2006

Evolutionary theory : a 'good' explanatory framework for research into technological innovation?

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Publication details

Myers, SK 2006, 'Evolutionary theory : a 'good' explanatory framework for research into technological innovation?', PhD thesis, Southern Cross University, Lismore, NSW.

Evolutionary theory: A ‘good’ explanatory framework for research into technological innovation?

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Submitted in fulfillment of the requirements of the degree of
Doctor of Philosophy

June, 2006

THESIS DECLARATION

I certify that the work presented in this thesis is, to the best of my knowledge and belief, original, except as acknowledged in the text, and that the material has not been submitted, either in part or in whole, for a degree at this or any other university.

I acknowledge that I have read and understood the University's rules, requirements, procedures and policy relating to my higher degree research award and to my thesis. **I certify that I have complied** with the rules, requirements, procedures and policy of the University (as they may be from time to time).

……
Stephen K Myers

ABSTRACT

This study attempts to answer the question; *does evolutionary theory provide a 'good' explanatory framework for examining the phenomenon of technological innovation?* In doing so, the study critically examines mainstream marketing's in-place explanatory frameworks, offers an explanation of 'evolution' based on new insights from a broad range of (sub)disciplines, and makes the practical proposition that this explanation is a 'good' analogous representation of the technological innovation process.

As an alternative to the 'scientific empiricist' approach that dominates much of marketing's research into technological innovation, the study develops a research methodology that is based within a *postmodern* philosophy, adopts an epistemology of *transcendental realism*, bases the research design on *abduction* and *textual explanation*, and brings together a research method based on the criteria of *interesting*, *plausibility* and *acceptability*.

Familiarisation with mainstream marketing's explanatory frameworks for research into technological innovation identified Diffusion theory, New Product Development theory and Network theory as dominant. It is concluded that these frameworks are based on problematic theoretical foundations, a situation considered as largely due to a pre-occupation with assumptions that are atomistic, reductionistic, deterministic, gradualistic and mechanistic in nature. It is argued, that in concert with the 'socialised' dominance of mathematical form over conceptual substance, mainstream marketing's research into technological innovation is locked into a narrow range of 'preordained axiomatics'.

The explanation of ‘evolution’ offered within the study is based on a *why*, *what*, *how*, *when* and *where* format. The resultant explanation represents a significant departure from the (neo)Darwinian biological perspective that tends to dominate evolutionary explanations of socio-economic behaviour, in that the focus is on the principles (and associated conceptualizations) of ‘variation’, ‘selection’ and ‘preservation’ within the broader context of open and dissipative systems. The offered explanation presents a number of theoretical ideas, and in particular, that evolution can only occur in a ‘multidimensional space of possibilities’, denotes a process of ‘adaptive emergence’, and is essentially concerned with ‘on-going resilience through adaptability’.

The practical proposition is made that the offered explanation of ‘evolution’ can be used in an ‘as if’ manner, that is, the principles of ‘variation’, ‘selection’, and ‘preservation’ (and the meanings ascribed to them through conceptualization) are analogically transferable to the technological innovation research area. The proposition is supported through reference to theoretical and empirical research, highlighting the similarity with respect to the generative mechanisms, structures and contingent conditions underpinning both ‘evolution’ and ‘technological innovation’.

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ACKNOWLEDGMENTS

I would like to acknowledge the supervision provided by Professor Lawson Savery, and in particular, his help in completing the degree as well as an openness to the research approach that underpins this thesis. To my dear and beautiful wife, Margaret McNeil, whom I can not thank enough, for the completion of this thesis would not have been possible without her emotional sustenance, mental input and editorial advice.

> Constructive imagination increases man's comprehension of his observable world. If we picture thinking as the combination of bits of information, then the combinations and permutations of such bits provide, for all practical purposes, an unlimited number of possible models that can be the product of man's mind. This would be approximately true if the fund of information bits was finite and fixed, for the unexplored combinations and permutations far exceed the number as yet produced by man's thought. The fund of information bits is not, however, finite and fixed. Each new advance in research technology provides accretions of information bits. Each model of man's world likewise adds to the sum total of information bits. Consequently, the opportunity to construct new models of the world as man sees it is never exhausted (Dubin, 1978:221).

1.0 INTRODUCTION

1.1 Background to the research

The social phenomenon of innovation as an object of study is receiving increasing attention within the literature due to research evidence clearly indicating that the process, particularly that of a technological nature, is the major driver of economic development (OECD, 1987; Porter, 1990; Leppalahti and Aerblom, 1991; DITC, 1993; Sanchez, 1996; Gatignon and Xuereb, 1997; Mandeville, 1998; Nelson, 2003). In itself this is not a revelation, for the positive influence of technological innovation on economic growth was a central theme in the writings of a number of early economic theorists (Marshall, 1890/1949; Veblen, 1899; Schumpeter, 1934). Within the marketing discipline a similar, though not so long history is also apparent, with a number of early researchers examining innovation within a number of considered marketing contexts (Robertson and Kennedy, 1968; Bass, 1969; Engel, Kegerres and Blackwell, 1969). A revival is similarly apparent, with a number of marketing researchers arguing that technological innovation, whether product or process orientated, is the primary influence on company performance due to the inescapable fact that the life of most, if not all commercial products is finite (Snelson and Hart, 1991; Lynn, Morone and Paulson, 1996; Gatignon and Xuereb, 1997; Poolton and

Barclay, 1998**).** The general conclusion of this literature is that “the accelerating pace of technological advancement magnifies the competitive importance of product and process innovation for manufacturing firms” (Paulson Gjerde, Slotnick and Sobel, 2002:1268).

Notwithstanding the logic of the need for ‘technological innovation’, what the term actually means is the subject of conjecture, the research area being criticised as highly fragmented with respect to both generated theory and empirical application (Kline, 1985; Utterback 1986; Braun, 1992; Hart and Baker, 1994; Nijssen and Lieshout, 1995; Wind and Mahajan, 1997; Gerwin and Barrowman, 2002). As Durand (1992) noted, the term has been invoked to cover a wide spectrum of activities such as; invention, product development, process creation and development, organisational change, and the diffusion of improvements. These activities have also been studied across a broad spectrum of levels of analysis, from the individual entrepreneur or 'product champion' (Moss Kanter, 1984; Drucker, 1985; Peters, 1987) to the nation state (Freeman, 1988; Lundvall, 1988; Porter, 1990), and points in between (Rothwell, 1983; Dosi, 1988; Nonaka, 1994).

It could be argued that this fragmentation in research is merely a reflection of the ‘nature of the beast’, for the word ‘innovation’ is a derivative of the Latin word *novus*, meaning ‘novelty’, and as such an appreciation of aspects deemed to be associated with the innovation phenomenon cuts across many areas of inquiry. However, it is the central proposition of the current thesis that while mainstream marketing research into the phenomenon of innovation may be considered as varied in a contextual sense,

the theoretical basis of such research is monotonic as it is determined largely within a perspective dominated by the ideology of 'scientific empiricism'. Such dominance is the result of imitation, for the ontological stance of the marketing discipline is largely a replication of its economic parent, that is, a Cartesian ontology that presupposes a universalised set of research methods that can be applied to any real world phenomena (Lawson, 1997; Wilson, 2005). Due to this dominant philosophical stance (and the paradigms, metaphors and research practice it promotes) explanations offered by mainstream marketing as to the underlying and essential causalities of innovation are caught in a gridlock of ‘positivism’ and ‘analytical orientation’.

This anaesthetisation of marketing thought has stifled the development of other explanations of innovation, and in doing so has limited our understandings of its realities. The purpose of the current thesis is to offer an alternative explanation of technological innovation, one that is considered to be a better representation of these realities than those currently on offer in mainstream marketing. The explanation takes an evolutionary perspective and as such is broadly applicable. Indeed, while the central focus of the thesis is directed towards innovation that is technological in nature, it is argued that the identified underlying principles, and the subsequent conceptualisation of these principles, could possible be used to explain the process of innovation irrespective of context. In essence this thesis attempts to answer the question; *does evolutionary theory provide a good explanatory framework for examining the phenomenon of technological innovation?* In the current research context ‘good’ refers to an explanation that is more interesting, plausible and acceptable than those currently used within mainstream marketing.

As highlighted above, there is a long history of marketing literature/research that attempts to explain the phenomenon of technological innovation, and in particular, which examines issues associated with its generation and/or diffusion. Generation issues, usually contained within the new product development (NPD) framework, are apparent within the early marketing literature (Hilton, 1961; Levitt, 1962; Eastlake, 1968). This work draws on research developed by the likes of Jewkes, Sawers and Stillerman (1958), Booz, Allen and Hamilton (1960) and Burns and Stalker (1961) within the management area. The diffusion of innovation seems to have wider appeal as a research topic, due largely to its seemingly easy theoretical fit and application across a number of research fields that provide the foundations for the marketing discipline. These fields include sociology (Tarde, 1903; Emery, Oeser and Tully, 1958), rural sociology (Ryan and Goss, 1943), cultural anthropology (Barnett, 1953) and medical sociology (Katz, Lewin and Hamilton, 1963). The influence of the 'diffusion' paradigm on the development of marketing thought with respect to innovation is readily apparent. It underpins the surge of publications during the discipline's early development that applied the conceptual and methodological aspects of this research to a number of marketing interests (Buzzel, 1966; Silk, 1966; Arndt, 1967; Cox, 1967; Robertson, 1967; Bass, 1969). Recent marketing research has attempted to tie together aspects associated with the generation and diffusion of innovation, utilising as an explanatory framework, a body of work encapsulated within the broad parameters of network theory (Radcliffe-Brown, 1940; Bott, 1957).

The continuing influence of the conceptual and methodological aspects associated with early research is apparent within recent mainstream marketing literature, in particular those endeavours examining concepts, propositions and boundaries of

technological innovation utilising diffusion, new product development and network theories as frames of reference (Mahajan, Muller and Bass, 1990; Porter, 1990; Rogers, 1995; Achrol, 1997; Bass, 2004). Without denying the important contributions of this research, there still remains a need to subject these explanatory frames of reference to careful review so as to isolate any virtues or flaws with respect to current understandings and realities (Hamel and Prahalad, 1994; Calder and Tybout, 1999; Lowe, Carr and Thomas, 2004). Perhaps more importantly, the philosophical stance of 'scientific empiricism' within which these frameworks were largely developed and propagated is unquestioned within the marketing literature. As a result, enhanced understanding of the innovation phenomenon (through the development of alternative explanations that consider new and/or different realities or experiences) is almost non-existent (Shane and Ulrich, 2004).

The dominance of a 'scientific empiricist' philosophy within mainstream marketing's examination of the technological innovation process can be easily seen in the proffered research goals of objectivity, measurement, control and prediction. In consequence the ideals of atomism, reductionism, determinism, gradualism and mechanism have come to pervade most, if not all of mainstream marketing's research into aspects of the innovation phenomenon (Calder and Tybout, 1999). This is evidenced through the reductionist separation of the technological innovation process into discrete aspects of generation and diffusion, with explanations usually formulated on mechanistic summation(s) of atomistic behaviour, which, in turn, is largely determined by given, individual preference functions made within a known context of objective constraints (Bass, 2004). Given this, it is hardly surprising that the phenomenon of technological innovation itself (and the generative mechanisms,

structures, and contingent conditions that influence its 'progression') is explained almost exclusively within gradualism. However, for marketing to offer explanations based solely on scientific empiricist logic is not sound, for such a logic has difficulty offering an epistemological and methodological context that allows for a more 'realistic' depiction of the discontinuous ebb and flow that is inherent within a socially-determined phenomenon such as technological innovation;

> Planets, billiard balls, and point particles are helpless slaves to the force fields in which they move, but people are not! People can switch sources of energy on or off and can respond, react, learn and change according to their individual experience and personality. They can see the potential usefulness for some modification in their timing, technique or tools, and they can tinker and experiment perhaps to find ways to overcome a problem, or a new way to achieve some desired result. This is where innovation comes from... (Allen 1994:6).

It is the contention of the present thesis that mainstream marketing stays firmly entrenched within empirically-based explanations of technological innovation due to not-so-subtle socialisation pressures within the discipline. While the status afforded by an ideology such as ‘scientific empiricism’ may indeed help confer on the marketing discipline (and its disciples) the intellectual respectability it so desperately desires (Brown, Bell and Carson, 1996), the almost single-minded application by marketing of an empiricist research agenda is also limiting, biased and oppressive (Alvesson, 1994; Brown, 1996; Brown, Doherty and Clarke, 1998; McAuley, 1998). Perhaps more disconcerting is that such an ideology has largely determined mainstream marketing's view of the business environment, an environment in which organised and stable order is (or should be) the norm, and in which any discontinuity is a distortion, or even an exception that just serves to prove the rule. If doubts are raised, as seen in marketing's continuing inability to overcome or address the issue of low success rates in new product development, the problem is usually considered as either an issue of poor business practice or ineffectual modelling approaches (Wind

and Mahajan, 1997). While both of these issues may indeed be impacting on low success rates of technological innovation, there is very little discussion of the possibility that low success rates are an integral aspect of its underlying process;

> There is bound to be a lot of purely fortuitous or non-transferability specific in the life and death of a single biological individual or social system or culture item. For a systematic selection criterion to make itself felt above this 'noise level', there must be numerous instances involved, and a high mortality rate (Campbell, 1969:75).

Much of marketing research continues to explain, represent and treat technological innovation as if it were "a set of prescriptions, linear procedures or a recipe" (Souder, 1987:5). That this has occurred is not only due to socialisation pressures that support the general maintenance of the status quo with respect to research methodology (ie. scientific empiricism), but also to the utilisation of a small number of explanatory frameworks (ie. diffusion, new product development, networks) that have been 'over operationalised'. This emphasis on more and more detailed analytical research on a limited number of in-place explanatory frameworks has led to the development and subsequent acceptance of theoretical assumptions that are little more than convenient fictions. While the inclusion of such assumptions can be criticised as an attempt to achieve mathematical tractability at the expense of a 'better' theoretical explanation of the real mechanisms and structures at work, somewhat more insidious is the fact that these fictitious theoretical assumptions have tended to direct technological innovation research within marketing (O'Shaughnessy, 1997; Sheth and Sisodia, 1999). Failure to appreciate the 'institutionalisation' of theoretical assumptions, that are at best problematic, leads to major shortcomings in research;

> … first of all, there appears to be a common misconception that, sooner or later, the assumptions can be removed, just as scaffolding is from an otherwise stable construction,... And second,… with a failure to recognise the significant role of assumptions, is a generally held supposition that, because the original, relatively contentless abstractions, or axioms, are intended to capture some domain of reality, the same is also true of the final conception, so that it can therefore be justifiably used for purposes of explanation… (Lawson, 1989:75).

