation, or social system who wishes to move from conventional Model I to constructive Model II, there is the tricky and troublesome task of reshaping and revisiting the governing values, norms, traditions, and expectations which in part scientific-rationality has brought to us. If one wishes to make sense and begin acting in an unconventional way, any advocate is inevitably condemned as the cause of new dilemmas. Should a large multinational financial institution, for example, risk losing its short-term rewards for a complex and doubtful product in order to create the conditions of behaving more responsible? Should it reveal ambiguities in its new product at the risk of frightening or confusing its customers? Should it risk experimenting with complexities and uncertainties in a controversial product when the customers might regard such experimentation as unacceptable, undesirable, or intrusive, and the shareholders might see it as financially irresponsible?

The way in which such risks and rewards present themselves is a function of the sort of theories-in-use, espoused theories, and behavioural world that practitioners and corporations are embedded within. These constructs may be conducive to the avoidance of risks, and open reflection on uncertainty, at the expense of creating manufactured risks, sweeping errors under the carpet until they are unavoidable, censoring uncertainty and enjoying sanitised stories, maintaining the façade of order, predictability, and stability at a high price – in short, to exercise Model I behavioural world and responses.

However, in the introductory chapter I discussed how what we believe to be the constants of our behavioural world are in fact historically and socially constructed. Our behavioural world is artificial and accidental, not only in the sense that it consists of artefacts of our convention but in the sense that it has been constructed, influenced and intensified by our own actions.

In this way, we construct the reality of our behavioural world through the same process by which we shape and modify our theories-in-use. This implies that we cannot begin to make up better theories-in-use without also trying to reform or change the behavioural worlds that are in turn conducive to the construction and further development of our theories-in-use. The formation and modification of our theories-in-use is, therefore, inevitably not only a learning process, but also a social and political process fraught with conflict and tension. This particularly the case when what is advocated and promoted involves what Argyris and Schön (1974, 1996) characterise as 'double-loop' learning.

According to Argyris and Schön (1974, 1996) there are two kinds of behavioural learning: single-loop and double-loop. If, under existing governing variables, we learn to play and juggle pre-existing means and ends and adopt new action strategies that shape intentional behaviour and guide our action, then this is called single-loop learning. If we learn to access and change our governing variables (the settings of our theories-is-use: world-views, values, insights, stratagems, and assumptions) then this is called double-loop learning. Drawing on an example used by Ashby (1960) Argyris and Schön (1974) make this distinction more explicit. When a household thermostat controls the household temperature around an already set temperature then the system is engaged in single-loop learning. But if we change the setting or the default of the thermostat thermometer, the system is involved in double-loop learning.

Using a thermostat as a metaphor, in the context of risk management, a practitioner engages in single-loop learning when he or she learns new calculating techniques for managing a particular risk. He or she engages in double-loop learning if he or she learns to be concerned with the activities relevant for the setting or settlement of manageable risks rather than techniques to manage them. Similarly a practitioner is engaged in single-loop learning when he or she learns to apply a new technique in monitoring and reducing the time for interconnected activities. But if he or she reflects on the technique, questions the tacit assumptions on which it rests, and learns that it fosters selective inattention to broader

socialpolitical variables he or she is involved in double-loop learning. If we are to refer to a more recent story, one can argue that in the case of the credit crisis single-loop actors favoured playing with interest rates while double-loop actors favoured a change in mentality: a greater willingness to heed, not just hear, contentious yet visionary views[9] (Layard, 2009).

In single-loop learning, our attempt to design and learn action strategies is accommodated within existing governing variables. In other words, change in our behaviour occurs yet we maintain the constancy of central aspects of our theories-in-use. This produces marginal change and leaves our core competencies untouched. In the context of risk management such changes take the shape of more sensible regulations, more monitoring techniques, and more transparency, all of which are accommodated within the existing framework.

In double-loop learning, our attempt to design and learn better theories-in-use would imply change in the existing governing variables. We learn to change the field of constancy in central aspects of our theories-in-use. In the context of risk management this takes the shape of conscious and explicit risk settlement, a process in which practitioners exercise spontaneous reflection and experimentation so as to impose a frame on the puzzling phenomena with the hope of settling a set of manageable risks and rewards that they later try to manage.

As identified in numerous studies of innovation, highly stable and predictable professional activities such as mass production of the same kind of successful product, single-loop learning enables corporations to avoid critical reflection and experimentation with regard to their core competencies. But this kind of learning carries the danger of making us prisoners of previous 'core competencies', lapsing to 'core rigidities' (Leonard-Barton, 1992) or 'competency traps' (Levitt and March, 1988).

---

[9] See for example a recent article by Lord Richard Layard from London School of Economics and Politics published in *Financial Times* on 11th March. 2009, 'It is time for a capitalism based on values' http://www.ft.com/cms/s/0/3f6e2d5c-0e76-11de-b099-0000779fd2ac.html

Under uncertain, unstable, indeterminate situations such as R&D projects, risk management, and product innovation single-loop learning fails to change the settings or frames on which the functioning of one's theories-in-use depends. One's theories-in-use continue to operate despite the likely errors in the setting of the governing variables. The disruptive effects may develop until they dominate and perhaps undermine the fundamental structure of one's theories-in-use and its behavioural world around.

The 'credit crunch' is a landmark in this respect. A silent tsunami (epochal event) such as this may overthrow or explode almost every established concept we have hitherto dogmatically regarded as stable, unshakable, enduring and sacred.

What I want to propose is this: our 'theories-in-use', 'espoused theories', and 'behavioural worlds' are all facts, artefacts, and anthropomorphisms which we jointly and socio-technically create and recreate. They are in Nietzsche's phrase:

> a sum of human relations which have been poetically and rhetorically intensified, transferred, and embellished, and which, after long usage, seem to a people to be fixed, canonical, and binding.

Thus, we can refine our theories-in-use, espoused theories, and behavioural world in the manner that is required if we regard them as intellectual hypotheses and if we have the competence and the will to do so. However, insofar as this requires changes in action and behaviour, in context, and in the real world, it will be contentious and political. It may be, however, that the kind of thinking and awareness advocated in this thesis aligns with prejudices in our culture and the personal and organisational interests of groups and institutions involved in innovation. If this is the case, then changes may be initiated gradually, incrementally mobilising the support of those individuals and organisations more favourable to such ideas. Corporations in the course of developing new products, for example, may voice the uncertainties they feel, stating that they want on the one hand to convey to their customers their evolving understanding of a product's complexities. While they are concerned about the risk of frightening and losing the potential customers, they make

it easier for the customers to admit that they might be frightened or confused by such an initiative – modelling an awareness and openness to theories-in-use that will help customers to surface problems and complexities.

There is no reason to believe that it is unproblematic to leap from a business and social world dominated by a commitment to rational problem solving and risk management to one that recognises the nature, importance and value of artistic problem setting and risk settlement. Expectations are not easily transformed, and the competencies for a reflective understanding and use of the 'colonisation as conversion process' framework are not acquired simply as a result of deciding to do so. Moreover, considerable work must be done in creating the conditions under which we increase the likelihood that practitioners and corporations will make such decisions. For every reflective practitioner, there are many other practitioners who are not willing to understand or would not be competent to exercise the kind of activities inherent in risk settlement. The level of antagonism and dogmatism that frequently exists among competing actors impedes such exercises.

6.3.1 Some Further Social Implications

If we recognise that professions, corporations and larger social systems may become reflective self-reforming agents in situations of uncertainty, then we need to argue for the recognition and development of a productive interaction between risk settlement and risk management, problem setting and problem solving, playful non-rationality and technical rationality, artistic intuition and applied scientific deduction, reciprocal reflection and instrumental functions. We then have to recast the conventional relationship between techno-scientific means and sociocultural ends, science and social progress, and above all risk management and the colonisation of the future.

From this perspective, coping with anxiety and ambiguity, and the ongoing conversion of uncertainty into packages of manageable problems is an embedded activity of professions, corporations, and larger social institutions with no *final settlement*.

'Colonisation as conversion' is an understanding and an acknowledged method of inquiry and interaction which, if explicitly acted upon, involves practitioners and corporations adopting a language and method of interaction very different from the understandings and forms of exchange advocated by the utopian methods of technical-scientific rationality. The protagonists do not merely apply science-based methods to well-defined tasks. They reveal an emotional and reciprocal way of transaction with problematic situations, and draw on their immediate reflection and experimentation as an aid to both understanding and changing the seemingly fixed conditions. Not only do they tend to question the frameworks and assumptions but they surface and inquire about the tacit principles and purposes embedded in the tasks with which they are engaged.

In so doing, they can neither maintain emotional detachment from the actors with whom they attempt to frame a common set of purposes nor can they maintain psychological distance from their repertoire of tools, schemes, and techniques they employ to frame the puzzling phenomena. This method of inquiry requires an emotional partnership of reflective protagonists determined to gain an inside view of the complex world of practice as it occurs in modern social institutions; a view that provides a more comprehensive understanding of practice than the rationalistic descriptions of prescriptive managerial rule following; a view that can contribute to the education of a more critical and reflective practitioners; a view that is held to be more pragmatically and existentially effective in creating successful practitioners and corporations, and more politically desirable in creating more reflective self-reforming human beings.