A loathing to (re)examine the phenomenon of technological innovation through alternative explanatory frameworks is symptomatic of the state of mainstream marketing in general, the discipline being characterised by a lack of evaluation with respect to in-place theoretical explanations (Jacoby, 1978; Sheth, Gardner and Garret, 1988; Hunt, 1994; Wind and Mahajan, 1997; Malhotra et al, 1999). This non-critical acceptance of in-place explanations, and the assumptions they contain, has led to a situation in which such explanations have become immutable axiomatics. As a result, progress in marketing thought seems to equate to the development of more analytically specific, yet more conceptually abstract models, with little attempt to develop theoretical insights that offer plausible alternative explanations of the underlying mechanisms and structures of the phenomenon in question (Sherry, 1991; Hunt, 1994; Brownlie and Saren, 1995; Brownlie, 1997).

The dominance of empirically-based conceptualisations and/or methodological practices, and the elevation of such to omnipotent status due to a lack of critical analysis, highlights the broad need for mainstream marketing to adopt a more pluralistic research orientation. More specifically, such ideological dominance, in concert with the narrow and limiting range of explanatory frameworks ascribed to the phenomenon of technological innovation, demands the consideration of a plausible alternative explanation of said phenomenon. The present thesis meets these needs, offering a plausible explanatory framework of technological innovation based on an evolutionary perspective. The proposed framework is formulated within a research methodology that incorporates a *postmodern* philosophy, an epistemology of *transcendental realism*, a research design based on *abduction* and *textual explanation*, and a research method that brings together the criteria of *interesting*, *plausibility* and

acceptability. That a measure of congruency exists between the research topic and the chosen methodology is supported by Weick's (1989:519) description of theory generation;

> When theorists build theory, they design, conduct, and interpret imaginary experiments. In doing so, their activities resemble the three processes of evolution: variation, selection, and retention. Because the theorist rather than nature intentionally guides the evolutionary process, theorizing is more like artificial selection than natural selection.

In accepting the premise that theory construction and dissemination is an innovative act, the present thesis adopts the proposition that explaining most, if not all processes that incorporate human experience and activity, requires strong links to aspects of evolutionary theory.

The choice to base the alternative explanation of technological innovation within an evolutionary perspective is not entirely novel, for evolutionary concepts can be found in the works of early socio-economic writers and researchers such as Marx, Veblen, Menger, Marshall, Schumpeter and Hayek (Hodgson, 1993). The development and application of an evolutionary perspective to socio-economic issues is also apparent in more recent literature (Dosi, 1988; Nelson, 1995; Saviotti, 1996; Johannessen, 1998; Fleming and Soreson, 2004). A small body of literature showing an appreciation of the explanatory link between evolutionary theory and technological innovation processes is also apparent within marketing (Reidenbach and Oliva, 1981; Tellis and Crawford, 1981; Henderson, 1983; Lambkin and Day, 1989; Holak and Tang, 1990; Foxall, 1993; Hunt and Menon, 1995; Massey 1999).

Notwithstanding the strong intellectual support within the social sciences for evolutionary-based explanations of human behaviours, application is still in its infancy as there is a diversity of views as to how the evolutionary analogy can and/or should be applied (Hodgson, 1998; Wilson, 2005). Such diversity however, is not apparent within marketing's limited efforts in applying the evolutionary perspective, for most identified research adopts a strict (neo)Darwinian perspective, focussing on biological notions of natural selection and random mutation as the basis for explanation and/or prediction. This is not to suggest that such notions themselves are ill-founded, but rather that problems can and do occur when transferring metaphorical representations from one discourse to another. For example, research that applies natural selection and random mutation to a business context usually simplifies these notions to issues of market sovereignty and fortuitous chance. Furthermore, taking recourse in a (neo)Darwinian perspective neglects the new realities of the process of evolution identified in a number of alternative perspectives. Within these different perspectives ‘natural selection’ is not merely a case of 'survival of the fittest', for it also contains characteristics such as self-organisation, emergence, exaptation, adaptation, and adaptability (Lewontin, 1982; Prigogine and Stengers, 1984). Likewise, the generation of ‘variation’ within a system should not be considered merely as the result of random mutation, but requires an appreciation of the fact that many of the machinations of a system may occur due to purposeful or intended behaviour (Prigogine, 1980; Kauffman, 1993). Perhaps more disconcerting is the fact that research, particularly within marketing, has largely confined evolutionary reasoning to 'vocabulary games', limiting itself to merely relabelling existing knowledge with biological expressions. An example of such metaphorical misappropriation within marketing is Holak and Tang's (1990: 19-20) assertion that

"analogous to genetic selection having an impact on a species is the effectiveness of brand-level advertising decision making within the ranks of the major cigarette manufacturers."

In conclusion, this section has presented a brief argument that identifies both a broad and specific need within mainstream marketing literature. The first need concerns the call within the general literature to focus attention on broader philosophical and paradigmatic aspects of research, and in particular, the problematic ideological dominance of 'scientific empiricism' and its application to issues of social reality (Arndt, 1985; Mayr, 1985; Capra, 1992; Alvesson, 1994; Hodgson, 1998). The more specific need concerns the limited range of explanatory frameworks of technological innovation within mainstream marketing, and the lack of challenge to the associated theoretical assumptions and conceptualisations on which such frameworks are based. While the explanations offered by the current frameworks of diffusion, new product development and network have contributed to an understanding of the technological innovation process, their almost complete subjugation to the empiricist ideals of atomism, reductionism, determinism, gradualism and mechanism is cause for concern. At issue are not problems associated with scientific empiricist philosophy or practice *per se*, as the ‘marketing: science versus art’ debate is wont to assert, but rather the appropriateness of using a scientific empiricist framework when attempting to explain the phenomenon of technological innovation. Technological innovation is a collective social leaning process, the principles of which are not as yet well understood (Hodgson and Knudsen, 2004). While the adoption of research schema based on scientific empiricism may provide protection against criticism, dogmatically following such a path will only capture that which is expedient (Galbraith, 1987). Of

more concern is that the scientific empiricist path may hamper the generative capacity of the research area.

The present thesis is an attempt to challenge the dominance of scientific empiricist ideology and to broaden the explanatory frameworks for technological innovation. The following sections summarise the major aspects of this thesis; identifying the research question itself and a brief outline the essential features of the proposed alternative conceptual explanation (1.2); presenting the methodology used to provide both initial impetus and subsequent direction with respect to the explanation (1.3); providing an outline of the thesis (1.4); and offering justification of the value of the research in both academic and applied contexts (1.5).

1.2 Research question

The purpose of this thesis is to offer a plausible alternative explanatory framework of the essential generative mechanisms, structures and contingent conditions that provide causality for technological innovation. As argued above, current explanations within mainstream marketing portray the phenomenon as largely atomistic, reductionist, deterministic, gradualistic and mechanistic in nature. The present thesis adopts a diametrically opposed perspective, viewing technological innovation as largely systemic, organic, indeterminate, and uneven, and taking as its cue the diversity of ideas pertaining to evolutionary theory. It is stated from the outset that while the collective principles of an evolutionary perspective are sacrosanct, the conceptual refinement of these principles is incomplete, and therefore open to interpretive analysis (Wilson, 2005). As such, the explanatory framework proposed within this

thesis is akin to 'seeing through a glass darkly', and should not be considered as a well-defined and refutable theory, with appropriate packaging and labelling. In essence, while the thesis ostensibly offers what is considered to be a plausible explanation of technological innovation, it is nevertheless merely a tentative signpost for possible research routes into the phenomenon of technological innovation. To this end, the reader is asked to not only consider the extrinsic worth of the explanatory framework, but also to assess the ideas presented in this thesis on their intrinsic worth as a stimulus for further thought and action.

The thesis poses the following research question;

> **Does evolutionary theory provide a 'good' explanatory framework for examining the phenomenon of technological innovation?**

In providing an answer to this question, the current thesis draws on knowledge in the broad body of work that is encompassed by the term 'evolutionary theory'. As previously suggested, a general evolutionary theory is as yet undeveloped, a fact readily apparent in the number of model variants within the literature (Hodgson, 1993; Vromen, 2001). However, there seems to be a growing consensus within a number of (sub)disciplines that an evolutionary system exhibits both fixity (ie. stability) and freedom (ie. instability), and that the latter state must dominate a system in order for on-going evolution to occur. In fact, it is argued that the defining characteristic of all evolving systems is the on-going creation of diversity; in essence, the creation of energy 'variation' is the *raison-d'etre* of all living systems as it is the only way of overcoming the entropic effects of the 2nd law of thermodynamics (Prigogine and Stengers, 1984; Boulding, 1987; Allen, 1994; Gould, 1996). In an effort to maintain a measure of structural and/or functional integrity within this

possibility pool of internally and/or eternally generated energy, a system will impose some sense of regulation through ‘selection’ mechanisms. These mechanisms constantly build up and breakdown ‘variation’, enhancing the ‘preservation’ of the system through the replication of things that do work, and the reproduction and renewal of things that could possibly work so as to facilitate further evolution (Popper, 1990; Hough, 1997; Nelson, 2003). It is the contention of the present thesis that these principles of evolution (ie. variation, selection, preservation) provide a general explanatory framework into which a specific explanation of technological innovation can be placed.

1.3 Methodology

As stated previously, this thesis is concerned with offering an explanation of the technological innovation process, based on the principles of evolution, that is a plausible alternative to those currently available in mainstream marketing. The following material discusses the methodology of the current thesis, identifying the philosophical stance, epistemology, research design, and research method. More importantly, it also offers an insight into the decision-making process that drove the research from its initial conception to its final conclusion, for while the material as presented is suggestive of a rational, logical and sequential train of thought, the development and refinement of the current thesis was anything but such a process.

In a general sense there are two distinct goals in research; prediction and understanding (Dubin, 1978). Prediction is concerned with outcome, and focuses on foretelling the value of one or more units of the phenomenon in question, or anticipating the condition or state of the phenomenon as a whole. On the other hand,

understanding is concerned with the development of knowledge about the underlying pattern or process, and with mechanisms of interaction occurring within the phenomenon in question. ‘Understanding’ does not necessarily provide the basis for predictions about the reality being modelled (Loasby, 1976). The present thesis has as its goal 'understanding through realistic explanation', and while such a goal is apparent in some instances within the marketing discipline, the academic high-ground of marketing is ostensibly that of predictive measurement and quantification. That this emphasis on numerically-based prediction should be a central tenet of marketing research is questionable, for as Baker (1994:632) elegantly noted, "while algebraic elegance will lead to theoretically defensible interpretations of behaviour, they are nevertheless a palpable absurdity with respect to reality." Although there is an identified need for the marketing discipline to direct more research endeavours to issues of conceptual substance and relevance, as distinct from those of mathematical form, methodological approaches to textually-based explanation(s) are sparse and uneven within the discipline (Wind and Mahajan, 1997; Lowe, Carr and Thomas, 2004).

It is argued that the emphasis on prediction is due largely to the almost obsessive drive for research validation within marketing. Notwithstanding the fact that the validation of quantitative research endeavours is a difficult proposition (Lastrucci, 1963; Homans, 1964; Freese, 1980; Lindblom, 1987), the issue of validation is exceedingly vexed with respect to narrative explanations. This is due to the fact that the validation of whether or not the explanation is indeed a 'true' representation of the reality it is attempting to model, does not necessarily have to ride on the outcome of

empirical tests (Dubin, 1978; Bhaskar, 1998). It is argued by Weick (1989:524) that in such situations two important issues need to be addressed;

> First, the criteria used in place of validation must be explored carefully since the theorist, not the environment, now controls the survival of conjectures. Second, the contribution of social science does not lie in validated knowledge, but rather in the suggestion of relationships and connections that had previously not been suspected.

The present thesis attempts to address the first issue through the utilisation of methodological elements that are broadly accepted within the literature as validation criterion with respect to theoretical research. The underlying rationale or premise of the thesis addresses the second issue. In particular, it is argued that while relationships and connections within an innovating system may seem positively progressive, rational, orderly, continuous, and symmetrical, this is rarely the case. Such neatness is seldom apparent in reality, for as Jantzen and Orstergaard (1998: 126-127) argue, "disorder, waste and destruction are part of existence. They are not mere deviations from the normal way of life or marginal to everyday existence. On the contrary, they often seem to be the most important part of existence…"

The philosophical ideals on which the current methodology is based are those of *postmodernism*, a school of thought that emphasises the continuous generation of ideas, the mixing of different intellectual discourses, and on-going critical reflection and transformation (Havel, 1995). Underpinning such ideals is a questioning of the over-arching assumption on which most research is based; that an objectively ‘knowable’ and 'truthful' world exists, and that such a world can be understood and controlled through human logic and action (Brown, 1997). While such an assumption might be appropriate in certain research circumstances, its broad application is tantamount to misplaced divinity. Within a *postmodernist* ideology a 'telling it like it

is' belief is replaced by one of 'telling it as it might be' (Gergen and Tojo, 1996). Within such a philosophical foundation the aim of research is not the 'polishing of mirrors', that is, it is not concerned with mounting arguments as to the validity of in-place explanations based solely on the (re)combining of a fixed set of elements or facts.

An epistemology deemed to be consistent with the postmodern project is that of *transcendental realism*. This view accepts the premise that a complete and certain understanding of all social phenomena is not possible, and therefore, the features of theoretical reality need not be (nor must be) based on objective scientific methods (Bhaskar, 1979). In utilising this view, the methodological emphasis is on perspective, experience, interpretation and rhetoric (Levy, 1981; Sayer, 1992). Such an epistemological orientation also allows for the incorporation of unmeasurable (unobservable?) elements within a conceptual model, a theoretical aspect not possible within the strict measurement confines that underpin most scientific empiricist methodologies (Fuchs, 1992; Ward, 1995). Of importance to the research context of the current thesis is the fact that *transcendental realism* also implicitly promotes the need for a broader appreciation of the open, dissipative and emergent nature of social systems (Simon, 1962; Popper, 1974; Leydesdorff, 1994; Hodgson, 2001).

A research design based on the above epistemology adopts the features of *abduction* and *textual explanation*. The former feature is somewhat distinct from the traditional research designs of inductive and/or deductive modes of reasoning, for *abduction* is concerned with theory generation through what Peirce (1934) refers to as ‘an act of insight’. In a pragmatic sense this insight refers to intellectual creativity being sourced

through the juxtaposition of frames of references from different discourses so that already existing, but previously separated ideas can cross fertilise (Quinne, 1953; Hanson, 1958). The current thesis adopts this methodological approach and brings together various aspects (ie. paradigms, metaphors, puzzle-solving) associated with the evolutionary perspective from a number of different (sub)disciplines (ie. biology, genetics, physics, chemistry, economics, sociology, marketing).

The other central feature of the research design is *textual explanation*, a modelling approach that explores a phenomenon via the descriptive identification and conceptualisation of its underlying mechanisms, and the interdependent relationships between these mechanisms (Kaplan, 1964; Greer, 1969; Sayer, 1992). While the *textual explanation* approach is open to interpretation, the current thesis adopts the suggestion of Campbell (1962) that explanations should follow a *why*, *what*, *how*, *when* and *where* format. *Textual explanation* is a valid research tool in its own right. In the current context it is also the only tool that offers the possibility of teasing apart the complexity of the evolutionary process (Boulding, 1982; Depew and Weber, 1997). While some may consider narrative explanations as irrelevant and lacking in 'scientific rigour', such a consideration not only dismisses the fact that knowledge is invariably present in the form of text, but also plays down its value;

> There is an implication that associates 'purely descriptive' research with empty-headedness; the label also implies that as a bare minimum every healthy researcher has at least a hypothesis to test, and preferably a whole model. This is nonsense. In every discipline,… purely descriptive research is indispensable. Descriptive research is the stuff out of which the mind of man, the theorist, develops the units that compose his theories (Dubin, 1978:87).

The research method in the current thesis is based around the criteria of *interesting*, *plausibility*, and *acceptance*. The *interesting* criterion, as proposed by Davis (1971),

was selected as it confirms and supports the purpose of the current thesis, that is, a need to challenge in-place explanations and associated assumptions. Within such a research method criterion, the initial starting point and subsequent conceptualisation process does not have to be determined and/or directed by an *a priori* established 'truth'. The rationale behind such a premise is that the 'truth', especially with respect to describing the realities of social phenomena, is largely subjective as it is socially constructed (Callon, 1987). Going further, Davis (1971:309) argues whether 'truth' should indeed be the central goal of research, suggesting that "the truth of a theory has very little to do with its impact, for a theory can continue to be found interesting even though its truth is disputed-even refuted!"

In utilising the *interesting* criterion, good theoretical contributions are those that challenge in-place assumptions, with such challenges largely based on dialectical assumptions (ie. what is taken for granted as *X* may actually be non-*X*). The applicability of the *interesting* criterion within marketing research in general has been canvassed by a number of writers, with the central premise being that mainstream marketing lacks 'generative knowledge capacity' due to a tendency to focus research on (re)combining a fixed set of in-place assumptions. Given little critical evaluation of such assumptions, the result is largely a narrow and limiting range of alternative explanations (Zaltman, Le Masters and Heffring, 1982; Sheth, Gardner and Garrett, 1988; Brownlie and Saren, 1995). While the *interesting* criterion offers a validation measure with respect to the initial selection of a theoretical frame of reference and subsequent research direction (Mohr, 1982; Daft, 1985; Schank, 1988), the present research method incorporates a number of additional elements. These are used not

only to judge the *plausibility* of the proposed alternative explanation, but also the likelihood that this explanation has some level of audience *acceptance*.

The *plausibility* criterion operates in tandem with the perspective, experience, and interpretation of the researcher, supporting the selection of conjectures generated in the process of explanation construction through a series of assumption tests. A generic assumption test for plausible conjectures is identified by Weick (1989:524), and consists of a series of posed questions;

> The centrality of plausibility to the theorizing process can be understood in the following way. When theorists apply selection criteria to their conjectures, they ask whether the conjecture is *interesting*, *obvious*, *connected*, *believable*, or *real*, in the context of the problem they are trying to solve. (Italics added)

While not a research method issue in a general sense, the notion of audience *acceptance* is an important consideration with respect to research that challenges widely-held assumptions. Such research is akin to walking a tightrope; a balancing act between questioning currently accepted assumptions and not alienating the audience that accepts such in-place assumptions as 'truths'. To this end, a number of additional selection criteria suggested by Whetten (1989) as pertinent to judging the publishing potential of conceptual research are used in the research approach of this thesis. As for the plausible criterion, a number of questions are posed to test the legitimacy of a theory contribution

In conclusion, the methodology outlined above exhibits a marked departure from the 'predictive instrumentality' that is commonly employed within mainstream marketing research (Arndt, 1985; Daft and Lewin, 1993), for while such an approach to research is appropriate for many research endeavours, it offers little for the present thesis. ‘Predictive instrumentality’ runs counter to the underlying research goal of increased

'understanding' with respect to the phenomenon of technological innovation, but also lacks the ability to incorporate evolutionary aspects within its ‘objective’ methodology. Instead, a methodology is used which recognises the fact that knowledge development is largely the result of imaginative (re)creation of some segment of the world within the mind of an observer, and that this (re)creation is often intuitive, blind, wasteful and serendipitous (von Bertalanffy, 1950; Popper, 1959; Campbell, 1962; Lindblom, 1987; Tsoukas, 1993). While the methodology is supportive of a 'reasoned pursuit of the truth' with respect to an alternative explanation of the phenomenon of technological innovation, it is also appreciative of the fact that such a process is also a question of self-observation. There has been an explicit recognition that irrespective of the tools, skills and knowledge applied as methodological parameters, the resultant research output is largely that of 'artificial selection', for one sees only what one wants to see.

1.4 Outline of the thesis

This thesis attempts to present a plausible alternative theoretical explanation of the phenomenon of technological innovation to those currently accepted as 'true' representations within mainstream marketing. It is accepted that there is neither a single best way for understanding this phenomenon, nor the possibility of holding any conclusions with certainty. However, the fact that mainstream marketing, after four decades of research, is as yet unable to offer a good descriptive theoretical model that explains the essential generative mechanisms, structures and contingent conditions of technological innovation, suggests that there is room for alternative explanations (Wind and Mahajan, 1997; Poolton and Barclay, 1998; Gatignon et al, 2002). As to why there is this dearth of 'good' theoretical explanations with respect to technological

innovation, it is argued that much of marketing's efforts are directed by a ‘scientific empiricist’ orientation that favours mathematical form, rather than conceptual substance. While the utilisation of nonlinear analytical techniques within innovation research is a welcome relief from the 'mechanistic determinism' of most statistical approaches, the down-side is that much of the research into technological innovation is being distracted from unresolved theoretical questions. This is due not only to the desire for analytical tractability, but also the seduction of mathematics itself, conditions that have ‘promoted tricks in technique and the assimilation of dogma at the expense of considered thought’ (Hodgson and Screpanti, 1991). Notwithstanding the highly problematic and simplistic theoretical assumptions needed to facilitate most mathematical procedures, it is argued that the emphasis on predicability should be balanced by conceptual research that attempts to realistically explain the underlying generative mechanisms, structures and contingent conditions of the technological innovation process.

In an attempt to highlight the mutually supporting interdependencies between the research schema, research process, and research outcome, the thesis will adopt a 'nested' approach with respect to both the overall structure of the methodology and its inherent content. While the methodological issues that constitute **Chapter Two** have already been briefly outlined in section 1.3, it is pertinent to reiterate that the methodology itself is an example of the process of evolution at work, and as such is a central tenet of the present thesis. As discussed previously, the development of knowledge within the marketing discipline is constrained by methodological strictures that largely favour validation at the expense of useful understanding. These strictures of objectivity, measurement and prediction weaken theory construction because they

either neglect or de-emphasise the contribution that imagination, representation, and selection makes to the research process. The methodology chosen for the present thesis embraces these contributions, and in doing so is supportive of Weick's (1989:516) contention that theorising is an evolutionary process, driven by "disciplined imagination that unfolds in a manner analogous to artificial selection."

The construction of an explanatory framework does not occur in a vacuum. It is not an independent exercise devoid from, or unrelated to, what is already 'known' about a phenomenon (Glaser and Strauss, 1967). A familiarity with mainstream marketing's accepted in-place theoretical assumptions about technological innovation is essential, for exploration of this tradition of theoretical debate not only identifies perceived tensions with respect to current explanations, but can also provide a springboard from which to develop plausible alternative explanations. **Chapter Three** identifies and examines the theoretical frameworks and associated assumptions that are perceived as dominant with respect to mainstream marketing research into technological innovation. In the current context ‘mainstream' refers to the large body of literature that exhibits consensus with respect to the theoretical features of technological innovation. Some have argued that the use of marketing texts as a ‘consensus identifier’ is problematic as they present a false sense of marketing's intellectual progress due to the recycling of inappropriate and outmoded models (Witcher, 1985; Hirschman, 1986). However, they are nevertheless "the repository, the shop window, the very epitome of marketing knowledge" (Brown, 1996:38).

Examination of the literature identified three theoretical frameworks utilised by marketing as explanatory devices for research into the phenomenon of technological innovation. These frameworks may be encapsulated within the terminologies of diffusion, new product development and networks, with the first two frameworks exhibiting historical dominance, and the latter showing recent popularity. The dominance of diffusion models is readily apparent in the research of Rogers (1962, 1971, 1983, 1995). His is an extremely influential body of work that initially focussed on the diffusion of innovation, with subsequent material specifically examining the generation of technological innovation. Although not as influential as the diffusion framework, new product development, as exemplified by the wide-spread use of Booz, Allen and Hamilton's work (1960, 1968, 1982), is also identified as a dominant explanation of the generation of technological innovations. Also identified within the marketing literature is the theoretical explanation of technological innovation through a network theory perspective. While the use of this explanatory device is as yet relatively limited, it is considered ripe for future application (Achrol, 1997; Rodan and Galunic, 2004).

The general conclusion drawn in Chapter Three is that current theoretical frameworks utilised by mainstream marketing to explain the phenomenon of technological innovation are based on problematic theoretical features. It is further concluded that these features are held in place by a 'shaky scaffolding' of expedient theoretical assumptions, due largely to a pre-occupation with analytical method within the marketing discipline. It is argued that as a consequence, the technological innovation research area within marketing had become locked into a narrow band of explanatory frameworks and associated theoretical assumptions that are little more than

preordained axiomatics. Given these theoretical and analytical shortcomings, the utilisation of marketing's current explanatory frameworks to further develop understandings of the phenomenon of technological innovation is considered to be inappropriate. Such a consideration runs counter to the *interesting* and *acceptable* criterion inherent within the methodology, that is, alternative explanations should stay close to the current locus of belief so as not to alienate existing audiences. However, dismantling the 'sticky' ecology of atomism, reductionism, determinism, gradualism and mechanism that pervades these explanations would not only be difficult, but would leave these explanations as mere empty shells.

While a shift to an explanatory framework based on evolutionary theory may alienate some sections of the marketing fraternity, there is strong support for such a paradigmatic repositioning in a number of (sub)disciplines examining technological innovation (Nelson and Winter, 1982; Dosi, 1988; Odogiri, 1997; Loch and Huberman, 1999; Vromen 2001; Becker and Knudsen, 2005). Even Veblen (1898), a founding father of economics argued that the discipline should abandon static (neo)classical analysis, with its emphasis on an alleged 'unalterable human nature', for a truly evolutionary analysis. However, as noted previously, despite this long history of identified need there is at present no single, cohesive and coherent understanding of an evolutionary approach to socio-economic behaviour (Nelson, 2003; Hodgson and Knudsen, 2004). The material presented in **Chapter Four** is not only a pragmatic response to this need, but represents a significant departure from the majority of research examining technological innovation from an evolutionary perspective. In the main this research utilises a (neo)Darwinian perspective of evolution, and although socio-economics and biology have much in common in terms

of their origins and the nature and complexity of their subject matter, making direct analogies is fraught with conceptual dangers (Foss, 1997). So as to expand the theoretical background of evolution theory, Chapter Four is an examination of the understandings of system evolution within the broader contextual research environment of the natural sciences. Three universal principles of evolution are identified during this examination, these being 'variation', 'selection' and 'preservation'. These principles denote the fundamental properties or characteristics that have to be included in any explanation of an evolving system, and while these principles are inviolable, they are open to differing conceptualisations (Spilsbury, 1974; Witt, 1991; Foss, 1997).

The explanation of evolution developed in Chapter Four provides the conceptual foundation for the explanatory framework of technological innovation presented in **Chapter Five.** An explanatory framework is somewhat different from a description in that it represents a research approach based on the proposition that a particular phenomenon (ie. technological innovation) resembles a more general one (ie. evolution), at least in terms of their underlying pattern or form (Quinne, 1960). This approach is congruent with the 'as if' postmodernist ideological basis of the thesis. Also, the material and arguments developed in Chapter Five are direct reflections of both the *abduction* and *textual explanation* features of the adopted research methodology. As previously noted, the proposed explanatory framework should be considered as a partial, rather than fully formed model. The framework, together with the explanation on which it is based, are simplifications of reality, based on tentative conceptualisations that are formulated more on theoretical agreement than observable fact. Such partiality is not a weakness, for all conceptualising is inherently abstract

and open (Dewey, 1938; Greer, 1969), and as Andreski (1974:115) argues, “an insistence on methodological perfection precludes one from giving an answer to anything but the most trivial questions.”

It was argued earlier that a major defect with much of the research that utilises an evolutionary perspective to explain technological innovation is the direct analogical transfer of biological metaphors. In fact it has been suggested that the use of (neo)Darwinian metaphors is the dominant criterion for socio-economic theories to qualify as ‘evolutionary’ (Foss, 1997). The issue is not direct analogical transfer *per se*, but what metaphors are actually being transferred between the biological and social worlds in this body of research (Gowdy, 1992; Hodgson, 1997). As argued, much of this research selects isolated, and usually out-dated metaphorical representations from the biology discipline, and slots these metaphors into a totally irrelevant social context as a form of ‘hard proof’ that said context is as professed. This sloppy, and perhaps totally inappropriate research behaviour is fraught with danger;

> The attraction of (neo)Darwinism to the social sciences is that it appears to offer easy and simple solutions to what are actually very difficult and complex aspects of socio-economic behaviour. It is becoming clear that this is an illusion, even in biology (Saunders, 1988:290).

Notwithstanding these difficulties, the central contention of the current thesis is that the expanded explanation of evolution presented in Chapter Four exhibits a high level of robust applicability. In particular, it is argued that the principles of ‘variation’, ‘selection’ and ‘preservation’ (and the meanings ascribed to them through conceptualisation) are directly transferable as an analogical explanation of

technological innovation. It is shown, through reference to theoretical and empirical research in the area, that the principles of system evolution, the evolutionary process that they explicitly depict, and the essential generative mechanisms, structures and contingent conditions associated with these processes, denote a plausible explanatory framework for increasing our understanding of technological innovation. In essence, Chapter Five argues that the answer to the research question driving this research is yes, though subject to qualification.