As such trends in education grow in importance and begin to occupy an acknowledged place of their own not only in the practices of corporations and professionals but also those of academic scholars and intellectuals, an increasingly valuable position will be given to an essentially primary activity and practical competency that has been considered peripheral under the realm of technical/scientific rationality. If this thesis in any way contributes to that end it will have served its purpose.

6.4 Afterword and Recommendations for Future Research

If we accept our principal thesis – that product innovation and risk settlement are both an iterative process involving the conversion of uncertainty into packages of manageable problems, namely manageable risks and rewards – then what follows for future research for further bridging theory and practice? What epistemology of practice do practitioners need in order to reflectively discuss and handle complexities of risk management and corporate innovation? What overarching method of inquiry is likely to be helpful to uncover further dimensions of colonisation as conversion process?

These questions bring us back to the problems with which I began my thesis. My argument about contemporary problems can be reformulated in terms of using this study as a lever to surface a loss. The metaphor that originally seemed to capture the nature of this loss is that embedded in the mythology of the Titanic – a case in which a behavioural world of technological hubris headed inevitably toward an eventual demise, with actors unable or unwilling to explore, experiment or enquire about their assumptions and governing variables, in short their traditional asocial epistemology.

This thesis is a personal attempt to argue that in the realm of technical/scientific rationality, practitioners, corporations and social systems lose in three ways. First, practitioners and corporations are incompetent in exercising double-loop learning: unable to reflect on the governing variables, meanings, assumptions, and values that not only shape their tasks but also their very personal theories-in-use. Second, this, in the long-term, has serious consequences for society as a whole given that such selective inattentions often result in destructive reflex knee-jerk type reactions in unsteady and uncertain situations. This impedes any discovery that changes in conditions which will influence our effectiveness in handling situations will be discovered and acted upon. Third, those theorists who are believed to be competent in systematic research on risk, risk management, and technological innovation will continue to exercise single-loop learning, producing techniques and theories that favour the

prevailing categories and classifications, rather than addressing the real and complex problems of reflective practice.

This triple loss reflects and reproduces the organised irresponsibility, boomerang effects, technological imbroglios, and dilemmas and discontinuities so well formulated by risk society authors.

What then is my conclusion? The colonisation as process model, invoking the notion of risk settlement and the four sets of activities that make it up, helps capture the key dynamics surrounding risk management in practice. This overarching model incorporates the issues addressed by the sociopolitical, cultural and psychological approaches to risk, and is subject to systematic repression and mythological justifications in modernist cultures and organisations. A commitment to reflective practice opens up a discussion around such issues, and all the technical and sociopolitical dilemmas that arise with it, and the role of this thesis is to provide just one lever for helping to raise such issues. It is hoped that the thesis legitimates and extends the understanding and exploration of risk management practice and addresses the broader sociopolitical dimensions of what is often presented as a sanitised, narrow technical and economic discipline.

What this all means to me, is a confluence of interweaving elements into a new method of inquiry – intuition, emotion, informal and playful (sometimes foolish) activity without having good reasons, politics, metaphorical inference, on-line improvisation, on-the-spot experiment and reflection, and of course logic – as a way of understanding what reflective practitioners (and here I include myself) do in practice and how to improve our 'dance on the feet of chance'.

A remaining issue around learning to 'dance on the feet of chance', however, concerns not only the *will* to confront chaos and confusion but also the *feel* for using a repertoire of images, schemes, tools, techniques, and theories as generative metaphors. In other words,

there are emotional undercurrents essential to dancing on the feet of chance. As Nietzsche (1976: 429) puts it:

> [courage] and adventure and pleasure in the uncertain, in the undared – courage seems to me man's whole prehistory.

What type of emotional openness and curiosity is necessary under conditions of uncertainty? What are the emotional bases that let some of us make sense of complexities and be fruitfully sensitive to what is happening in the existential here-and-now? What strength, courage and conviction does it take for people to put their necks (theories-in-use, behavioural world, and espoused theories) on the block, face fear of failure and toil with tricky, treacherous, and turbulent phenomena? How does one develop the will to meet fearful situations of radical uncertainty without defensiveness or projection? Such considerations lead to an inquiry well beyond the present one.

References

Abernarhy, W. and Utterback, J. (1978), 'Patterns of Industrial Innovation', *Technology Review*, 41-47

Abrahamson, E. (1991), Managerial Fads and Fashions: The Diffusion and Rejection of Innovations, *The Academy of Management Review*, Vol. 16, No. 3, pp. 586-612

Ackoff, R.L. (1979), The Future of Operational Research is Past, *The Journal of the Operational Research Society*, Vol. 30, No. 2

Adams, J. (1995), *Risk*, London: UCL Press

Adler, P. (1986), New Technologies: New Skills, *California Management Review*, Vol. 29, No., 1 pp.9-28

Adler, P. (1992), *Technology and the future of work.* New York: Oxford University Press

Allen Consulting Group (2005), *The Economic Impact of Cooperative Research Centres in Australia – Delivering Benefits for Australia*, A report for the Cooperative Research Centres Association Inc, prepared for the Dept. of Education, Science and Training, Insight Economics, Melbourne

Arendt, H. (1971), *The Life of the Mind*, Jovanovich, New York: Harcourt, Brace

Argyris, C. (2006), *Reasons and Rationalizations: The Limits to Organizational Knowledge*, Oxford University Press

Argyris, C. (1999), *On Organizational Learning*, Blackwell

Argyris, C. and Schön, D.A. (1974), *Theory in Practice: Increasing Professional Effectiveness*, San Francisco: Jossey-Bass Publishers

Argyris, C. and Schön, D.A. (1978), *Organizational Learning: A Theory of Action Perspective,* Reading, Mass.: Addison-Wesley Publishing Co.

Argyris, C. and Schön, D.A. (1996), *Organizational Learning II: Theory, Learning and Practice,* Reading, Mass.: Addison-Wesley Publishing Co.

Aristotle (2004), *Poetics*, Kessinger Publishing

Aronson, E. (1973), The Rationalizing Animal, *Psychology Today*, Vol. 6, No. 5, pp.46-52

Arthur D. Little, Global Innovation Excellence Study (2005) *Innovation as strategic lever to drive profitability and growth Rotterdam*

Ashby, W. R. (1960), *Design for a brain: the origin of adaptive behavior*, New York: Wiley

Ashley, D. and Orenstein, D. M. (2004), *Sociological Theory: Classical Statements*, Allyn & Bacon, Sixth edition

Bacharach, S.B. (1989), Organizational theories: Some criteria for evaluation. *Academy of Management Review*, vol. 14, no. 4, pp 496-515

Bacon, F. (1939), The Great Instauration and The Novum Organum in Burtt E. A*., The English Philosophers*, The Modern library

Badham, R. (1986) *Theories of industrial society,* St. Martin's Press New York

Badham, R. (2005), Technology and the transformation of work. In S. Ackroyd, R. Batt & P. Thompson (Eds), *Handbook of work and organization*, Oxford: Oxford University Press, 115–37.

Badham, R. and Jurgens, U. (1998), Images of good work and the politics of teamwork, *Economic and Industrial Democracy*, Vol. 19, pp 33-58.

Badham, R. and Garrety, K. (2003), Living in the blender of change: The carnival of control in a culture of culture. *Tamara,* 2(4), 22–38.

Badham, R. and Mathews, J. (1989), The new production systems debate. *Labour and Industry*, 2(2), 194–247.

Barley, S.R. (1986), Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments. *Administrative Science Quarterly*, 31, 78–108.

Bauman, Z. (1991), *Modernity and Ambivalence*, Polity Press

Bauman, Z. (2007), *Liquid Times: Living in an Age of Uncertainty*, Polity Press

Beck, U. (1992), *Risk Society: Toward a New Modernity*, London: Sage,

Beck, U., Giddens A. and Lash S., (1994), *Reflexive Modernization: Politics, Tradition and Aesthetics in Modern Social Order*, Polity Press: Cambridge, UK

Beck, U. (1999), *World Risk Society*, Polity Press: Cambridge, UK

Beck, U. (2006), Living in the world risk society, *Economy and Society* Vol. 35 No. 3 pp. 329- 345

Beck, U., Bonss W. and Lau Ch. (2003), *The Theory of Reflexive Modernization Problematic, Hypotheses and Research Programme*, Theory, Culture & Society 2003, SAGE, London, Thousand Oaks and New Delhi, Vol. 20(2): 1–33

Becker, C.L. (1932), *The Heavenly City of the Eighteenth-Century Philosophers*, Yale University Press

Ben-Daya, M. and Raouf, A. (1996), A revised failure mode and effects analysis model, *International Journal of Quality & Reliability Management*, Vol. 13 No. 1, 1996, pp. 43-47,

Benders, J., De Haan, J., and Bennett, D. (1995), *The symbiosis of Work and Technology*, London: Taylor and Francis

Bernstein, P.L. (1996) *Against the Gods: The Remarkable Story of Risk*, John Wiley and Sons, New York

Bernstein, R.J. (1979), *The Restructuring of Social and Political Theory*, Routledge

Bessant, J. and Tidd, J. (2007), *Innovation and Entrepreneurship*, John Wiley and Sons

Beynon, H. (1973), *Working for Ford*. London: Allen Lane

Bijker, W.E., Hughes, T.P. and Pinch, T.J. (Eds) (1987), *The social construction of technological systems: New directions in the sociology and history of technology*. Cambridge, MA: Cambridge University Press,

Bijker, W. (1995), *Of Bicycle, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change*, Cambridge, Mass: MIT Press

Blauner, R. (1964), *Alienation and Freedom*, University of Chicago Press

Blumer, H. (1986), *Symbolic Interaction: Perspective and Method*, University of California Press

Bohn, R. and Jaikumar, V. (2000) 'Stop Fighting Fires', *Harvard Business Review*, 78 (4): 82– 91.