The broad outcomes of the thesis are presented in **Chapter** S**ix**, along with perceived contributions to research area, implications for theory and practice. The main outcome of the thesis is the development of an explanatory framework (ie. formal model) for technological innovation. In developing this explanatory framework the thesis offers two principal contributions to the knowledge base that constitutes the marketing discipline. The first is a rough synthesis of evolutionary theory, as outlined earlier, highlighting the shift from a purely biological (neo)Darwinian perspective to one that incorporates a range of different ideas from a number of (sub)disciplinary sources. Based on this developing perspective of evolutionary theory, a number of specific contributions to knowledge have been possible, including;

- An explanation of evolution that incorporates the principles and associated underlying constructs of new ‘realities’ of the phenomenon
- A explanatory framework model for explaining the broad ‘emergent systemic dynamics’ of the technological innovation process
- The incorporation within this model of the apparent paradoxes of instability and stability, micro and macro level processes, and ‘known’ and ‘unknown’ relational interdependence.

The second contribution is a relatively rigorous methodology for theory development, outlined earlier in this chapter. As discussed, the philosophical foundation of the methodology is *postmodern*, and incorporates an epistemology of *transcendental realism* that is translated to a practical research design involving idea *abduction* and *textual explanation*. While the validity of the offered explanatory framework itself is a relative measure based on the criteria of *interesting*, *plausibility* and *acceptability*, the contributory merit of the methodology is based on the belief that the adopted approach is more suited to exploratory theory generation with regard to complex phenomenon.

The proposed explanatory framework and the explanation of evolution on which it is based, have numerous implications for marketing theory and practice. The general implication for marketing theory and practice is the issue of (in)appropriate use of atomism, reductionism, determinism, gradualism and mechanism 'ideals' when attempting to explain socio-economic realities, and in particular, technological innovation. Many of these realities are constituted by a complex and uncertain mosaic of relational interdependencies that deny and defy formalism, and are therefore necessarily opaque to research based in these aforementioned 'ideals'. Marketing theory needs to move beyond these 'ideals' and the methodological shackles they impose, for to do otherwise will reinforce the criticism that "the marketing discipline, both of itself and what it produces, is all about rationality, efficiency, conformity and certainty; the tying of knots to pin down the world" (Brownlie, 1997:228).

More specifically, the implications (and contributions to knowledge) for marketing theory and practice include: *open and dissipative structures* which questions the

assumption/modelling of system causality as regularity; *emergence* which questions the assumption/modelling of systems as states of equilibrium; and *partial indeterminacy* which questions the assumption/modelling of system behaviour as a 'given'. Lower level conceptualisations developed within the current thesis have implications for a number of theoretical frameworks, in particular, *organisational theory*, *human agency theory*, and *information theory*. Implications for policy and management include: accepting limits to *predictability*; managing the influence(s) of *discontinuity*; developing an ability for *adaptive flexibility*; incorporating the duality of *competitive/cooperative intent*; identifying 'untraded' *relational interdependencies*; and recognising the impact(s) of *historical contingencies*. The chapter concludes by outlining suggested areas for future research.

1.5 Justification for the research

1.5.1 Academic

Given that technological innovation is the major driver of sustainable economic growth and impacts (in both a positive and negative manner) across most aspects of human society, it could be argued that this is reason enough for any research into the phenomenon. However, the call for a broad and pluralistic research agenda in marketing is also an important rationale, the overall premise being the belief that a greater understanding of the questions raised by marketing will only be achieved through research diversity (Alvesson, 1994; O'Shaunghnessy, 1997; Shane and Ulrich, 2004). In spite of this call for methodological variety much of mainstream marketing's research into social phenomenon such as technological innovation seems in a state of blissful ignorance with regard to the insights and ideas developed in other (sub)disciplines. It is argued that the methodology adopted by the present thesis which

abducts understandings of evolutionary theory from a broad range of fields, will contribute to this identified need for research pluralism.

It has been argued that much of mainstream marketing's research into technological innovation is exceedingly narrow, with the major focus on 'how' the dominant frameworks (ie. diffusion, new product development, networks) can be used as predictive models (Miller, 1998; Sheth and Sisodia, 1999; Lowe, Carr and Thomas, 2004). This 'predictive' approach to research can only validate existing knowledge, and will therefore contribute to a stifling of intellectual development within the marketing discipline. This is not to suggest that the current frameworks are of little value. Rather it is to identify the need to move beyond current theoretical explanations, ones that are held in place by scientific empiricism's 'acceptable' research methodologies which perceive 'reality' in atomistic, reductionist, deterministic, gradualistic and mechanistic terms.

The dominant influence of the ideals of 'scientific empiricism' is readily apparent within much of mainstream marketing's research into technological innovation. As noted previously, much of the research is 'atomistic' in a broad sense in that it is focused on either the generation or diffusion of technological innovation, and shows little interest or appreciation of the interrelationship(s) between these two central process aspects (Shane and Ulrich, 2004). The atomistic tendency to compartmentalise technological innovation into discrete spatial and/or temporal confines is also readily apparent within research examining these central aspects. Much of the research pays scant regard to the 'relational embeddings' (whether they

be of the consumer, organisation and/or industry) that are deemed to constitute the ‘collective process’ of technological innovation (Gatignon and Xuereb, 1997; Rodan and Galunic, 2004). The idea that technological research can start at the atomistic level (however defined) should be abandoned, for “human behaviour cannot be reduced to the choices and decisions of isolated individuals alone. Circumstances are in part a consequence of individual actions, but also individuals are moulded by circumstances including their interactions with others” (Hodgson and Screpanti, 1991:3).

The ideal of reductionism, that is, the belief that phenomena at one level can be explained entirely in terms of another level, is very much in evidence within marketing’s research into technological innovation. Supposed causality at the micro level (eg. rational intent, utility maximisation) is deemed to also occur at a more macro level. The presumption that individual members of a technological system operate according to the same set of heuristics, behaviours, learning approaches, and so forth, and therefore that the technological system itself can be causally explained in the same manner, is untenable (Boulding, 1991). That this is the case is due to the notion of ‘emergence’, a widely-held view which accepts that change at higher levels may arise out of lower levels, but is not reducible to such due to causal incompleteness and partial indeterminacy (Bohman, 1991). Mainstream marketing has invested intellectual energy in attempting to reduce the macro aspects of technological innovation to micro level causality, rather than focusing on the more appropriate research endeavour of explaining how the various levels might be theoretical linked or interconnected (Lawson, 1997).

The notion of partial indeterminacy inherent within the explanatory framework also challenges the ideal of *determinism* which characterises much of mainstream marketing's research into the phenomenon of technological innovation. That such determinism exists is readily apparent in the emphasis on prediction and the inherent view that immutable causal laws govern outcomes. This determinism is (neo)classical in flavour. It presupposes that human behaviour is goal-directed and largely determined by 'programmed' responses (such as maximisation, rationality and instrumentality) to the given circumstances in which individuals find themselves. Such a view however, denies variant behaviour by imprisoning individuals, not only within their immanent and often invariable preference functions and beliefs, but also within the supposed certainty of their social environment (Granovetter, 1973, 1985). As Hodgson and Serepanti (1991:2) argue, such an view is spurious, for "*homo rationalis insatiabilis*…, this pale simulacrum of *homo sapiens*, is a fake. A society simply made up of such molecules of desire is an impossibility." The tendency within marketing to adopt a 'superstitious' belief in determinism is also questioned by Boulding (1987) who argues that all social phenomena (in which information is an essential feature) are unpredictable in some measure, not because of a deficiency in human knowledge, but because indeterminacy is an inherent and unescapable property of information itself.

While gradualism may not have originally been an ideal of empiricism, its elevation to such is not surprising given its logical association with the ideals of reductionism and determinism. These two ideals promote the view that the process aspects of all social phenomena follow a gradual 'progression' between successive (near)equilibrium states. This view manifests within mainstream marketing research

into technological innovation through the S-shaped diffusion curve, the linear routine-like flow of the new product development process, and the neat, tidy and organised depiction of economic and/or social interdependencies associated with industry network formation. While there is no doubt that aspects associated with technological innovation could exhibit and/or experience a smooth progression towards an ordered state, 'gradual equilibrium' is not a fundamental property of system 'progression' in either the natural or social worlds (Prigogine, 1987; Popper, 1990; Gould, 1996). There is ample evidence that the 'progression' of technological innovation is largely a process of jumps, splutters, fits and starts, and is both driven by, and ultimately driven towards, a state of disorder (Sourey, 1989; Robertson and Langlois, 1995; Lynn, Morone and Paulson, 1996; Gatignon and Xuereb, 1997).

The dominance of the mechanistic ideal is readily apparent within much of mainstream marketing research into technological innovation. To some extent, mechanism may be seen as a manifestation of those ideals of 'scientific empiricism' already discussed. The relevant literature is filled with mathematical formulas that attempt to prove that these ideals are central to all cause and effect relationship(s). While the predictive application of mathematical cause and effect modelling to a dynamic phenomenon such as technological innovation is problematic in itself due to its inherent reliance on static parameters (Capra, 1992; Hamilton, 1994; Allen, 1994), the implicit idea of a linear and sequential structure is also suggestive of a somewhat predictable technological innovation process that follows an organised, orderly, stable and rational path. However, this tendentious depiction is at odds with reality, for technological innovation involves novel creativity, an activity that is often irregular, unpredictable, uncertain, seemingly aimless, and often involving abandonment

(Midgley, 1977; Day, 1981; Sourey, 1989; Morris and Lewis, 1995). As Boschma and van der Knaap (1997:178) argue, the fundamental uncertainty that surrounds technological innovation makes it “impossible to predict which major innovations will emerge, by which specific triggers they are induced, and by which elements of the environment they are selected.” While it could be argued that including random probability functions within these models (eg. $x=x+rx[1-x]$) incorporates the discontinuities inherent within novelty, one has to be careful that they don’t become simply a stochastic apology for poor theory construction (Mirowski, 1989; Appleyard, 1992). As Shackle (1972) points out, randomness is not a valid substitute for the mistakes, misunderstandings, blind passions, surprises, and complexities that constitute the social phenomenon of technological innovation. The use of numerical mathematics as a language to explain innovation is also questioned by Sayer (1992:179), who points out that mathematics "lacks the categories of 'producing', 'generating' or 'forcing' which we take to indicate causality".

The arguments presented above are considered as justification of the academic timeliness and relevance of the present thesis in offering an alternative explanation of the process of technological innovation. The general theme of these arguments is that the theoretical frameworks utilised by mainstream marketing for research into the phenomenon are much too simplistic. Many of their theoretical assumptions are flawed and favour analytical tractability for predictive modelling (Lambkin and Day, 1989; Day, 1990; Foxall, 1993; Poolton and Barclay, 1998). This situation may not only be confined to mainstream marketing's research into technological innovation, for as Brown (1996:260) argues;

> Much of post-war marketing scholarship has proved to be a complete waste of time and effort, an heroic but utterly wrongheaded attempt to acquire the unnecessary

> trappings of 'science', a self-abusive orgy of mathematical masturbation which has rendered us philosophically blind, intellectually deaf and spiritually debilitated.

While not as blunt as Brown (1996) on the issue of inappropriate stumblings towards scientific status, a number of other writers have also questioned the decided lack of conceptual variety within the marketing discipline as a whole (Farmer and Mathews, 1991; Alvesson, 1994; Hubbard, 1995; Rogers, 1995; Brown, Doherty and Clarke, 1998; Shane and Ulrich, 2004). The general consensus is that much of the intellectual space sanctioned by mainstream marketing theory is too conservative, limiting, passive, biased, oppressive and sterile, a situation largely due to academic colonisation by the inherent ideals and associated research practice of empiricism. As Arndt (1985) points out, such colonisation seeps over into the endeavours of young researchers, with the majority socialised into accepting as verbatim the 'correct' and 'proper' research objectives and the approaches associated with the scientific empiricist 'ways of doing things'. This lack of questioning within marketing, both with respect to research methodology and in-place explanations/assumptions, is also highlighted by Witcher (1985:23) who argues that "a few less marketing PhD's with the model-hypothesis format is likely to help things; there are far too many competing hypotheses in business research for most of the doctoral work to mean anything." The present thesis, by not only challenging mainstream marketing's current explanations of technological innovation, but by doing so through a relatively novel methodology, is an attempt to offer the discipline a research contribution that gives rise to new descriptions of social phenomenon.

In accepting the need to challenge in-place dogmatic explanations, research must present plausible alternatives that are neither slick, opportunistic, nor conflicting

merely for conflict's sake (Davis, 1971). The alternative explanation developed within the present thesis, based around the broad parameters of an evolutionary perspective, is deemed to offer a number of advantages and improvements over in-place frameworks for technological innovation research within mainstream marketing. These include: a concern with on-going processes over time through long run development rather than short term marginal adjustment; an emphasis on the dynamic rather than static assumption; a focus on underlying quantitative and qualitative mechanisms of change; the linking of different hierarchical levels within technological systems; an appreciation of both competitive and cooperative forces; an affinity with novelty; and the ability to encompass the complexity of tangled structures and causalities (De Bresson, 1989; Mokyr, 1990; Fransman, 1994; Nelson, 1995). While these positive aspects indicate that in taking recourse in an evolutionary perspective the present thesis is not simply playing the 'vocabulary game', no claims are made that this approach is a panacea for technological innovation research. The transposition of philosophical foundations, paradigms, metaphors and puzzle solving approaches from a number of discourses on evolutionary theory to a marketing context opens up problems for both the source(s) as well as the destination.

Much of the social sciences' research into evolutionary theory is contained within a (neo)Darwinian biological framework, the case in point being highlighted by Foss (1997:72) who argued that "too much energy has been invested in the search for precise analogies and isomorphism in the mapping from biological mechanisms to social mechanisms." As argued in previous material, much of marketing's limited foray into evolutionary theory (Tellis and Crawford, 1981; Reidenbach and Oliva, 1981; Henderson, 1983; Holak and Tang, 1990; Foxall, 1993; Hunt and Menon, 1995;

Massey, 1999) exhibits such wasted investment. While there is no doubt that recourse to biology can make a contribution to innovation research, much of the metaphorical transfers from biology to the social sciences are used to bolster existing, and possibly ill-founded ideas, rather than replace them (Hodgson, 2001). The present thesis heeds the call within sections of the evolutionary literature to mix theoretical elements created in different disciplines (Nelson, 1995; Saviotti, 1996; Vromen, 1997), drawing from a broad range of research areas so as to develop a plausible alternative explanation of technological innovation, rather than becoming caught up in a debate as to the theoretical supremacy of any one field of research.