Booz Allen Hamilton, (2007), The Global Innovation 1000, special report, issue 49, winter

Bradbury, J.A. (1989), The Policy Implications of Differing Concepts of Risk, *Science, technology, & human values*, Vol. 14, No. 4

Brunsson, N. (2006), *Mechanisms of Hope: Maintaining the Dream of the Rational Organization*, Copenhagen Business School Press

Bryman, (1988) *Designing Research in Organization.* London: Routledge

Bucciarelli, L.L. (1988), An Ethnographic Perspective on Engineering Design, *Design Studies*, 9(3): 159-168.

Bucciarelli, L.L. (1994), *Designing Engineers*. Cambridge: MIT Press

Buchanan, D. and Boddy, D. (1983), *Organisations in the computer age.* Aldershot: Gower,

Buchanan, D. and Badham, R. (2008), *Power, Politics, and Organizational Change: Winning the Turf Game,* Sage

Burns, T. and Stalker, G.M. (1961), *The Management of Innovation*, Oxford University Press, USA; Revised edition

Burns, R.B. (1994), *Introduction to research methods*. Melbourne: Longman Chesire

Burrell, D. and Hauerwas, S. (1977), From system to story: An alternative pattern for rationality in ethics, in *Knowledge, Value and Belief.* T. Engellhardt and D Callahan, eds. Pp. 111-152. Hastings-Hudson, NY: The Hastings Center

Burrell, G. and Morgan, G. (1979), *Sociological Paradigms and Organizational Analysis: Elements of the Sociology of Corporate Life*, Heinemann

Bury, J.B., (2004 org.1932), *The Idea of Progress*, Kessinger Publishing

Burtt, E.A. (1939), *The English philosophers from Bacon to Mill*, Michigan: The Modern library

Callon, M. (1980), The State of Technical Innovation - A Case Study of the Electrical Vehicle in France." *Research Policy*, 9: 358-376.

Callon, M. (1986), Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay. In John Law (ed.), *Power, Action and Belief: A New Sociology of Knowledge*, London: Routledge & Kegan Paul

Callon, M. (1991) 'Techno-economic networks and irreversibility.' pp. 132-165 in A Sociology of Monsters: Essays on Power, Technology and Domination, edited by John Law. London: Routledge

Campos, P., Lester, R. and Piore, M. (1999), *Organizational Integration in Situations of Uncertainty: A Case Study of MITRE Corporation*, MIT IPC Working Paper # 99-006

Cannon, W.B. (1939), *The wisdom of the body*, W.W. Norton & Company

Carr, E.H. (1986), *What is History*, Harmondsworth: Penguin

Casey, C. (1999), Come, join our family: Discipline and Integration in Corporate Organizational Culture, *Human Relations*, Vol. 52, No.2, pp.155-178

Cassirer, E. (1953), *Language and Myth*, Dover Publications; Dover Ed edition

Cassirer, E. (1968), *The philosophy of the enlightenment*, Princeton University Press

Checkland, P. (1981), *Systems Thinking*, Systems Practice, Wiley

Checkland, P. and Poulter, J., (2006), *Learning for Action: A Short Definitive Account of Soft Systems Methodology, and Its Use Practitioners, Teachers and Students*, John Wiley & Sons

Chiles, J.R. (2001) *Inviting Disaster: Lessons from the Edge of Technology*. New York: Harper Business

Christensen, C.M. (1999), *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Harvard Business School Press

Clark, J. (1995), *Managing innovation and change*. London: Sage,

Clark, N. (1985), *The political Economy of Science and Technology*, Blackwell: Oxford

Clark, K. and Wheelwright, S. C. (1992), *Managing New Product and Process Development: Text and Cases*, NY: Free Press

Clausewitz, C. (1976 org. 1832), *On war*, Princeton University Press

Clegg, S. and Bailey, J., (2007), *International Encyclopedia of Organization Studies*, Sage

Clegg, S., Courpasson, D. and Phillips N., (2006), *Power and Organizations*, Sage

Collins, D. (1998), *Organizational change: Sociological perspectives*. London: Routledge,

Collins, H., Pinch, T., (1998), *The Golem at Large: What You Should Know About Technology*, Cambridge University Press: Cambridge

Constant II, E.W., (1973), A Model for Technological Change Applied to the Turbojet Revolution, *Technology and Culture*, Vol. 14, No. 4, Oct 1973, pp 553-572

Constant, E. (1980), *The Origins of the Turbojet Revolution*. Baltimore, Johns Hopkins University Press.

Cooley, C.H., (1983), *Human Nature and the Social Order,* Transaction Publishers

Cooley, M. (1982), *Architect or bee: The human technology relationship.* London: Abacus

Coombs, R., Saviotti, P., Walsh, V., *Economics and Technological Change*, (1987), Rowman and Littlefield, New Jersey

Cooper, C.M. (1971), 'Science, Technology and Development', *Economic and Social Review*, Vol. 2. No 2, pp 165-189

Cooper, R.G. and Kleinschmidt, E.J. (1987), What separates winners from losers, *Journal of Product Innovation and Management*, 4, 169-184

Cooper, R.G. (1990), Stage-gate systems: A new tool for managing new products, *Journal of Business Horizons*, Vol. 33, 3, pp44-54

Cooper, R.G. (1993), *Wining at new products: Accelerating the process from idea to launch*, Reading. MA, Addison-Wesley

Cooper, R.G. (1994), Third-Generation New Product Processes, *Journal of Product Innovation Management*, Vol. 11, No. 1, pp. 3-14(12)

Cooper, R.G. (1999) From Experience, The invisible success factors in product development, *Journal of Product Innovation and Management*, 16,115-133

Cooper, R.G, Edgett, S.J. and Kleinschmidt, E.J. (2002), Optimizing the

Stage-Gate Process Product Innovation Best Practices Series What Best Practice Companies are Doing, *Research Technology Management,* Vol. 45, No. 5.

Couchman, P.K. and Fulop, L. (2002a). "Collaboration between divergent organizational cultures: perspectives on risk in cross-sector strategic R&D alliances". In D. Purdue & M. Stewart (eds.) *Understanding Collaboration: International Perspectives on Theory, Method and Practice*. Bristol: University of the West of England.

Couchman, P.K. and Fulop, L. (2002b). "The meanings of risk and interorganizational collaboration". In S. R. Clegg (Ed) *Management and Organization Paradoxes*. Amsterdam: John Benjamins

Couchman, P.K. and Fulop, L. (2004) Managing risk in cross-sector R&D collaborations: lessons from an international case-study, *Prometheus*, 22 (2): 151 - 167.

Couchman, P.K. and Fulop, L. (2005) Bringing Innovation to Centre Stage: The Rhetoric of Commercialisation and Cross-Sector Collaboration, Paper presented at the *11th APROS Colloquium*, Melbourne, Australia

Couchman, P.K. and Fulop, L. (2007), The Dance of Trust in High Risk Multi-Partner Collaborations: An Exploration of the Antecedents of Trust in Cross-Sector R&D Projects, Paper presented at the *23rd EGOS Colloquium*, Vienna, Austria

Crawford, C.M. (1977), *Marketing Research and the New Product Failure Rate*, Journal of Marketing, Vol. 41, No. 2. Apr. 77, pp. 51-61.

Crawford, C.M. (1987), 'New product failure rates: a reprise', *Research Management*, No. July-August, pp.20-4

Crawford, C.M. (1993), The hidden cost of APD, *Journal of Product Innovation and Management*, Vol. 9, p. 188-199

Czarniawska B. (2004), Narratives in social science research, Sage

Czarnitzki, D. and Kraft, K. (2008), On the profitability of innovative assets, *Applied Economics*, 1-13.

Davila, T., Epstein, M.J., and Shelton R. (2005), *Making Innovation Work: How to Manage It, Measure It, and Profit from it*, Wharton School publishing

Dawson, P. (1997) In at the deep end: Conducting processual research on organisational change. *Scandinavian Journal of Management*. 13(4): 389-405.

Dawson, P. (2003), *Reshaping change: A processual perspective.* London: Routledge

Dawson, P., Clausen, C. and Nielsen, K.T. (2000) Political processes in management, organization and the social shaping of technology, *Technology Analysis and Strategic Management*, Vol. 12, No. (1).

Denning, S. (2007), *The Secret Language of Leadership: How Leaders Inspire Action Through Narrative*, John Wiley and Sons

Denzin, N.K. and Lincoln, Y.S. (1994) Introduction: Entering the Field of Qualitative Research, in Denzin (Ed.) *Handbook of Qualitative Research*, Thousand Oak: Sage Publication.

Descartes, R. (2004 org. 1637), *Discourse on the Method of Rightly Conducting the Reason and Seeking Truth in the Sciences,* Kessinger Publishing

Descartes, R. (2004 org. 1644), *Principles of Philosophy,* Kessinger Publishing

Dewey, J. (1930), *The Quest for Certainty. A study of the relation of knowledge and action,* Southern Illinois University Press

Dewey, J. (1933), *How We Think*, revised edition, Southern Illinois University Press

Dewey, J. (1938), *Logic: The Theory of Inquiry*, Rinehart and Winston, New York: Holt

Dick, P. (2005), Dirty work designations: How police officers account for their use of coercive force, *Human Relations*, Vol. 58, No. 11

Diesing, P. (1971) *Patterns of discovery in social sciences*, Chicago, Aldine

Donaldson, L. (2001), *The Contingency Theory for Organizations*, Thousand Oaks: Sage

Dosi, G. (1982). Technological Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinant and Directions of Technical Change, *Research Policy*.

Dosi, G. (1984). *Technical Change and Industrial Transformation*. London, Macmillan.

Dosi G., Freeman, C., Nelson, R., Silverberg, G., and Soete, L., (1988), *Technical Change and Economic Theory*, Printer Publishers: London and New York

Douglas, M. (1966) *Purity and danger : an analysis of the concepts of pollution and taboo*. London, Ark, 1984.

Douglas, M. (1985) *Risk acceptability according to the social sciences*. London, Routledge & Kegan Paul, 1986.

Douglas, M. (1992) *Risk and blame* : essays in cultural theory. London, Routledge.

Douglas, M. and Wildavsky, A.B. (1982), *Risk and culture*: *an Essay on the selection of technological and environmental dangers,* Berkeley, CA: University of California Press

Drucker, P.F. (1992), *The Age of Discontinuity: Guidelines to Our Changing Society*, Transaction Publishers

Drucker, P.F. (1983), *Modern Prophets: Schumpeter or Keynes*? www.peterdrcuker.at

Dunphy, S.M., Herbig, P.R., and Howes, M.E., The innovation funnel, *Technological Forecasting and Social Change* Vol. 53, pp. 279-292

Edvardsson, B. (1992), Service Breakdowns: A Study of Critical Incidents in an Airline, *International Journal of Service Industry Management*, Vol. 3, No. 4, 17-29.

Edvardsson, B. and Roos, I. (2001), Critical Incident Techniques: Towards a Framework for Analyzing the Criticality of Critical Incidents, *International Journal of Service Industry Management*, Vol. 12, No. 3, pp. 251-68.

Ewald, F. (1991), Insurance and risks, in Burchell, G., Gordon, C. and Miller, P. (eds), The Foucault Effect: Studies in Governmentality. London: Harvester/Wheatsheaf pp.197-210

Falanagan, F.C. (1954), The Critical Incident Technique, *Psychological Bulletin*, Vol. 51, No.4

Ferm, V. (1950), *A History of Philosophical Systems*, 1st edition, The Philosophical Library

Fischler, R. (2009), *Reflective Practice*, Unpublished Paper

Fleck, J. (1995), Learning by trying: The implementation of configurational technology, in D. Mackenzie and Wajcman, *The social shaping of technology* (2nd edn), London: Open University Press

Flyvbjerg, B., Bruzelius, N., and Rothengatter, W., (2003) *Megaprojects and Risk: An Anatomy of Ambition,* Cambridge University Press

Forrestal, L., (2008), Change in Context, *Business Review Weekly (BRW)*, Vol. 30, No. 9, p.46

Foss, S.K. and Waters W. (2007), *Destination dissertation: a traveller's guide to a done dissertation*, Rowman & Littlefield

Foucault, M. (1984), The politics of health in the eighteenth century. In Rainbow P. (ed), *The Foucault Reader*. New York, Pantheon Books, pp. 273-89

Foucault, M. (1998), *The History of Sexuality Vol.1: The Will to Knowledge*, London: Penguin

Foucault, M. (2007), *Security, Territory, Population: Lectures at the College de France 1977-1978,* Palgrave Macmillan

France, A. (1918), *Le Petit Pierre,* University of Michigan Press

Freeman, C. (1974), *The Economics of Industrial Innovation*, Harmondsworth: Penguin

Freeman, C. (1991), The Nature of Innovation and the Evolution of the Productive System', in *Technology and Productivity: the challenge for economic policy,* Vol. 22, OECD Publishing: Pins

Freeman, R. (2006), Learning in Public Policy in Moran, M., Rein, M., Goodin, R., *The Oxford Handbook of Public Policy*, Oxford University Press

Freud, S. (1937). Analysis Terminable and Interminable. *International Journal of Psycho-Analysis*, Vol 18, 373-405

Fromm, E. (1994), *Escape from Freedom*, Owl Books; Owl Book Ed edition

Fukuyama, F. (1992), *The End of History and the Last Man*, Maxwell Macmillan, Canada

Fulop, L. (2002), *The Devil is in the Detail – Making Sense of Risk and Trust in University – Industry Partnerships*, Lecture delivered at Griffith University

Gabbott, M. and Hogg G. (1996), "The Glory of Stories: Using Critical Incidents to Understand Service Evaluation in the Primary Healthcare Context," *Journal of Marketing Management*, 12, 493-503.

Gabriel, Y. (2000), *Storytelling in Organizations*. Oxford: Oxford University Press

Galbraith, J.K. (1969), *The affluent society*, Houghton Mifflin

Gallie, D. (1978), *In search of the new working class: Automation and social integration within the capitalist firm*. Cambridge: Cambridge University Press,

Garfinkel, H. (1984), *Studies in ethnomethodology*, Wiley-Blackwell

Garrety, K. and Badham, R. (2003), User-centred design and the normative politics of technology, *Science, Technology and Human Values*, Vol. 29, No. 2, pp. 191–212.

Garrety, K. and Badham R. (1999), Trajectories, social worlds, and boundary objects: A framework for analyzing the politics of technology, *Journal of Human Factors and Ergonomics in Manufacturing*, Vol. 9, No. 3 , pp. 277 – 290

Garrety K. and Badham R. (2000), The Politics of Socio-technical Intervention: An Interactionist View, *Journal of Technology Analysis & Strategic Management*, Volume 12, No. 1

Garro L.C. and Mattigly C. (2000), Narrative as Construct and Construction, in C. Mattingly & and L.C. Garro (Eds), *Narrative and the cultural construction of illness and healing*, University of California Press

Gellner, E. (1972), *Thought and Change*, Weidenfeld and Nicolson, London

Giddens, A., (1985), *The nation-state and violence*, Cambridge: Polity Press

Giddens, A., (1999), *Risk and Responsibility*, Journal of The Modern Law Review Vol. 62, No. 1

Giddens, A., (2003), *Runaway World: How Globalization is Reshaping Our Lives*, Taylor & Francis

Gluck, F. and Foster, R., (1975), Managing technological change: A box of cigars for Brad, *Harvard Business Review*, Vol. 53, No. 5, p.139-150

Goffman, E., (1961), *Asylums: Essays on the Social Situation of Mental Patients and Other Inmates*, Anchor

Goffman, E., (1974), *Frame Analysis: An Essay on the Organization of Experience*, Harvard University Press

Goodman, N., (1978), *Ways of worldmaking*, Hackett Publishing

Gordon, C. (1991), Governmental rationality: an introduction. in Burchell, G., Gordon, C. and Miller, P. (eds), *The Foucault Effect: Studies in Governmentality*. London: Harvester/Wheatsheaf pp. 174-195

Gremler, D. (2004), The Critical Incident Technique in Service Research, *Journal of Service Research*, Volume 7, No. 1

Griffin, A. (1997), Modeling and measuring product development cycle time across industries, *Journal of engineering and technology management,* Vol. 14, No.1-24

Grimes, R.L. (2000), *Deeply Into the Bone: Re-inventing Rites of Passage*, University of California Press

Grint, K.,(1997), *Fuzzy Management: Contemporary Ideas and Practices at Work*, Oxford University Press

Grint, K. and Woolgar, S. (1997), *The machine at work: Technology, work and organization.* Cambridge: Polity Press

Habermas, J., (1971), *Knowledge and Human Interest*, London: Heinemann

Hainer, R.M. (1968) Rationalism, pragmatism and existentialism. In *The research society*, E. Glatt and M. W. Shelly, eds. NY: Gordon and Breach.