1.5.2 Applied

That the current frameworks used by mainstream marketing to explain the phenomenon of innovation lack a measure of practical relevance has been highlighted within the literature. Del la Mothe and Paquet (1996) argue that much of mainstream marketing's research into technological innovation discounts reality, continuing to emphasise commodities over knowledge, competition over cooperation, rationality over uncertainty in choice, and simplistic stylisations over complexities. Similarly, researchers have pointed out that while the business environment with respect to the generation and diffusion of technological innovation has become more complex and uncertain, marketing research has failed to incorporate these changes (Wind and Mahajan, 1997; Bhuiyan, Gerwin and Thompson, 2004; Hodgson and Knudsen, 2004). While it has been suggested that the alternative explanation of technological innovation presented in the present thesis is not a panacea, it does however, offer some value when applied to policy and management areas as suggested by the following examples.

With regard to government policy, it has been argued that there must be an appreciation of the distinction between policies that take the technological innovation possibilities of firms as given and those that seek to enhance those possibilities (Metcalfe, 1994; de la Mothe and Paquet, 1996). For some time the former category has tended to dominate policy development, the overall aim being the reduction of costs and/or the increase in expenditure on technological innovation through policy means such as R&D subsidies, R&D tax incentives, and the duration and scope of patent protection. Although a policy focus on supply side aspects is warranted, the present thesis argues that it is a false and dangerous logic to assume that increased R&D resources lead to increased linear gains in technological innovation. The possible negative outcome of such a deterministic fallacy is highlighted by MacDonald (1986:269);

> If imbalance in the allocation of resources results in poor returns to innovative effort while belief endures that inadequate funding of R&D is responsible, then a likely consequence is a spiral of greater funding for R&D, greater neglect of other parts of the innovative process, poorer returns and yet more funding for R&D.

Another questionable policy issue is the current fascination with the supposed superiority in innovative behaviour that cooperative industry networks have over large vertically integrated firms (BIE, 1991; Lazonick, 1991; Fulop and Kelly, 1995; Rodan and Galunic, 2004). The promotion and development of these networks is based on the premise that a new orthodoxy of industrial development is emerging, an era of specialisation based on flexible techniques, skilled workers, and new forms of industrial community that will see the demise of the Fordist model of mass production (Piore and Sabel, 1984). However, as Amin and Robins (1990:19) point out, to tout industrial networks as 'hot beds' of innovative activity, whether in the general sense of

a new way of doing things, or specifically as a generator of technological innovation, is a little too grandiose, for

> They are often in fierce competition with each other as a result of close product similarities as well as severe pressures on prices, notably from subcontractors… The producers possess a restricted degree of freedom in the marketplace and receive little support from the rest of the system… 'Flexibility', here, tends to refer to an ability simply to survive and, on the basis of an artisanal capacity, to respond to new designs and new market signals.

There is little doubt that industrial networks made up of small flexible firms can act as the locus for technological innovation (Hakansson, 1989; Lundgren, 1993), however, to presume that such a 'given' organisational context will naturally generate technological innovation is erroneous. Instead, by adopting the more polytheistic context of organisational diversity, there is an explicit call for a policy shift to develop ‘systems of technological innovation’ that include both competitive and collective activities. More importantly, the depiction of technological innovation as basically the evolution of informational understanding is suggestive of a complete shift in policy perspective. Rather than working from the policy premise that a 'given' industry structure generates and diffuses technological innovation through information transformation and transfer, perhaps more pragmatic insight may occur if the initial starting point revolved around the notion that the evolution of information itself may create the most worthy industrial system designs (Lee, 1994; Blauwhof, 1994; Boisot, 1995).

Aspects associated with the broader government policy issues identified above are also considered as having relevance to management, in particular, the development, design, and on-going support of competitive/cooperative relationships with other

institutions. While mainstream marketing literature shows an appreciation of this issue, much of the research is focussed on the individual firm, and neglects pragmatic aspects associated with the broader system of technological innovation (Drazin and Schoonhoven, 1996; Laurent and Nightingale, 2001). The focus of the present thesis on interrelated interdependencies operating within a system of structural and/or functional diversity provides a more 'realistic' contextual environment for managerial understanding of the complexities of technological innovation. Furthermore, by basically considering technological innovation as a nested system that generates and diffuses asymmetrical information, the focus is placed on knowledge management, an area largely neglected within marketing (Glazer, 1991; Slater and Narver, 1995; Moorman and Miner, 1997).

Although there is a need for management to appreciate the systemic or interrelational nature of technological innovation, this appreciation must also be transferred into competitive advantage(s). Burt (1992) argues that such competitive advantage can be gained through the manipulation of the structure of informational interdependencies within which an organisation is embedded, such manipulation being designed to render competition imperfect through linkages to nonredundent knowledge sources. The premise is that while increasing the size of a knowledge source network can mean increased information exposure, to do so also increases the cost associated with the management of the network (ie. information overload, time, access, timeliness). The underlying rationale is that an organisation’s technological innovation system must be designed and developed around other system actors that can supply a diversity of information. Whilst disagreeing with the simplifying assumptions, the network analysis methodology, and the individual firm perspective employed by Burt (1992),

the present thesis supports his underlying premise. That is, management needs to move beyond the simple assumption that technological innovation *per se* enhances organisational performance, and to focus on the proactive management of the system of innovative knowledge in which an organisation is embedded.

While it is hoped that the present thesis will stimulate the imagination of management across a broad range of additional issues associated with technological innovation, perhaps its most important pragmatic contribution relates to the notion of discontinuity. As argued previously, technological innovation has a measure of discontinuity that is more pronounced than current explanations within mainstream marketing explicitly denote (Nonaka, 1994; Vromen, 1997). That such discontinuity occurs is due to the diversity of broad nondiscretionary elements that impact on technological innovation within organisations, including learning, search patterns, information availability and access, knowledge transformation and transfer, and history. Marketing academics and practitioners largely shy away from discontinuous technological innovation, the former group because it is difficult to incorporate into predictive models, the latter group because the risks involved are considered as too high. It is not surprising therefore, "that most innovations are 'me-too' products focussing on product line extensions, improvements to current products, or cost reduction" (Wind and Mahajan, 1997:3). Such risk aversion however, places restrictive limits on an organisation's potential, for the generation and diffusion of novel products and processes is clearly the fundamental driver of growth within contemporary markets (Lynn, Morone, Paulson, 1996; Hodgson and Knudsen, 2004). However, discontinuous technological innovation (whether in the form of entirely new products, processes or businesses) is very different in character from continuous

improvement, and what may be sound business practice in the latter context, may be inapplicable, impractical, or detrimental in the former. While there will never be an infallible formula for 'successful' technological innovations, the present thesis identifies a number of the critical issues and trade-offs that present management with potential opportunities and constraints.

1.6 Conclusion

The central premise of the present thesis is that while there is wide support in the literature with respect to the importance of technological innovation to ‘socio-economic success’, many of the fundamental realities of the phenomenon are not well-understood and/or depicted within mainstream marketing’s current explanatory frameworks. This situation has occurred due to the dominance of scientific empiricist ideals (ie. atomism, reductionism, determinism, gradualism, mechanism) and the associated emphasis on mathematical formalism within mainstream marketing. The central focus of the present thesis has been identified as the development of an alternative explanatory framework of the phenomenon of technological innovation based on an explanation of the process of evolution. A research methodology has been described and defended, and an outline of constituent chapters has been offered. Justification for the relevance and timeliness of the research has been argued across a range of academic and applied issues. The following chapter provides a detailed discussion and defence of methodological issues associated with the current thesis, the central premise flowing from Scriven's (1959) observation that greater weight in the science of complex systems should be placed on explanation rather than prediction.

> It is not the fact that science occurs that gives the world a structure such that it can be known by men. Rather, it is the fact that the world has such a structure that makes science, whether or not it actually occurs, possible. That is to say, it is not the character of science that imposes a determinate pattern or order on the world; but the order of the world that, under certain determinate conditions, makes possible the cluster of activities we call 'science'. It does not follow from the fact that the nature of world can only be *known* from (a study of) science, that its nature is *determined* by (the structure of) science (Baskar, 1998:23).

2.0 METHODOLOGY

2.1 Introduction

This chapter identifies and addresses the methodology utilised for the current thesis by clarifying the philosophical basis, the research design, and the research method used to undertake it. The particular methodology chosen reflects, and is supportive of the purpose of the present thesis, that is, to offer an alternative explanation of the causal mechanisms, structures and contingent conditions of the phenomenon of technological innovation to those currently in use within mainstream marketing. Causality, as understood and applied within the present research, is concerned with explaining a manifest social phenomenon by postulating the essential or necessary features that bring it about. In developing this explanation, the current thesis is not concerned with establishing 'representational facts' of technological innovation through empirically derived observation, but rather with the conceptual development of 'explanatory knowledge' through experience, perspective and interpretation. In adopting such a project, heed is paid to Rorty's (1989, 1991) argument that research methodology should be designed around explaining the 'social reality that is out there', rather than attempting to identify the 'truth that is out there'. As Brown (1995:88) points out, social reality is indifferent to researchers' description of it, and as such, the "truth is made rather than found, a creation rather than a representation of how things really are."

The development of an explanatory framework for technological innovation through conceptual argument dictates a different methodology from the empirically-based approach commonly employed within mainstream marketing research. Such a choice is risky, not because of methodology validation issues *per se*, but rather because methodology within marketing is dominated, both intellectually and politically, by 'scientific empiricism' (Arndt, 1985; Woolgar, 1988; Pickering, 1992; Holbrook, 1998). The arguments presented by these authors are similar in tone to the criticism that Bourdieu, Chamboredon and Passeron (1991:258) offered on dominant methodologies in general, the suggestion being that they become "a series of recipes and precepts that you have to respect, not in order to know the object but in order to be recognized as knowing the object." The following material identifies and offers support for the philosophical stance, underlying research design, and research method that constitute the chosen methodology.

2.2 A *Postmodern* condition incorporating an epistemology of *transcendental realism*

Epistemology, in essence, refers to the various philosophical frameworks that are applied so as to understand and explain a world that is not our own invention. However, in their application the world undoubtedly becomes our own 'reality', for while philosophy allows no limitations on what is questioned, it is also pragmatic in that the different epistemological foundations contain theories of what knowledge is, the process of how it comes into being, and how it is obtained (Gladwin, Kenelly and Krause, 1995). In an attempt to develop a high level of congruence between aspects of methodology and the subject of inquiry, the present thesis adopts a *postmodern condition*.

Postmodernism is essentially a sensibility, predominantly critical, that is gaining an intellectual space within a range of disciplines as a mechanism for dismantling the *corpus* of in-place assumptions and practices (Gergen and Tojo, 1996). The underlying rationale for this new sensibility is a belief that the common assumption of a 'knowable world', explained and controlled through objective means, is somewhat illusionary given the plurality and parallelism of intellectual, spiritual and social understandings. In many respects this belief mirrors the often said; 'the more you learn, the more you realise the less you know', an idea readily apparent within Havel's (1995:47) description of a postmodern world "where everything is possible and almost nothing is certain." Within postmodernism, methodology loses its status as the chief arbitrator of truth because it is inevitably based within a socially- constructed language (ie. metaphysical beliefs, theoretical perspectives, and conceptions of methodology). Therefore research can never be used to verify, falsify, or otherwise justify a theoretical stance beyond that of a commitment to a range of socially embedded conceptualisations (Fay, 1996).

The present thesis is committed to a perspective that views the phenomenon of technological innovation, like all innovative activities, as a complex social process, one that cannot be captured fully in observable characteristics and/or events. Given this perceived 'real-world' uncertainty, the efficacy of a 'scientific' philosophical foundation such as empiricism is inappropriate due to its emphasis on the placement of 'truth' claims over proposed descriptions or explanations (Clegg, 1990). This is not to suggest that in following a postmodern discourse the present thesis is unconcerned with the 'truth', rather it accepts that many social phenomena, and the *explanada* derived from such, are irremediably opaque to objective truth. As such,

postmodernism is deemed to be an appropriate philosophy in which to frame a research methodology (Nooteboom, 1992; Sayer, 1992; Holbrook, 1995; Cornish, 1995). The underlying approach is identified within Brown's (1995:166) description;

> Postmodernism is a way of looking at the world. It is a way of looking askance at the world. Postmodernists offer ambiguity where modernists offer certainty, they seek complexity where their predecessors sought simplification, they find disorder where their forebears found order, they see a glass that is half empty instead of half-full and they challenge convention by refusing to accept the accepted…. In short, they replace the traditional modernists' emphasis on reason, objectivity and control, with unreason, subjectivity and emancipation, with paradox, uncertainty and instability, with a rationale that rejects rationality.

An epistemological basis considered to reflect the condition of both the postmodernist approach and the presumed reality of technological innovation is 'realism', a collective representation that considers knowledge discovery as an all-too-human activity, where experience, perspective, interpretation and rhetoric should prevail, rather than having reliance on the 'scientific' uncovering of immutable facts (Nietzsche, 1955). The notion of 'collective representation' is important given that there is no clear definition of realism, which is subject to "considerable disagreement regarding its very meaning, its implications (on any level of theory or practice, of semantics or ontology), and even regarding its place in the overall structure of the disciplines in question" (Ronen, 1995:184). While realism could be considered as a loose bundle of arguments in opposition to other philosophical positions that are spread across the wider discourse, a level of substance in the form of characteristic claims is offered by Sayer (1992). The claims made by realism are as follows;

- The world exists independently of the knowledge of it
- Our knowledge of the world is fallible and theory-laden
- Knowledge develops neither wholly continuously nor wholly discontinuously
- There is necessity in the world
- The world consists not only of events, but of objects, including structures, which have powers and liabilities capable of generating events
- Social phenomena are concept dependent, requiring not only explanation but understanding

- Science or the production of any other kind of knowledge is a social practice
- Social science must be critical of its object.

While these claims form the ontology of realism in the general sense, the particular epistemology adopted for the current methodology is that which Lawson (1997) has referred to as *transcendental* realism, as distinct from *scientific* realism. The former distinguished from the latter by two additional characteristics. The first additional characteristic of *transcendental realism* is based on the premise that there is more to the reality of a manifest social phenomenon than that which is observable. Such a premise resonates in Hempel's (1966) observation that laws formulated at the observational level are generally poor approximations that only hold within a limited range. The reasoning of *transcendental realism* however goes deeper, arguing that "the world is composed not only of events and states of affairs and our experiences, but also of underlying structures, powers, mechanisms and tendencies that exist, whether or not detected, and govern or facilitate actual events" (Lawson, 1997:20). That social phenomena can and do manifest through unobservable underlying influences is also canvassed by Tsoukas (1993), who points to the undeniable occurrence of countervailing forces and the simultaneous operation of a number of mechanisms that deny empirical observation. The notion that the explanation of causality is problematic when only patterns of observed events are considered is also argued by Bhasker (1975, 1998). He suggests that while all social phenomena are law-governed, many of these laws are intransitive, being independent of human activity and existing and acting independently of our descriptions of them. This is not to suggest that unobservable causal influences on social phenomena are unknowable, for they are introduced into research endeavours as 'thought' objects of knowledge, as distinct from 'real' objects of knowledge. Perhaps the central point of this additional

characteristic of *transcendental realism* is that social reality cannot be taken for granted, and that understanding and/or explanation needs to move beyond the mere 'facts' of observation and experience (Nagel, 1961; Laudan and Leplin, 1990; Enfield, 1991; Outhwaite, 1998). While appealing to observable facts may engender confidence or faith in the 'truth' of resultant explanation(s), such an appeal is an illusion, for at best it is derived from a belief that observation and experience bestow unproblematic access to social phenomena, and at worst, it fails to distinguish factual statements from their referents, nor knowledge from what it is about.