Hainer, R.M., Kingsbury S., and Gleicher D., (1967), *Uncertainty in Research, Management, and New Product Development*, Reinhold Publishing Corporation: New York

Hamel, G. and Prahalad C.K., (1990), *The Core Competence of the Corporation*, Harvard Business Review, 90 - May-June

Hamel, G. (2000), *Leading the revolution: how to thrive in turbulent times by making innovation a way of life,* Harvard Business School Press

Hammersley, M. (1992), *What's Wrong with Ethnography?* London: Routledge

Hammersley, M. and Atkinson, P. (1983), *Ethnography: Principles in Practice*. London: Tavistock.

Hannabuss S. (1996), Research Interviews, *New Library World*, Vol. 97, No. 1129, pp. 22–30

Haraway, D. (1991), *Simians, cyborgs, and women: The reinvention of nature.* London: Routledge,

Hatab, L.J. (2005), *Nietzsche's Life Sentence: Coming to Terms with Eternal Recurrence*, London: Routledge

Hayes, R. H. (1981), Why Japanese Factories Work, *Harvard Business Review,* pp.57-65.

Hegel, G. W. F. (2001 org. 1837), *The philosophy of history*, Batoche Books, Kitchener

Hepburn, R. W. and Murdoch, I., (1956), Symposium: Vision and choice in morality. *Proceedings of the Aristotelian Society*, Dreams and Self-Knowledge, Vol. 30, pp.14-58

Herrmann, J.W. (2004), Decomposition in Product Development, University of Maryland Working paper # TR 2004-6, accessed at http://www.isr.umd.edu

Herzberg, T. (2006) Towards a Mid-Range Theory of Method Selection for Innovation Pre-project Activities, PhD Thesis, Cranfield University

Hesse, H. (1969), *The Glass Bead Game*, Bantam Books, New York, NY

Hobday, M. (2005), Firm-level Innovation Models: Perspectives on Research in Developed and Developing Countries, *Technology Analysis & Strategic Management*, Vol. 17, No. 2, 121–146

Hoffmann, H. and Wynne, B. (2002), *In risk assessment, one has to admit ignorance*, Nature 416, 123

Hagedoorn, J. (1989), *The Dynamic Analysis of Innovation and Diffusion: A Study in Process Control*, Pinter Publishers

Hopkins, A. (1999), The limits of normal accident theory, Safety Science, 32, 93-102

Hyman, R., and Streeck, W. (1988), *New Technology and Industrial Relations*, Oxford: Basil Blackwell

James, W. (1953), The Power and Limitations of Science in '*The Philosophy of William James*', Random House

Janesick, V.J. (1994) The Dance of Qualitative Research Design: Metaphor, Methodolatry and Meaning, in Denzin (Eds.) *Handbook of Qualitative Research*, Thousand Oak: Sage Publication.

Kahneman, D. and Slovic, P. (1982). *Judgment under uncertainty: heuristics and biases*. Cambridge, Cambridge University Press.

Kaplan, A. (1964) *The conduct of inquiry*, New York, Harper & Row

Katz, R. et al. (2003), *The human side of managing technological innovation*, Oxford University Press

Kern H., and Schumann, M. (1984), *Das Ende der Arbeitsteiung? Rationalisierung in der Industriellen Produktion*, Munich: Beck

Keynes J. M. (1970), *The General Theory of Employment Interest and Money*, London: Macmillan

Kim W. C., Mauborgne R. (2005), *Blue Ocean Strategy*, Harvard Business School Press

King, N. and Anderson, N. (2002), *Managing Innovation and Change: A Critical Guide for Organizations*, London: Thomson

Kirk, J. and Miller, M.L. (1986), *Reliability and Validity in Qualitative Research.* Beverly Hill: Sage Publications

Knight, F.H. (1935), *The ethics of competition and other essays*, Allen and Unwin.

Knight, F.H. (2006 org. 1921), *Risk, uncertainty and profit*, Mineola, NY, Dover Publications.

Knights, D. and Murray, F. (1994), *Managers divided: Organization politics and information technology management*. Chichester: Wiley

Koen, B.V. (2003), *Discussion of the Method of Rightly Conducting the Engineers' Approach to Problem Solution*, Oxford University Press

Koestler, A. (1964), *The Act of Creation: A Study of Conscious and Unconscious in Science and Art*, Dell Publishing New York

Kohler, W. (1947), *Gestalt psychology*, New York, Liveright

Krishnan V., Eppinger S., Whitney D., (1997) A model-based framework to overlap product development activities, Journal of Management Science Vol. 43, No. 4

Kuhn T. (1996 org. 1970), *The Structure of Scientific Revolutions*, University Of Chicago Press; 3rd edition

Landes, D. (1969), *The Unbound Prometheous: Technological Change and Industrial Development in the Western World from 1750 to the present*, Cambridge University Press

Lash S. (2003), Reflexivity as Non-Linearity, *Theory, Culture & Society*, Vol. 20(2): 49–57

Latour, B. and Woolgar, S. (1979). *Laboratory Life: The Social Construction of Scientific Facts*, Beverly Hills, Sage Publications.

Latour, B. (1987), *Science in Action - How to Follow Scientists and Engineers Through Society*. Milton Keynes, Open University Press.

Latour, B. (1996). *Aramis, or the Love of Technology*. Cambridge, Harvard University Press.

Latour, B., (1993), *We Have Never Been Modern*. Brighton: Harvester Wheatsheaf

Latour, B. (2002), Morality and Technology: The End of the Means'. *Theory, Culture and Society* 19: 247-60

Latour, B. (2003), Is Re-modernization Occuring-And If So, How to Prove It? A commentary no Ulrich Beck, *Journal of Theory, Culture & Society*, Vol. 20(2): 35-48

Latour, B. (2005), *Reassembling the Social: An Introduction to Actor-Network-Theory,* Oxford University Press, USA

Law, J. and Callon, M. (1992), The Life and Death of an Artifact: A network Analysis of Technical Change, *Shaping Technology/Building society: Studies in Sociotechnical Change*, Edited by Bijker W., Law J., Cambridge, Mass: MIT Press

Lawson, T. (1985), Uncertainty and Economic Analysis, *The Economic Journal*, 95, 909-927

Layard, R. (2009), *A Good Childhood: Searching for Values in a Competitive Age*, Penguin

Laybourne, S. (2006), Improvisation within the Project Management of Change: Some Observations from UK Financial Services, *Journal of Change Management* Vol. 6, No. 4, pp. 365-381

Leonard-Barton, D. (1995), *Wellspings of knowledge: Building and sustaining the sources of innovation*, Boston, MA: Harvard Business School Press, 1995.

Lester, R.K., Piore M.J. and Malek K. (1998), Interpretive Management: What General Managers Can Learn from Design, *Harvard Business Review*, March- April, pp. 86-96

Lester, R.K. and Piore M.J. (2004), *Innovation: The Missing Dimension*. Cambridge, Mass.: Harvard University Press

Lewin, K. (1947), Frontiers in Group Dynamics: Concept, Method and Reality in Social Science; Social Equilibria and Social Change, *Human relations*, Vol. 1, No. 1, pp. 5-41

Lewit, B., and March J. G., (1988), Organizational Learning, *Annual Review Sociology*, Vol. 12, pp 319-340

Lindblom, C.E. (1959), The Science of Muddling Through, *Public Administration Review* 19:79–88.

Lindblom, C.E., (1979), Still Muddling Not Yet Through, *Public Administration Review*, Vol. 39 Issue 6, p517

Lindblom, C.E., (1987), Alternatives to validity. Some thoughts suggested by Campbell's guidelines in: *Knowledge creation, diffusion, utilization*, Vol. 8, pp 509-520

Loewenstein, G. F., (2001), Risk as Feelings, *Psychological Bulletin*, Vol. 127, No. 2, 267-286

Luhmann, N. and Barrett R., (1993), *Risk: A Sociological Theory*, Walter de Gruyter

Lupton, D. (1999a), *Risk*, London; New York: Routledge.

Lupton, D. (1999b), *Risk and sociocultural theory: new directions and perspectives*. Cambridge: Cambridge University Press.

MacKenzie D., (1993), *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*, Cambridge, Mass: MIT Press

MacKenzie D., (1996), *Knowing Machines*: *Essays on Technical Change*, Cambridge, Mass: MIT Press

MacKenzie, D. and Wajcman, J. (1985), *The social shaping of technology*, 1st edn. Milton Keynes: Open University Press

MacKenzie, D. and Wajcman, J. (1999) *The social shaping of technology*, 2nd edn. Milton Keynes: Open University Press

Mahajan, V., Muller, E. and Wind Y., (2000), *New-product Diffusion Models*, Springer

Mahdi, S., (2003), Search strategy in product innovation process, *Industrial and Corporate Change*, Vol. 12, No. 2, pp 235-270

Malinowsky, B. (1954; orig. 1926), *Myth in Primitive Psychology*, London: Kegan Paul.

Mangham, I.L. and Overington M. A., (1987), *Organizations as theatre: A social psychology of dramatic appearances*, John Wiley & Sons

March, J., (1978), **'**Bounded Rationality, Ambiguity, and the Engineering of Choice', *The Bell Journal of Economics*, Vol. 9, No. 2 (Autumn,), pp. 587-608

March, J.G. (1991), Exploration and exploitation in organizational learning, *Organization Science,* 2: 71–87.

March, J.G. (2006), Rationality, Foolishness, and Adaptive Intelligence, *Strategic Mgmt. Journal.*, 27: 201–214

March, J.G. and Olson, J.P. (1983), Organising Political Life: What Administrative Reorganisation tells us about Government, *American Political Science Review*, 77(2): 281-296.

March, J.G. and Weil, T. (2005), *On Leadership*, Blackwell

Marglin, S. (1976) 'What do bosses do?, in A. Gorz, *Division of Labour*, London Macmillan

Martin, J. (1992), *Cultures in Organizations: Three Perspectives* by Joanne Martin, Oxford University Press

Mathias, P., (1972), *Science and Society 1600-1900*, Cambridge University Press

Mattingly, C. (1991a), Narrative reflections on practical actions, In Schön D., (Ed.), *The reflective turn: Case studies in and on practice*. New York: Teachers College Press

Mattingly, C., (1991b), The narrative nature of clinical reasoning, *The American Journal of Occupational Therapy*, Vol. 45, No. 11

Mattingly, C. (1998), In search of the good: Narrative reasoning in clinical practice, *Medical Anthropology Quarterly*, Vol. 12, No. 3

Mattingly, C., and Lawlor, M. (2000), Learning from stories, Narrative interviewing in cross-cultural research, *Scandinavian Journal of Occupational Therapy*, Vol. 7, pp. 4-14

Maylor, H., et al. (2006) From projectification to programmification, *International Journal of Project Management* , Vol. 24, pp. 663–674

McLoughlin, I. (1999), *Creative technological change: The shaping of technology and organization*, London: Routledge,

McLoughlin., I. and Badham, R. (2005a), The three dimensions of e-government. Paper presented to the 21st Annual EGOS Colloquium, Berlin, July/August

McLoughlin, I. and Badham R. (2005b), Political process perspectives on organization and technological change, *Human Relations*, Vol. 58, No.7, pp. 827–843

McLoughlin, I., Badham, R. and Couchman, P. (2000), Rethinking political process in technological change: Sociotechnical configurations and frames. *Technology Analysis and Strategic Management*, 12(1), 17–38.

McLoughlin, I. and Dawson P. (2003), The mutual shaping of technology and organisation: 'Between cinema and a hard place', in D. Preece and J. Laurila (eds), *Technological Change and Organizational Action,* London, Routledge.

McLoughlin, I., Koch, C. and Dickson, K. (2001), What's this tosh? Innovative networks and new product development as a political process, *International Journal of Innovation Management*, Vol. 5, No. 3, pp. 275–98.

McLuhan, M. (1967) *The Medium is the Massage: An Inventory of Effects*, New York: Bantam

McLuhan, M. (1964*) Understanding Media: The Extensions of Man*, Routledge, London

Meek, R. (1973) *Turgot on Progress, Sociology and Economics*, Cambrdige University Press, Cambrdige

Merton, R.K. (1968) *Social theory and social structure*, New York, Free Press

Michel, S. (2001), Analyzing Service Failures and Recoveries: A Process Approach, *International Journal of Service Industry Management*, Vol. 12, No.1, pp. 20-33

Miles, M.B. and Huberman, A.M. (1994) *Qualitative data analysis: An expanded sourcebook* (2nd ed.) Thousand Oaks: Sage

Morgan, G. (1997), *Images of Organization*, Sage Publications, Inc; 2nd edition

Morgan G. and Sturdy A. (2000), *Beyond Organizational Change: Structure, Discourse and Power in UK Financial Services*, Palgrave Macmillan

Moore, W.E. (1972), *Technology and social change*, Chicago, IL: Quadrangle,

Morison, E. (1966), *Men, machines, and modern times*, MIT press

Mumford, L. (1934), *Technics and Civilization*, London: Routledge

Murray, R. (1972), Underdevelopment, International Firms and International Division of Labor in Society for International Development, *Towards a New World Economy*, Rotterdam University Press pp.161-247

Nadesan M.H. (2008), *Governmentality, Biopwer, and Everyday Life*, Routledge

Nietzsche, F. (1873-1875), Thus Spoke Zarathustra, in '*The Portable Nietzsche*', in Kaufmann, Walter, (1976), Penguin Press

Nietzsche, F. (1873), On Truth and Lie, in '*The Portable Nietzsche*', in Kaufmann, Walter, (1976), Penguin Press

Nietzsche, F. and Breazeale D., (1979), *Philosophy and Truth: Selections from Nietzsche's Notebooks of the Early 1870's,* Humanities Press

Nisbet, R. (1994), *History of the Idea of Progress*, Transaction Publishers; 2Rev Ed edition

Noble, D. (1984) *Forces of Production,* New York: Monthly Review Press

Noble, D. (1997) *The Religion of Technology: The Divinity of Man and the Spirit of Invention,* Penguin

Nelson, R. (1994) The Co-evolution of Technology, Industrial Structure, and Supporting Institutions, *Industrial and Corporate Change*, Vol 3 (1)

Nelson, R.R. and Rosenberg N. (1993 org.1983), Technical Innovation and National Systems', in R Nelson (ed), National lnnmatum Spurns: A Comparative Study, Oxford University Press: New York, NY.

Nelson, R.R. and Winter, S.G. (1977), *In search of useful Theory of Innovation*, Research Policy 6, 36-76

Nelson, R.R. and Winter S.G. (1982), An Evolutionary Theory of Economic Change, Harvard University Press: Cambridge, MA.

Nelson, R.R. and Winter S.G., (2002), Evolutionary Theorizing in Economics, *Journal of Economic Perspectives*, Vol. 16, No. 2, pp 23-46

Ogburn, W. (1964), The culture lag. In O.D. Duncan (Ed.), *On culture and social change*. Phoenix, AZ: University of Chicago Press, pp. 45–63.

Olsen, M.J. and Thomasson B., (1992), "Studies in Service Quality with the Aid of Critical Incidents and Phenomenography," in QUIS 3: Quality in Services Conference, Eberhard E., Edvardsson B., Lascelles D., and Little C. H., eds. Jamaica, NY: *International Service Quality Association*, 481-505.

Orlikowski, W.J. (1992), *The Duality of Technology: Rethinking the Concept of Technology in Organization*, Journal of Organization Studies, 3/3: 398-427

Orlikowski, W.J. (2000), Using Technology and Constituting Structures: A Practice Lens for Studying Technology in Organization, *Journal of Organization Science*, Vo. 11, No. 4, pp.404-28

Orlikowski, W. and Gash, D.C. (1994), Technological frames: Making sense of information technology in organizations. *ACM Trans. Inform. Systems*, 2(2), 174–207.

Parker, S. and Wall, T. (1998), *Job and work design: Organizing work to promote well-being and effectiveness*. Thousand Oaks, CA, London and New Delhi: Sage

Patton M.Q. (2002), *Qualitative Research and Evaluation Methods*, (eds). London: Sage

Pavitt, K. and Worboys (1977), Science, Technology and the Modern Industrial State, London: Butterworth

Perrow, C. (1999). *Normal Accidents: Living with high-risk technologies*; Princeton University Press.

Peters T.J., Austin, N., (1985), *A passion for excellence: the leadership difference*, University of Michigan Press

Peters T.J., Waterman R.H. (1985), *A passion for excellence*, AMR/Advanced Management Reports

Pettigrew, A.M. (1990) Longitudinal Field Research on Change: Theory and Practices, *Organization Science*, Vol. 1, No. 3, pp. 267-292.

Pettigrew, A.M. (1997) What is a Processual Analysis? *The Scandinavian Journal of Management*, Special Issue: Reflections of Conducting Processual Research on Management and Organizations, Vol. 13, No. 4, pp. 337-348.

Philips, A. (1971) *Technology and Market Structure*, Lexington: Lexington Books

Pidgeon, N. (1997), The Limits to Safety? Culture, Politics, Learning and Man-Made Disasters, *Journal of Contingencies and Crisis*, Vol. 5, No. 1

Pinch, T. and Bijker, W. (1987), *The Social Construction of Technological Systems*, Cambridge, Mass: MIT Press

Piore, M.J., Lester, R. K. and Malek K. M. (1995), *Case Studies in the Organization of Product Development: The Cellular Telephone Equipment Industry*, Industrial Performance Center Working Paper, MIT, Cambridge, MA

Piore, M.J., Lester R.K. , Kofman, F., Malek, K. M. (1994), The Organization of Product Development, *Industrial and Corporate Change*, Vol. 3, No.2

PMBOK: *A Guide to the Project Management Body of Knowledge*, Third Edition (PMBOK Guides) by Project Management Institute, (2004), 3rd edition

Polanyi, M. (1998 org.1958), *Personal Knowledge: Towards a Post-critical Philosophy*, Routledge

Polanyi, M. (1966) The Logic of Tacit Inference*, Philosophy*, Vol. 41, No. 155, pp. 1-18

Polanyi, M. (1966) *The tacit dimension*. Garden City, NY: Doubleday.