The second additional characteristic of *transcendental realism* is the notion of system 'openness' due to hierarchical stratification and emergence, that is, the idea that social phenomena contain a number of levels that are usually out of phase with each other (Lawson, 1997). This characteristic echoes the central theme of systems theory which posits that all systems, whether natural or social, are constituted and/or maintained by a dynamic process of interaction and interdependency with and between system elements, the system itself, and other systems (von Bertalanffy, 1950; Boulding, 1956; Simon, 1962). Because of system emergence, stratification, and openness *transcendental realism* argues against the explanation of social phenomena through a reductionist approach. On this view, a social phenomenon and the elements that constitute it presuppose each other; they are not the same thing, for neither can be explained in terms of a reduction to the other. Furthermore, imposing hypothetical closure on a social system through logical or mathematical manipulation (in an attempt to explain its causal structure) is merely a flirtation with the 'truth', for it is highly unlikely that the laws governing these kinds of manipulation correspond to the laws governing the nature of the system under observation (Sayer, 1992).

Explanations framed within a *transcendental realism* perspective consider the social system under investigation as being open for it is necessarily peopled, an aspect central to any explanation of technical innovation;

> If, *per impossible*, we could shut the door of any social situation against the intervention of extraneous factors (thus effecting extrinsic closure) we would only have closed in those whose innovativeness enables them to design a new exit or creatively to redesign their environment (absence of intrinsic closure). There is, in short, no such thing as an enclosed order in society because it is not just the investigators but the inhabitants who can engage in thought experiments and put them into practice (Archer, 1998: 190).

This is not to suggest that social totality needs to be evoked in the research of social phenomena, but it does mean that one should have awareness of broader contexts, and in particular, the need for explanations pertaining to micro social systems to connect with explanations associated with macro social systems.

Transcendental realism posits that social phenomenon are generated, retained and/or exhausted through generative mechanisms, structures, and contingent conditions that may 'exist unexercised', a troublesome ‘reality’ issue that can be compounded by a researcher’s 'unrealised exercisation' of such aspects (Archer, 1998). Due to this double research hermeneutic, *transcendental realism* does not find any solace in empirically-based regularity models that basically assume causation of a social phenomenon as a matter of law-like regularities or patterns. As Sayer (1992:136) argues, "what can be promised in terms of the scope for prediction in social science is much less than the orthodox regularity theories claim, but the miserable failure of the latter to achieve accurate prediction attests to the unfeasibility of their programme." The problematic nature of research adopting the 'regularity' assumption is that it usually mixes causation with prediction, justifying and supporting such a consideration through a 'symmetry thesis' in which the empirical operation, which

supposedly predicts the social phenomenon, can be treated as its causal explanation. However, such treatment is spurious, for not only are the laws underpinning the operation (usually statistical analysis) a poor reflection of those underpinning the social phenomenon, causation has nothing to do with the number of times something has been observed to occur, and nothing to do with whether it is able to be predicted (Hodgson, 1993).

To conclude, in choosing an epistemology of *transcendental realism* the current thesis accepts the argument that 'true' knowledge of the realities of social phenomena does not arise solely from sensory inputs in the guise of 'observable facts'. The utilisation of such facts, whether for constructing, testing and/or validating knowledge (ie. theories) can be problematic, for not only is the 'unobserved' missed, but also the use of facts can become tautologous. Indeed, all a theory needs to show that it is true is agreement with the observable facts (Enfield, 1991). Within the epistemology used in the current thesis, knowledge is considered to be meaning, understanding and explanation, rather than registration, measurement and control. As such, it calls for the ongoing questioning of our assumptions and insights, while positing that it is possible to develop increasingly 'adequate' explanations of social reality without the need to identify or resort to empirically generated law-like patterns. In replacing the regularity model with one in which generative mechanisms, structures, and contingent conditions inherent within a social phenomenon may or may not produce predictive regularities, research design selection within a *transcendental realist* epistemology must preclude those approaches based on inductive and/or deductive reasoning. The following section discusses this issue more fully, identifying a research design based on *abduction* and *textual explanation*.

2.3 Research design

While the worthiness of a selected research design within the marketing discipline can revolve around such issues as reliability, generalisability, replicability, and validity, the criterion that appears to be central across all judgements is whether or not the selected design has potential for outcome prediction (Lambkin and Day, 1989; Alvesson, 1994; Brownlie, 1997). This preoccupation with prediction is understandable given that 'accurate' or 'true' knowledge is viewed within mainstream marketing as either the outcome of inductive verification of empirical observations, or deductive empirical falsification of theoretical statements. *Transcendental realism* finds such 'scientific' reasoning processes, both in themselves and as 'truth' assessments, problematic for a number of reasons. Firstly, ascertaining the 'truth' through empirically-based induction or deduction is questionable due to the strong limitations on such reasoning approaches to discover and/or capture the multi-dimensionality of social reality (Riordan, 1998). Limitations within these approaches include the inherent social system aspects of stratification, emergence and openness that restrict observation, in concert with the strong probability that different laws underpin the particular research method and the particular social phenomenon being researched. Secondly, even if empirical evidence of a particular reality could be found, it can never be grounds for selecting one philosophical stance over another, one theory over another, or one method over another, for it ignores the 'underdetermined' status of a discipline's knowledge (Quine, 1953; Snow, 1959; Kuhn, 1962; Lakatos, 1970). That it is 'underdetermined' is due to socialisation pressures, with knowledge largely operating as the 'collective representation or mythologies' of the group. It serves as an organiser of normative activities,

establishing hierarchical boundaries between disciplines, routinising decision making, and ritualising the research process (Fuchs, 1992; Ward, 1995).

As a response to these issues, Lawson and Bhaskar (1998:5) argue that the process of reasoning within *transcendental realism* should not depend on either deduction and/or induction. They posit instead a mode of inference that is 'retroductive', a process that;

> involves drawing upon existing cognitive material, and operating under the control of something like a logic of analogy and metaphor, to construct a theory of mechanism that if it were to work in the postulated way, could account for the phenomenon in question.

This process of reasoning is also supported by a number of prominent theorists across a diversity of disciplines (Whitehead, 1929; Pascal, 1932; Peirce, 1934; Koestler, 1964; Georgescu-Roegen, 1971; Loasby, 1976). All these researchers refer to the process as *abduction*. The common theme in their questioning of induction and/or deduction as supposedly superior modes of inference is the belief that experiment and observation play only a minor role in the generation and/or assessment of theory. Induction does little more than determine a value for a presupposed aspect of reality, and deduction merely involves the application of an assumed law of reality to a social context (Hodgson, 1993; Emami and Riordan, 1998). In applying the *abduction* mode of inference within the current research design, two separate, but interrelated reasoning principles, are addressed.

The first principle refers to 'abducting' the necessary relations, conditions and properties of a social phenomenon that are deemed to be essential, rather than most general, to its existence and efficacy (Sayer, 1992). The rationale for this principle of *abduction* recognises the limitations of researchers to cognitively manage the complexity inherent within open systems due to the influence(s) of numerous, often

countervailing causal mechanisms, while at the same time grasping enough complexity so as not to lose substantive content. Abduction in the realist sense is in sharp contrast to abduction undertaken in the social sciences in general, for within the latter the process "seems mainly to mean something like forming artificial constructs, or fictionalising" (Lawson, 1989:70). Such an argument could be directed at much of mainstream marketing's research into technological innovation, for it abounds with abducted artificial constructs and fictions such as perfect competition, rational expectations, perfect foresight, symmetrical information transfer, and so forth. In essence, this first principle of *abduction* is concerned with identifying enduring causalities that govern the flux of social phenomenon, with such causalities holding not only in thought but also in the real world.

While the first principle of *abduction* is concerned with 'what' is to be the focus of research, the second is concerned with 'how' this is to be accomplished. Within the methodological context of *transcendental realism* abduction refers to a logic of reasoning based on analogy and metaphor (Bhaskar and Lawson, 1998). The use of this logic within a realist research design is largely due to its inherent focus on the generation of theory rather than testing of such. As alluded to earlier, the ability of inductive and/or deductive reasoning to deliver theoretical novelty is limited as they restrict research endeavours to 'observable facts' and/or 'covering laws'. Such restrictions are deemed to place knowledge accumulation in a somewhat static state, as distinct from being in a continual discovery process that requires constant revision.
The use of analogies or metaphors 'abducted' from different areas of social reality and/or discourse so as to furnish new insights and understandings is canvassed within a diversity of literature (Peirce, 1934; Quine, 1951; Black, 1962; Laudan, 1977;

Hesse, 1980; Hodgson, 1993). This use of ‘abduction’ within the research design is also congruent with the focus of the thesis itself, for “we see the explanation when we discern the identity, recognizing that what is going on is nothing other than something already known. But to *have* the explanation it is necessary that what is apparently different be really the same” (Kaplan, 1964:338). The underlying premise is that knowledge should be viewed as a web, network, or class of models which is brought into being through the juxtaposition of two (or more) frames of reference, a view that resonates in Nietzsche's (1979) notion of truth as a 'mobile army of metaphors'. Central to this process of cross-fertilisation of disparate ideas through metaphorical reasoning is textual explanation, for "all reality is shaped and must pass through language and representation" (Ward, 1995:118).

That *textual explanation* should provide the foundation in the development of explanatory frameworks is supported by a number of researchers (Harre, 1986; Douven, 1996; Calhoun, 1998), the theme of their arguments encapsulated within Outwaite's (1998:291) assertion that;

> common-sense descriptions of social phenomena can and must be taken as a starting point in social scientific theorising. *Can*, because they provide the beginnings of definitions of the phenomena and this helps in the otherwise bewildering activity of objective constitution… given the mish-mash nature of social reality. *Must*, because however imperfect they may be, to the extent that they are the perceptions of agents involved in that situation they will influence the very nature of that situation.

This promotion of the legitimacy and importance of *textual explanation* does not devalue numerically-based research, but rather supports the belief that the current research design needs to exhibit a 'linguistic' basis, as distinct from a 'numerical' one. Mathematics is not the language of discovery in the context of the current thesis. The social phenomenon of technological innovation is as yet undefined, with its nature and underlying causalities still open to debate (Nelson, 2003; Hodgson and Knudsen,

2004). Therefore research design should be framed within a why, what, how, where and when format so as to tease out subtleties of meaning, understanding and explanation (Kaplan, 1964). As Sayer (1992:263) argues, the task of explanation requires "a rich vocabulary, not one purged in the interest of scientific neutrality, of terms that seem either too mundane or too ‘literary’; rather than 'literal' " (Sayer, 1992:263).

In conclusion, the chosen research design is compatible with, and supportive of, both the purpose of the current thesis and the *transcendental realist* epistemology that provides its research foundation. The reasoning process of *abduction* directs the research to 'what' is to be explained and offers a basic approach as to 'how' this is to be accomplished. The incorporation of *textual explanation* within the research design, while a natural extension to the process of *abduction*, also provides the linguistic framework which is deemed central to the construction of a more plausible explanation of technological innovation than that currently displayed within mainstream marketing. While accepting that the social reality of technological innovation is largely an unfathomable riddle, it is argued that the research design outlined above will at the very least provide an *entrée*. However, to capitalise on this, an appropriate research method is required, an aspect which is addressed in the following section.

2.4 Research method

Research method in mainstream marketing is commonly depict as a structured linear sequence of stages, a collection of boxed activities, usually incorporating introduction, literature review, hypotheses, analytical methodology, results,

discussion, conclusions, and limitations. Brown, Doherty and Clarke (1998) liken the quasi-ritualistic adherence to these strictures as akin to the reverence bestowed on 'religious totems'. However, while adherence to this demi-god of research design may offer a sense of confidence with respect to the validity of research, it does not necessarily deliver 'truthful' knowledge, nor is it necessarily a 'truthful' depiction of the research process itself (Nagel, 1961; Campbell, 1969). As Brown (1995:176) notes, in promoting the (seemingly) logical and rigorous research methods of the physical sciences, "academic marketing has downplayed and de-emphasised… creativity, spontaneity, adaptability and individual insight." Holbrook (1998:251) concurs, arguing that research method within marketing has "devolved to a repetitive and obsessively literal-minded condition of inveterate blandness." While the research method identified in the following material may be considered by some to lack the linearity of 'scientific' rigor deemed 'correct' within mainstream marketing, such a view is ill-formed. Rather, in attempting to generate new and/or different understandings of reality, the research journey is more important than the particular route taken (Popper, 1959).

The construction of theoretical frameworks is described by Dubin (1978) as an attempt to impose some measure of ordered understanding on unordered experiences, these experiences being both external (ie. social phenomenon under examination) and internal (ie. mindset of those undertaking the examination). Both sets of experiences have inherent complexities and bringing them together in the research process will only heighten complexity, such that resolution will not be found through rational means alone. It is argued, therefore, that research method in the context of explanatory framework generation is never rational, instrumental or linear, but rather,

a dynamic process of editing, winnowing, and shifting that attempts to resolve and bring together subjective (eg. imagination, passion, curiosity, puzzlement) and objective (eg. familiarity, opportunity, practicality, relevance) factors and influences. In many ways it is like putting a jig-saw puzzle together without first seeing the complete picture, a process that Campbell (1962) refers to as 'ideational trial and error'. Each of the jig-saw pieces constitute intriguing bits of information which are not easily placed until a new idea or a new piece of information stimulates curiosity to find some pattern to these bits. This conceptualisation of the somewhat chaotic process realities underlying knowledge accumulation is in essence the research method of the current thesis. The following material discusses this issue more fully, identifying the tools and techniques used to assemble some degree of order within the process.

2.4.1 Questioning in-place theoretical assumptions as a starting point

For research to find some semblance of communality with the body of knowledge associated with a particular phenomenon, an initial identification or familiarisation with the frame of reference must be made (Blauwhof, 1994). Such familiarisation offers an understanding, to both the researcher and reader, of where the research is coming from, and more importantly, where it is going. Notwithstanding the logic of an initial frame of reference, the question of which particular topic to investigate, and where such investigation should start, are vexed issues. That this is the case is due largely to research being very much a value-laden exercise, a process influenced by the complex interrelationships of cognitive, intellectual, technical, cultural, social and historical characteristics of both the researcher and his/her environment (Feyerabend, 1975). To overcome the possible tendency for knowledge generation to degenerate

into a highly subjective 'sermon from the mount', some measure of objective assessment of the validity of the research area and associated point of departure must form the initial element of the research method. In essence, without a clear understanding of what is to be explained, one cannot assess the validity of any subsequent output.