Popper, K. (1968), *Conjectures and Refutations*, New York: Harper and Row

Popper, K. (1971), *The Open society and its enemies*, Princeton University Press

Porter, M.E. (1990), *The Competitive Advantage of Nations*, Macmillan: London

Power, M. (2004). *The risk management of everything: rethinking the politics of uncertainty*. London, Demos.

Power, M. (2007), *Organized uncertainty: designing a world of risk management*, Oxford University Press.

Reason, J.T. (1997), *Managing the Risks of Organizational Accidents*, University of Michigan Press

Reddy, S.G. (1996), Claims to expert knowledge and the subversion of democracy: the triumph of risk over uncertainty, *Economy and Society*, Vol. 25, No. 2, pp 222 - 254

Repenning, N.P. (2001), Understanding fire fighting in new product development, The *Journal of Product Innovation Management,* Vol. 18, p. 285–300

Richmond, J. (1998), A life of reflection: remarks in memory of Donald Schön, *Journal of Planning Literature*, Vol. 13, No. 1, 3-10

Ricoeur P. (1984), *Time and narrative*. Vol. 1, Chicago: University of Chicago Press

Ritzer, G. (1996), *The McDonaldization of Society*, Thousand Oaks, California: Pine Forge.

Robinson, J. (1983), *Economic Philosophy*, Harmondsworth: Penguin

Rogers, E.M. (1995*), Diffusion of Innovation,* (4th Edition) New York, Free Press

Rosenberg, N. (1976), '*Perspectives on technology'*, Cambridge University Press

Runkel, P.J. and Runkel, M. (1994) A guide to usage for writers and students in the social sciences. Totowa, N.J., Rowman and Allanheld

Sahal D. (1985), Technological guideposts and innovation avenues, *Research policy*, Vol. 14, Issue 2, pp. 61-82

Schilling M.A., (2005), *Strategic Management of Technological Innovation*, McGraw Hill/Irvin

Schmidt, M.R. (2000), You know more than you can say: In memory of Donald A. Schön (1930-1997), *Public Administration Review*, 60(x): 266-75.

Schneiderman, A. M., (1998), Are there limits to Total Quality Management? *Measuring Business Excellence*, Vol. 2, No.2

Schön, D.A. (1958), Ultimate Rules and the Rational Settlement of Ethical Conflicts, *Philosophy and Phenomenological Research*, Vol. 19, No. 1

Schön, D.A. (1963), Champions for radical new inventions, *Harvard Business Review*, Vol. 41, No 2. pp. 77- 86

Schön, D.A. (1963), *Displacement of Concepts*, London: Tavistock Publications

Schön, D.A. (1967), *Technology and Change: The new Heraclitus*, Pergamon Press: Oxford

Schön, D.A. (1971), *Beyond the Stable State: Public and Private Learning in a Changing Society*, London: Temple Smith.

Schön, D.A. (1975), Deutero-learning in organizations, *Organisational Dynamics*, No. 2, pp.1-16

Schön, D.A. (1978), "Generative Metaphor: A Perspective on Problem Setting in Social Policy," in *Metaphor and Thought*, A. Ortony, ed. (Cambridge: Cambridge University Press), pp. 254-283.

Schön, D.A. (1982), Some of What a Planner Knows: A Case Study of Knowing- in-Practice, *Journal of the American Planning Association*, 48(x): 351-364.

Schön, D.A. (1983), *The Reflective Practitioner: How Professionals Think in Action* (New York: Basic Books).

Schön, D.A. (1984), "The Architectural Studio as Exemplar of Education for Reflection-in-Action, *Journal of Architectural Education*, 38(1): 2-9.

Schön, D.A. (1985), *The Design Studio: An Exploration of Its Traditions and Potentials* (London: RIBA Publications).

Schön, D.A. (1986), "Towards a New Epistemology of Practice," in Barry Checkoway, ed., *Strategic Perspectives on Planning Practice*, Lexington, Mass.: Lexington Books, pp. 231-250.

Schön, D.A. (1987), Educating t*he Reflective Practitioner: Toward a New Design for teaching and Learning in the Professions*, San Francisco: Jossey-Bass.

Schön, D.A. (1988), "Toward a Marriage of Artistry & Applied Science" in the *Architectural Design Studio Journal of Architectural Education*, Vol. 41, No. 4

Schön, D.A. ed. (1991), *The Reflective Turn: Case Studies In and On Educational Practice*, New York: Teachers College, Columbia University.

Schön, D.A. (1992), The Theory of Inquiry: Dewey's Legacy to Education, *Curriculum Inquiry*, Vol. 22, No. 2. , pp. 119-139.

Schön, D.A. (1994), An Autobiographical Note, *Planning Theory*, Vol. 12, pp. 37-52

Schön, D.A. (1995), Educating the Reflective Legal Practitioner, *Clinical Law Review*, Vol. 2 pp. 231-250

Schön, D.A. and Rein, M. (1994), *Frame Reflection: Toward the Resolution of Intractable Policy Controversies*, New York: Basic Books.

Schroeder, R. G., Van de Ven, A. H., Scudder, G. D. and Pooley, D. (2000), The development of innovation ideas In A.H. Van de Ven et al., *Research on the management of innovation: The Minnesota studies* pp.107-134, New York: Oxford University Press

Schumpeter, J.A. (1912), *The Theory of Economic Development*, Oxford University Press, Oxford

Schumpeter, J.A (1942) *Capitalism, Socialism and Democracy* (Harper and Row, New York,

Schwab, D.P. (1980), Construct validity in organizational behavior in Staw, BM., Cummings L.L. (ed): *Research in organizational behavior*, vol. 2, Greenwich, CT (AI Press) 1980. S 3-43

Scudder, G.D., Schroeder, R. G., Van de Ven, A. H., Seiler, G.R., Wiseman R.M., (2000), Managing Complex innovations: The case of defense contracting, in A.H. Van de Ven et al., *Research on the management of innovation: The Minnesota studies* pp.401-437, New York: Oxford University Press

Selznick P. (1992), *Moral Commonwealth - Social Theory and the Promise of Community: Social Theory and the Promise of Community*, University of California Press

Shaiken, H., (1985), *Work transformed*, New York: Holt, Rinehart and Winston

Shiller, R., J. (2008), *The subprime solution: how today's global financial crisis happened, and what to do about it*, Princeton University Press

Silverman, D. (1993) *Interpreting Qualitative Data: Methods for Analyzing Talk, Text and Interaction.* London: Sage Publication.

Simon, H.A. (1957). A Behavioral Model of Rational Choice, in *Models of Man, Social and Rational: Mathematical Essays on Rational Human Behavior in a Social Setting*, New York: Wiley

Simon, H. (1969), *The sciences of the artificial*, M.I.T. Press.

Simon, H.A. (1982). *Models of Bounded Rationality*, volume 2. Cambridge, Mass.: MIT Press.

Smith, P. and Reinertsen D.G. (1997), *Developing the Products in Half the Time: New Rules, New Tools*, John Wiley and Sons

Smith, P. and Merritt G.M. (2003), *Proactive Risk Management: Controlling Uncertainties in Product Development*, Productivity Press

Stacey, R.D. (2002), Organizations as Complex Responsive Processes of Relating, *Journal of Innovation Management*, Volume 8 Number 2

Stake, R.E. (1994) Case Studies, in Denzin (Ed.) *Handbook of Qualitative Research, Thousand* Oak: Sage Publication.

Stauss, B. and Mang, P. (1999), Culture Shocks' in Inter-Cultural Service Encounters?, *Journal of Services Marketing*, Vol. 13 No. 4/5, pp. 329-46.

Stauss, B., and Weinlich, B. (1997), Process-Oriented Measurement of Service Quality: Applying the Sequential Incident Technique, *European Journal of Marketing*, Vol. 31, No. 1, 33-55.

Storey, J. (1992), *Development in Management of Human Resources*, Oxford: Blackwell

Storey, J. and Salaman, G. (2005), Managers of Innovation: Insights Into Making Innovation Happen, Blackwell Publishing

Strauss, A.L. and Corbin J. L., (1998), *Basics of Qualitative Research,* London: Sage

Suarez, F. and Utterback J.M. (1995), Dominant Designs and the Survival of Firms, *Strategic Management Journal*, Vol. 16, No. 6, pp. 415-430.

Sullivan, H. S. and Cohen, M.B. (1965), *The Collected works of Harry Stack Sullivan*, 2 vol. W. W. Norton & Co.: New York.