Determination of validity with respect to research methods is problematic within the social sciences. The issue generating most concern within the literature is whether or not social science research can achieve a degree of validity roughly comparable to that supposedly achieved in the 'hard' sciences (Calder and Tybout, 1999; Wilson, 2003). Given that the social sciences are largely concerned with human behaviour (which is not subject to the laws of physics like atoms and such like), it seems logical to assume that this is not possible. Supporting such a view Lindblom (1987:513) argues that within the social sciences "scientific validity would be a great prize if it could be won," yet pursuing such a prize is "foolish in the same way that attempting to fly without mechanical aids is foolish." However, the pursuit of scientific validity is readily apparent within much of the marketing literature, the issue highlighted by Brown's (1996:244) conclusion to an examination of the 'Marketing as Art or Science?' debate, where it is suggested that "the pursuit of 'scientific status' and the academic legitimacy it confers, has been the *leitmotif* of post-war marketing scholarship." Such a pursuit can be seen in the fervent focus on computer-driven analytical techniques within mainstream literature to the extent that statistical packages such as SPSS and SAS have become the conceptual prisms through which marketing views the world. While the employment of various significance tests may indeed offer 'scientific' validation to mathematical procedures and outcomes, Lawson

(1989:75) offers a caution with respect to extending such validity to the 'supposed' reality they describe; "the nature of data, the criteria of fit, the degrees of freedom in model specification, and so on, are such that a total fiction can be found to 'fit' the specific set of data to hand! We could deduce little more."

That such 'fitting' commonly occurs can be seen in the tendency for much of marketing research to focus on any research issues that facilitates the use and/or testing of particular mathematically-based research designs, rather than on developing a specific research design so as to ‘better’ study a particular issue (Alba, 1982; Paulson, 1985; Marsden, 1990; Galaskiewicz and Wasserman, 1993). The general situation has been eloquently described by Rogers and Kincaid (1981:295) as "an invisible college of toolmakers looking for a nail to pound." Notwithstanding the contentiousness of placing the 'cart before the horse', there is also the tendency for research framed within a mathematically-dominated research design to be driven by problem-solving, a tendency which has a number of shortcomings. Firstly, it unduly narrows the research topic area to the solution of an *a priori* determined problem (Ziman, 1987). Secondly, the rationality of the 'scientific' problem-solving approach is dismissive of other research methods and the reasons as to why they might provide insights (Whetten, 1989). Thirdly, it depicts research method as somewhat mechanistic, linear and sequential, with little or no appreciation of the sometimes intuitive, blind, wasteful, and creative character of the research process (Weick, 1989). Lastly, and perhaps most importantly, while the use of a numerically based research design may result in inventive discovery;

> its application involves logical syllogism rather than real theoretical novelty. Furthermore, by focussing attention on the formalistic chain of reasoning, rather than implicit categories or fundamental assumptions, mathematics encourages theoretical

> conservatism rather than innovation, despite any gains that may be made in terms of elegance and precision (Hodgson, 1993:16).

A common alternative to 'scientifically' determined research methods, particularly with respect to validity of research topic selection and starting point, is the utilisation of commonly held beliefs. 'Shared beliefs' or paradigms not only define the appropriate field(s) of inquiry, but also the associated laws, theories, applications and analytical techniques applicable to that inquiry (Sterman, 1985). However, the utilisation of shared belief as a basis for the selection of research method within marketing, has been attracted criticism due to over-tones of 'ideological dominance' (Belk, 1986; Rogers, 1987; Holbrook and O'Shaughnessy, 1988; Firat, Dholakia and Venkatesh, 1995). For example, in an examination of the *Journal of Consumer Research* from 1980 to 1990, Hirschman (1993:537) concluded that "consumer research inadequately represents the worldviews of social classes other than the middle class, of racial groups other than whites, and of occupational groups other than the managerial-professional group." That an accepted orthodoxy can evolve from an inappropriate ideology due to social group dominance, legitimate or otherwise, has been recognised for some time;

> …human understanding when it had once adopted an opinion draws all things else to support and agree with it. And though there may be a greater number and weight of instances to be found on the other side, yet these it either neglects and despises, or else by some distinction sets aside and rejects, in order that by this great and pernicious predetermination, the authority of its former conclusions may remain inviolate. (Francis Bacon, 1620; 1960: quoted in Zaltman, LeMasters and Heffring 1982:26)

In many respects the utilisation of a widely-held belief within a discipline as validation of a particular research method, and in particular, when used to validate an initial frame of reference, can be tantamount to adding another grain of sand to an

existing mountain of sand. While knowledge accumulation may indeed occur through a rational process of cumulative sequential additions to the existing knowledge stockpile, to adopt continuity as the sole perspective on knowledge progression is problematic. The belief that knowledge progression is a steady, organised and stable process of accumulated 'truth' has a long history of explicit and/or implicit criticism within the social sciences (Quine, 1953; Nietzsche, 1955; Nagel, 1961; Carnap, 1967; Putnam, 1978; Latour, 1987; Lawson, 1997). The critique is encapsulated within Bhaskar's (1998:16) comments on the paradox of science, which claims;

> That men in their social activity produce knowledge which is a social product much like any other, which is no more independent of its production and the men who produce it than motor cars, armchairs or books, which has its own craftsmen, technicians, publicists, standards and skills and which is no less subject to change than any other commodity.

The premise that knowledge accumulation is a social process, and, therefore, subject to the vagaries of human nature, challenges the traditional view of knowledge progression as a neat and clean process, positing instead the combination of both continuity and discontinuity. Perhaps more important is the argument that continuity in thinking acts largely as an unconscious suppressant of novel theory generation, whereas discontinuity in thinking is a conscious questioning of in-place assumptions (Kuhn, 1962; Enfield, 1991).

Questioning in-place, widely-accepted theories is not a commonly held orientation within the marketing discipline as testified by the comments of Sheth, Gardner and Garrett (1988:29);

> One of the weaknesses in the development of marketing thought has been the lack of metatheory evaluation and noncritical acceptance of previously proposed theories. Marketing theorists do not consistently attempt to critique other theories to identify their strengths and weaknesses when they formulate their own theories.

As to why this may be, the American Marketing Association (1988:6) identified the significant contribution of the ‘publish or perish’ mentality, arguing that it "has led to conditions under which a significant contribution to knowledge may not be at the forefront of most participant's thoughts as they engage in the research and publication process." Hunt (1994:15) suggests that such a scenario is very typical of marketing, arguing that "quite inconsistent with non-marketing reviewers and non-marketing journals, marketing reviewers react quite negatively when a manuscript offers a genuine original contribution to knowledge." In a similar vein, Baker (1994) argues that much research within the marketing discipline is analogous to that of Levitt's (1983) *'marketing myopia*', with research being directed almost exclusively by the survival needs of the individual researcher, rather than the discipline as a whole. The suggestion is that, while some publications demonstrate innovative scholarship, many are created from a personal desire for salary increases, promotion, enhanced employment mobility, tenure and the like. This is inimical to knowledge development. The possible solutions offered by Armstrong (1995), such as changes to the reward system within academia, journal support of unorthodox or high-risk research, editorial de-emphasis on quality control, and so forth, may indeed lead to an increase in the publication of innovative papers. However, mainstream marketing literature offers little on appropriate research methods for developing such innovative publications.

In conclusion, research method within the marketing discipline is characterised by the ‘scientific empiricist’ approach that supports research design based on either mathematical tractability and/or the preservation of paradigmatic positions. Within such an approach the 'correct' research design is one that emphasises the supposed rationality and objectivity of the easily replicated theory-observation (induction) or

covering-law (deduction) formats. The elevation of such research designs to axiomatic status has led to a situation in which the theories, whether in support of, or supported by such inductive and/or deductive formats, have themselves become axiomatic (Day, 1990; Lowe, Carr and Thomas, 2004). That in-place and widely-held theories within mainstream marketing have assumed the mantle of uncontested dogma, and are therefore stifling its knowledge progression, has been argued by a number of authors (Morgan, 1980; Zaltman, LeMasters and Heffring, 1982; Arndt, 1985; Day, 1990; Brown, 1996; Wind and Mahajan, 1997). The conclusion reached by these authors is that the 'generative capacity' of the marketing discipline lies in (re)considerations of what is taken for granted. The present research method adopts as its starting point such a challenging stance to in-place theory and associated assumptions within mainstream marketing. The following section identifies a number of criteria that can be incorporated into a research method so as to provide guidance in this challenge.

2.4.2 An *interesting*, *plausible* and *acceptable* challenge

Zaltman, LeMasters and Heffring (1982) appreciate the problematic issues associated with research method in mainstream marketing as identified above. In particular, they bemoan the lack of guidance available to young marketing researchers who attempt to generate new theories, explanations and/or understandings. Instead the dominance of a ‘scientific empiricist’ orientation within the discipline tends to focus marketing's intellectual concerns primarily on applied issues that are amenable to mathematical assessment. Their argument is not that this orientation is wrong, rather that its sway has tended to unbalance the marketing discipline such that the richness of theoretical variety, long considered the wellspring of intellectual endowment and progress

(Popper, 1966), is being constrained by the conceptual, analytical and numerical uniformity of ‘scientific empiricism’. More recent contemporaries concur (Day, 1990; Alvesson, 1994; Baker, 1995; Brown, 1996; Brownlie, 1997), though some go a little further in their condemnation of ‘scientific empiricism’;

> The vast bulk of contemporary marketing scholarship comprises little more than intellectual necrophilia… all of the discipline's long-dead ideas, decomposing concepts and mouldering metaphors are being recuperated, resuscitated, reanimated and recycled in a frantic, forlorn and utterly futile attempt to demonstrate that there is life after Kotler (Brown, Bell and Carson, 1996:11).

Zaltman, LeMasters and Heffring (1982) argue that the 'generative capacity' of marketing needs to be fostered, and point to the challenging of commonly accepted theories and associated assumptions and the development of plausible alternatives as a good starting point. This notion has been canvassed by a number of writers (Lundberg, 1976; Mohr, 1982; Poole and Van de Ven, 1989; Daft and Lewin, 1993), with many drawing on the work of Davis (1971), whose seminal piece sought to answer the question; 'What makes a theory good?' Most common answers to this question relate in some manner to the criteria of 'truth', however, Davis (1971: 309) believed this approach to be inappropriate, suggesting instead the criteria of *'interesting*';

> A theorist is considered great, not because his theories are true, but because they are *interesting*. Those who carefully and exhaustively verify trivial theories are soon forgotten; whereas those who cursorily and expediently verify interesting theories are long remembered. In fact, the truth of a theory has very little to do with its impact, for a theory can continue to be found interesting even though its truth is disputed - even refuted!

The question then becomes 'what makes a theory interesting?'. To provide a possible answer, Davis (1971) examined a number of theoretical assertions that are widely circulated both within and outside his discipline area. The common element identified is negation, that is, "an *interesting* proposition was one which attempted first to

expose the ontological claim of its accredited counterpart as merely phenomenological pretence, and then to deny this phenomenological pretence with its own claim to ontological priority" (Davis 1971:311). In effect, a good theoretical contribution is one that questions/tests past 'taken-for-granted' assumptions based on new assumptions (ie. what seems to be *X* may in reality be non-*X*, or what is accepted as *X* may actually be non-*X*). A schema was proposed by Davis (1971), identifying a number of logical categories of interest (Table 2.1). It is the contention of the present thesis that these categories could either individually, or in concert, form the basis for a challenge to marketing's in-place assumptions with respect to technological innovation. Of specific interest are the categories of *form (B)*, *separation* (*B*), *abstraction (A)*, *organisation* (*B*), and *stabilisation* (*A*). In a broad sense, these identified categories could be used to challenge the ideals of atomism, reductionism, mechanism, determinism and gradualism that dominate marketing research into technological innovation. However, the aforementioned categories will be used to challenge a number of specific theoretical assumptions underpinning marketing's explanatory frameworks of technological innovation.

Table 2.1 Categories for Studying the Interestingness of Propositions

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1. Form
- A. What appears to be a multidimensional phenomenon is in reality a unidimensional one
- B. What appears to be a unidimensional phenomenon is in reality a multidimensional one

2. Measurement
- A. What appears to measure a concept well does not
- B. What does not appear to measure a concept well does

3. Evidence
- A. What was considered evidential support for a position is not
- B. What was not considered evidential support for a position is

4.Methodology
- A. What seems to be an appropriate methodology is not
- B. What seems to be an inappropriate methodology is appropriate

5. Assertion
- A. What seems to be an underlying rationale for an act is not
- B. What seems not to be an underlying rationale for an act is

6. Values
- A. What seems to be an objective assessment of a phenomenon is in fact value-laden
- B. What seems to be a value-laden assessment of a phenomenon is in fact objective

7. Separation
- A. What appears to be inseparable are separable
- B. What appears to be separable are inseparable

8. Supply
- A. What appears to be a fixed resource is not
- B. What does not appear to be a fixed resource is

9. Abstraction
- A. What seems to be an individual phenomenon is in reality a holistic phenomenon
- B. What seems to be a holistic phenomenon is in reality an individual phenomenon

10. Organisation
- A. What seems to be a disorganised (unstructured) phenomenon is in reality an organised (structured) phenomenon
- **B.** What seems to be an organised (structured) phenomenon is in reality a disorganised (unstructured) phenomenon

11. Composition
- A. What seems to be assorted heterogeneous phenomena are in reality composed of a single element
- B. What seems to be a single phenomenon is in reality composed of assorted heterogeneous elements

12. Generalisation
- A. What seems to be a local phenomenon is in reality a general phenomenon
- B. What seems to be a general phenomenon is in reality a local phenomenon

13. Stabilisation
- A. What seems to be a stable and unchanging phenomenon is in reality an unstable and changing phenomenon
- **B.** What seems to an unstable and changing phenomenon is in reality a stable and unchanging phenomenon

Table 2.1 Continued

14. Function
- A. What seems to be a phenomenon that functions ineffectively as a means for the attainment of an end is in reality a phenomenon that functions effectively
- B. What seems to be a phenomenon that functions effectively as a means for the attainment of an end is in reality a phenomenon that functions ineffectively

15. Co-Relation
- A. What seems to be an unrelated (independent) phenomena are in reality correlated (interdependent)
- B. What seems to be related (interdependent) phenomena are in reality (independent) phenomena

16. Co-existence
- A. What seems to be phenomena that can exist together are in reality phenomena that cannot exist together
- B. What seems to be phenomena that cannot exist together are in reality phenomena that can exist together

17. Co-Variation
- A. What seems to be a positive co-variation between phenomena is in reality a negative co-variation between phenomena
- B. What seems to be a negative co-variation between phenomena is in reality a positive co-variation between phenomena

18. Opposition
- A. What seems to be similar (nearly identical) phenomena is in reality opposite phenomena
- B. What seem to be opposite phenomena is in reality similar (nearly identical) phenomena

19. Causation
- A. What seems to be the independent phenomenon in a causal relation is in reality the dependent phenomenon
- B. What seems to be the dependent phenomenon in a causal relation is in reality the independent phenomenon

Source: Adapted from Zaltman, G., LeMasters, K. and Heffring, M. (1982)

While application of the *interesting* criterion within the research method is deemed to be an appropriate mechanism for determining the starting point and possible direction for research endeavours, one can still be left with the impression that research is a relatively straightforward rational process. Indeed, Zaltman, LeMasters and Heffring's (1982) depiction of the process using a three-stage format compounds such an impression. Their schema operates as follows. Firstly, locate a category within the typology of interesting propositions that is considered appropriate to the problem being studied. Secondly, specify the assumption ground currently accepted as 'truth'. And thirdly, show that what was thought to be true might, in reality, not be true at all.