Sutton, R. and Staw, B.M. (1995), What theory is not, *Administrative Science Quarterly*, no. 40, pp 371-384

Sztompka, P. (1994), *The Sociology of Social Change*, Blackwell Publishing

Tabrizi, B. and Walleigh, (1997), Defining Next Generation of Products, *Harvard Business Review*, Dec

Taleb, N. (2007), *The Black Swan: The Impact of the Highly Improbable*, Allen Lane

Tawney, R. H. (1926), *Religion and the Rise of Capitalism: A Historical Study*, John Murray

Teece, D., (2003), *Essays in Technology Management and Policy,* World Scientific Publishing Company; 1st edition

Thomas, R. J. (1994), *What Machines Can't Do: Politics and Technology in the Industrial Enterprise*, Berkeley and Los Angeles, University of California Press

Thomke, S. and Von Hippel, E. (2002), *Customers as innovators: a new way to create value*, Harvard Business Review, April, Harvard

Tidd, J., Bessant, J., and Pavitt, K. (2006) *Managing Innovation: Integrating Technological Market and Organizational Change,* John Wiley and Sons

Toynbee, A.J. (1963), Sorokin philosophy of history, in P.J., Allen, *Pitirim A. Sorokin in Review*, pp 67-94, Durham NC: Duke University Press

Tulloch, J. and Lupton D., (2003), *Risk and everyday life*, London ; Thousand Oaks, Sage Publications.

Tushman, M, and Anderson P., (2004), *Managing Strategic Innovation and Change: A Collection of Readings,* Oxford University Press

Tushman, M., and Nadler, D., (1986), Organizing for innovation, *California Management Review*, Vol. 28, Issue 3, pp74-92

Tversky, A. and Kahneman D. (1974), Judgment under Uncertainty: Heuristics and Biases, Science, New Series, Vol. 185, No. 4157, pp. 1124-1131

Ulrich, K.T., Krishnan, V. and Eppinger, S. (1993), Including the Value of Time in Design-for-Manufacturing Decision Making, *Management Science*, Vol. 39, No. 4, pp. 429-447

Ulrich, K.T. and Eppinge,r S.D., (2004), *Product Design and Development*, Third Edition, McGraw Hill

Utterback, J., M. (1971), The Process of Technological Innovation Within the Firm, *Academy ot Management Journal,* Vol. 14, No. 1, pp. 75-88

Utterback, J. M., and Suarez F., (1993), Innovation, Competition, and Market Structure, *Research Policy*,

Van de Ven, A.H., Polley D.E., Garud R., Venkataraman S. (1999), *Innovation Journey*, Oxford University Press, USA

Van de Ven, A.H., Poole M.S., Angle H.A., (2000), *Research on the management of innovation: the Minnesota studies,* Oxford University Press, USA

Van Gennep, A., Vizedom M. and Caffee G. L. (2004), *The Rites of Passage*, Routledge

Van Maanen, J. Beyond account: The personal impact of police shootings, *The Annals of the American Academy of Political and Social Science*, 1980, 452, 145–56.

Vaughan, D. (1996), *The Challenger Launch Decision: Risky Technology, Culture and Deviance at NASA*. Chicago, Ill.: University of Chicago Press, 1996

Vlaar, P. W.L., Van Den Bosch F. A.J., and Volberda H. W., (2007), Towards a Dialectic Perspective on Formalization in Interorganizational Relationships: How Alliance Managers Capitalize on the Duality Inherent in Contracts, Rules and Procedures, Organization Studies 28 (04): 437–466

Von Hippel, E., (1986), *Lead users: a source of novel product concepts,* Journal of Management Science, Volume 32, Issue 7, Pages: 791 - 805

Von Hippel, E. (1994), Sticky Information and the Locus of Problem Solving: Implications for Innovation, MIT Sloan School of Management Working Paper Published in *Management Science* Vol. 40, no.4: pp 429-439

Wajcman, J. (1991), *Feminism Confronts Technology*, University Park: Penn State University Press

Walker, N. (1956), Freud and Homeostasis, *The British Journal for the Philosophy of Science*, Vol. 7, No. 25, Sigmund Freud Centenary., pp. 61-72

Walker, S. and Truly E. (1992), The Critical Incidents Technique: Philosophical Foundations and Methodological Implications, in American Marketing Association Winter Educators' Conference Proceedings: *Marketing Theory and Applications*, Vol. 3, Chris T. Allen and Thomas J. Madden, eds. Chicago: American Marketing Association, 270-75.

Weber, M. (1974), *The Protestant Ethic and the spirit of Capitalism*, London: Allen and Unwin

Weber, R. P. (1985), *Basic Content Analysis*. London: Sage

Weick, K.E. (1989), Theory construction as disciplined imagination *Academy of Management Review*, vol 14, no 4, pp 516-531

Weick, K.E. (1995), *Sensemaking in Organizations*, Sage Publications, Thousand Oaks, California.

Weick, K.E. and Sutcliffe K., (2001), *Managing the Unexpected: Assuring High Performance in an Age of Complexity*, Jossey-Bass

Weick K., (2000), *Making Sense of the Organization*, Wiley

Weick, K., (2002), Leadership When Events Don't Play by the Rules, *Reflections*, vol. 4, No. 1

Weick, K. (2005), Organizing and the Process of Sensemaking, *Organization Science*, Vol. 16, No. 4, pp. 409–421

Wertheimer, M. (1959; orig. 1944), *Gestalt Theory*, New York: Hayes Barton.

Wheelwright S.C., Clark K.B., (1992), *Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency, and Quality*, Free Press: New York

Wheelwright S.C., Clark K.B., (1995), *Leading Product Development*, Free Press: New York

Wilkinson, B. (1983), *The Shopfloor Politics of New Technology*, London: Heinemann

Whitehead, A.N. (1925), *Science and the modern world*. New York: Macmillan

Whitney D.E., (1988), Manufacturing by design. *Harvard Business Review,* (1988), pp. 83–91

Whittle A. and Spicer A., (2005), *Why Organization studies should resist translation by Actor-Network Theory,* 21st EGOS Colloquium, Berlin

Williamson, O.E. (1975), *Markets and Hierarchies: Analysis and Antitrust Implications*, Free Press, New York.

Williamson, O.E. (1985), *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*, Free Press, New York.

Williamson, O.E. (1989) *"Transaction Cost Economics" in Handbook of Industrial Organization*, Volume 1, Ed. by Richard Schmalensee and R.D. Willig, Elsevier Science, New York.

Williamson, O.E. (1991), *Comparative Economic Organization: The Analysis of Discrete Structural Alternatives*, in Administrative Science Quarterly, 36, pgs. 269-296

Williamson, O.E. (1996), *Mechanisms of Governance*, Oxford University Press, New York.

Winner, L. (1977), Autonomous technology: Technics-out-of-control as a theme in political thought. Boston, MA: MIT

Wittgenstein, L. (1953), *Philosophical investigations*, New York,, Macmillan.

Wittgenstein, L., Anscombe, G.E.M. (1969), *On certainty*, Oxford,, Blackwell.

Woodward, J. (1958). *Management and Technology*. London, HMSO

Wotherspoon, R., (2001), *The Multiple Faces of Engineering Design*, PhD Dissertation, University of Wollongong

Wynne, B., (1982), *Rationality and Ritual: The Windscale Inquiry and Nuclear Decision in Britain*, British Society for the History of Science Ltd

Wynne, B., (1988), *Unruly Technology: Practical Rules, Impractical Discourses and Public Understanding*, Journal of Social Studies of Science, Vol. 18, No. 1 (Feb., 1988), pp. 147-167

Wynne, B., (1996), *May the sheep safely graze? A reflexive view of the expert-lay knowledge divide*, Risk, Environment and Modernity: Towards a New Ecology, Sage

Wynne, B., (2001), Managing Scientific Uncertainty in Public Policy, Harvard University Conference on "The Multiple Faces Of Uncertainty - Biotechnology and Global Governance: Crisis and Opportunity

Wynne, B., (2002), *Risk and Environment as Legitimatory Discourses of Technology: Reflexivity Inside Out?* Journal of Current Sociology, Vol. 50(3): 459-477

Yanow, D. and Tsoukas, H., (2008), *What is reflection-in-action? A phenomenological account*, Unpublished Paper

Yin, R.K. (1984/1989), *Case study research: Design and methods*. London: Sage.

Yin, R.K. (1993), *Applications of case study research*, London: Sage.

Yin, R.K. (1998) The abridged version of case study research: Design and method. In Bickman, L. and Rog, D.J. (eds), *Handbook of applied social research methods*. London: Sage.

Zeithaml, V. A. and Bitner M.J. (2003), *Services Marketing: Integrating Customer Focus across the Firm*. New York: McGraw-Hill.

Zizek S. (1989), *The sublime object of ideology*, Verso

Zuboff, S. (1988), *In the Age of the smart Machine: The future of work and power*, London: Heinemann

Zwicky, F. (1969), *Discovery, Invention, Research - Through the Morphological Approach*. Toronto: The Macmillan Company