To some extent this approach is an example of what the aforementioned authors wish to avoid within marketing research, that is, problem solving as a continuous process that utilises linear and mechanistic staging, with each stage an outcome based on a selection of 'best fit' through purely rational means. Not only is this process inappropriate *per se*, but it is also a poor reflection of the realities of theorising, a mental activity that is conditioned by variations in human perception, thought and scholarship (Simon, 1962). The process underlying research method is not a staged sequence of ordered thought. This fact is highlighted in Bourgeois's (1979) depiction of thinking as a 'sticky swim through a morass of simultaneous interactions of subjective and objective reality'. This 'stickiness' is very evident in the current thesis, for unlike an empirical study which is inclined to attribute a large number of measurements to a small number of variables, what is required is the concurrent manipulation of a large number of constructs that span a broader hierarchy of abstractions.

While the *interesting* category provide a basis for challenging marketing's in-place assumptions with respect to technological innovation, one still needs to develop plausible alternative theoretical assertions without alienating those that support current assertions. This is a difficult proposition, for as Davis (1971:343) notes, "there is a fine definite line between asserting the surprising and asserting the shocking, between the interesting and the absurd." Thus, within the *interesting* approach an alternative theoretical assertion is not merely a conflicting point of view, nor is it an invitation to engage in opportunistic, slick theorising, for both are counter productive to symbiotic or mutually beneficial learning. So as to add a level of rigour to the research design beyond that of the *interesting* criterion, two additional criteria are

utilised. The first acts as a measure of theoretical *plausibility* with respect to both the explanation of evolution (Chapter Four) and the generated explanatory framework (Chapter Five), and the second acts on both as a judgment about audience *acceptability*.

The research design element of *plausibility* is addressed through the utilisation of selection criteria proposed by Weick (1989:525), such criteria being a number of questions that are asked of the theoretical conjectures raised during the process of explanation/explanatory framework generation; "thus plausibility is a substitute for validity, the process of theory testing by an experimental test is mimicked by the process of conjecture testing by an assumption test." Theoretical conjectures raised within the generation process are tested by the following questions;

- *Real*: are the essential features of the theoretical explanation a combination of experience, practice and convention?
- *Obvious*: are the essential features of the theoretical explanation significant or trivial?
- *Connection*: are all the essential features of the theoretical explanation interrelated?
- *Believable*: is the theoretical explanation lifelike, coherent and verisimilar?
- *Beautiful*: is the theoretical explanation elegant?

While not a research method issue in the normal sense, the notion of public *acceptance* is an important consideration with respect to research that challenges widely-held assumptions. While the logic underpinning the research methodology in the present thesis can provide a strong buttress against dissenting voices, such an argument has no validity if the alternative explanation fails to reach the intended audience. To this end, a number of selection criteria suggested by Whetten (1989) as pertinent to publishability are utilised within the research method as surrogates for *acceptability*. These include;

- *What's new*: does the alternative explanation make a significant, value-added, and different contribution to current thinking?
- *So what*: does the alternative explanation offer a solution for remedying alleged deficiencies in current theoretical explanations?
- *Why so*: is the alternative explanation built on a foundation of convincing argumentation and grounded in reasonable, explicit views of human nature and organisational practice?
- *Well done*: does the alternative explanation reflect seasoned thinking, conveying completeness and thoroughness?
- *Done well*: is the alternative explanation well written so that the arguments are logical and easily accessible?
- *Why now*: is the alternative explanation contemporary?
- *Who cares*: does the alternative explanation address an issue of broad audience interest?

It has been argued that the strictures of commonly used research methods would limit the present thesis for they favour theory validation rather than knowledge generation. Developing an alternative explanation of the causalities underpinning social phenomenon is analogous to artificial selection, a trial-error process that Weick (1989) has argued can easily lead to misrepresentation(s) without some discipline being applied to this imaginative process. So as to provide some level of structure to the thought process that underpins the present thesis, a research method has been developed which incorporates the criteria of *interesting*, *plausibility* and *acceptability*. The first criterion of *interesting* provides a number of propositional characteristics which can be used as the basis for and direction of an alternative explanation. This is an important research method consideration in the current context, for the proposed challenge to in-place assumptions is based on an alternative explanation with respect to the underlying causalities of technological innovation, one that is quite distinct from those assumptions widely held with mainstream marketing. The second criterion of *plausibility* is essentially a validation measure, consisting of a number of questions that are directed at conjectures raised during the construction of the alternative explanation. The inclusion of this criterion within the research method offers a level

of deliberation and shows respect for a process that is bounded by the researcher's frame of reference. The third criterion of *acceptability,* while not directly contributing to theoretical merit, is an objective format that operates as a counter to audience alienation.

2.5 Conclusion

Although there is strong support for the proposition that knowledge accumulation is a process incorporating constant selection between competing views (Kaldor, 1972; Feyerabend, 1975; Galbraith, 1987), within marketing, "the presence of contrary or contradictory assumptions, explanations, or conclusions is often viewed as an indication of poor theory building, and theorists are encouraged to devote their efforts to carefully defined and delimited analysis" (Poole and Van De Ven 1989:562). While not denying the need for and value of rigour and coherence within research, there is a tendency for the supposedly 'scientific empiricist' methodologies common to mainstream marketing to assume the mantle of preordained strictures. That this has occurred is not the result of privileged access to reality and/or the superior explanatory power of these strictures, but rather due to the social/political power of 'scientism' such that it has been able to establish its symbolic and methodological structure as supreme (Latour, 1987; Fuchs, 1992; Ward, 1995). However, such faith in 'scientific empiricist' methodology, and its inherent focus on 'observable facts', has the potential to blind marketing to social phenomena as they really are, confining research to an "academic tower like the Lady of Shalott, only able to view the world via a reflection in a mirror" (McAuley, 1998:217). In an attempt to overcome these largely conceptual confines, the methodology of the present thesis is a marked departure from

that commonly employed within marketing in general, and its research into technological innovation in particular.

To establish a high level of congruency between the purpose of the research, the perceived characteristics of the social phenomenon being investigated, and the methodology employed to undertake the investigation, the lens of *postmodernism* is adopted. While postmodernism has been criticised as a collection of 'episto-babble' (Hunt, 1994), its embrace of ambiguity, uncertainty and chaos is in keeping with the process of generating novel explanation(s). The present thesis accepts Feyerabend's (1975) argument that 'anything goes' in knowledge progression, though such a position does not necessary mean that ‘anything goes’ with respect to knowledge itself. This principle of variety is embodied in a methodology framed within a postmodern perspective, which does not accept;

> that there is one particular way of doing things and one way only.… we should exercise the cut of judgement in the absence of rules, emphasis the importance of pragmatism, provisionality and local forms of knowledge, and revile in the proliferation of incompatible language games (Brown, 1995:88).

So as to ground the somewhat abstract nature of postmodernism, the epistemology of *transcendental realism* forms the conceptual basis from which the explanation of technological innovation is generated. In adopting such an epistemological stance, the present thesis argues that the social reality of technological innovation is more than that which is immediately observable due to issues of system emergence, stratification and openness. In identifying and explaining causalities within such an epistemology, the research methodology requires an ontology distinct from the regularity model of prediction. The emphasis is on why technological innovation happens, what actually occurs, how it occurs, and possibly the ‘when and where’ of this occurrence. The

ontology underpinning the conceptualisation process of this thesis views knowledge not as a 'mirror' of reality, or a 'fixed set' of propositions, but rather as a web of understandings, an 'ill-defined map' if you will, that allows researchers to cope with reality and to research this reality.

In developing an explanatory framework that represents the realities of technological innovation, a research design based on *abduction* and *textual explanation* is used. As the purpose of the current thesis is the generation of a novel explanatory framework, it is believed that such novelty is better served by shifting out of the paradigmatic frameworks which mainstream marketing uses to explain technological innovation. Subsequent chapters will cover this issue detail, using an amalgamation of ontological imputations and theoretical assumptions abducted from a number of (sub)disciplines. While the use of 'truths' from other areas of discourse may be viewed as merely ornamental and substitutes for plain thought, Black (1962) has argued that metaphorical transfer is a distinctive mode for achieving insight. Tsoukas (1989) also points out the high level of external validity that is derived from incorporating a broader field of knowledge into the subject area.

Specifically, the notion of *abduction* is based on two concepts, the first of which refers to the abstraction of those explanatory aspects that are considered as essential to the causality of technological innovation. While this first concept gives insight into 'what' needs to be explained (that is, the essential causality mechanisms, structures, and contingent conditions of technological innovation) the second concept is concerned with 'how' such causality influences are to be explained. As the current thesis basically views technological innovation within a context of evolving open and

dissipative system complexities, it is thought that a narrative approach is best suited for the explanation process. That this novel conceptualisation of technological innovation is formed within a *textual explanation* should not be dismissed as 'merely semantic' or 'academic', for it is fundamental to constructing models of social reality (Dubin, 1978; Metcalfe, 1994). Given that the current thesis is an attempt to produce solid research into technological innovation phenomenon by combining and working up insights from a range of theories, such a textually-based approach is neither antithetical to theory, nor synonymous with narration.

The adopted research method is different from that commonly employed within mainstream marketing. Indeed it may be seen as a logical outcome of the thesis' purpose, over-arching philosophical stance, methodological epistemology and research design. Congruence of research methods with that which has gone before, is a platitude rather than a practice within marketing (Alvesson, 1994; Holbrook, 1998), and this malaise seems endemic the broader social sciences;

> it is quite extraordinary to compare the attention given in social science courses to 'methods' in the narrow sense of statistical techniques, interviewing and survey methods and the like, with the blithe disregard of questions of how we conceptualise, theorize and abstract (Sayer, 1992:2).

So as to offer a measure of discipline to a conceptualisation process that requires a large measure of imagination, the research method incorporates three broad criteria of *interesting*, *plausibility*, and *acceptability*. The first criterion offers a basis from which to develop and direct an alternative explanation, the second criterion provides a number of characteristics to test the validity of conjectures raised in this explanation, while the third criterion suggests features that may possibly engender audience acceptance of such an explanation.

To conclude, the methodology of the current thesis is predicated on knowledge generation being a process of 'ideational trial and error', the dynamic interplay of variant information creation, of selecting possibilities from this diversity of information, and preserving those that seem plausible in the face of current realities, while allowing some measure of openness such that the explanation is adaptable to future understandings. Paradoxically, these dynamics of methodology provide both a basis for the challenge to in-place assumptions within marketing with respect to technological innovation, and allow the formulation of the proposed alternative explanatory framework. The common approaches within mainstream marketing to explaining technological innovation are based within diffusion, new product development, or network theories. These frameworks explicitly or implicitly explain the phenomenon as a rational process that results in a gradual progression towards an eventual state of (near)optimality or stable equilibrium. Notwithstanding that "equilibrium is a figment of the human imagination and stability is largely the result of a defect in our time perception" (Boulding, 1987:115), much of mainstream marketing research continues to conceptualise technological innovation through such a comparative-static perspective that over-emphasises its neat, organised and stable qualities. The purpose of the current thesis is to show that such an explanation is not only a flawed, lifeless representation of the 'realities' of technological innovation, but to also offer a plausible alternative based on evolutionary causalities that may be found within the dynamic interdependency between variation, selection and preservation. The following chapter addresses the first issue and shows how current explanations of technological innovation within mainstream marketing are flawed representations.

> In searching for academic elegance or in protecting themselves against professional criticism, even the best scholars have spread themselves widely over the important and also the expendable (Galbraith, 1987:1).

3.0 'FAMILIARISATION': MAINSTREAM MARKETINGS' EXPLANATORY FRAMEWORKS FOR TECHNOLOGICAL INNOVATION RESEARCH

3.1 Introduction

Material was presented in the previous chapter arguing the general merits of the methodology used in the current thesis in developing explanatory frameworks. It was further argued that the central tenet of this chosen methodology (challenging existing widely-held assumptions with plausible alternatives) should be applied to mainstream marketing thought with respect to the phenomenon of technological innovation. The rationale for this argument rests on the proposition that the treatment of technological innovation within mainstream marketing is contained exclusively within a 'scientific empiricist' orientation of unattached objectivity, rationality and measurability. However, it is argued within the present thesis that the 'objective truth' deemed to flow from this orientation requires theoretical assumptions that have little in common with the reality they attempt to explain. It is further argued that these assumptions are essentially atomistic, reductionist, deterministic, gradualist and mechanistic in nature, and while some of these assumptions may be appropriate in specific circumstances, their broad application by mainstream marketing across the spectrum of technological innovation research is at best questionable.

The adherence by much of marketing to a 'scientific empiricist' orientation, and its associated research filters of paradigms, metaphors and puzzle-solving practice(s), has also limited the development and/or appreciation of possible alternative explanations.

It has been suggested that this adherence is largely sociological, and is due mainly to the general failure within the marketing discipline to critically evaluate in-place theories so as to identify their particular strengths and weaknesses. Pool and Van de Ven (1989:563) point out;

> …researchers are adjured to perfect their theories and to test them. As they do this, there is a tendency for the theory to dominate researcher's thinking. The researcher must focus on the theory, iron out its problems, work out measurement techniques, test the theory and revise it, and defend test against criticism. As a result, the theory tends to bind the researcher's judgement. The researcher develops a 'trained incapacity' to appreciate aspects not mentioned in her or his theory.

As a counter to this singularity in research approach, the present thesis adopts a methodology deemed more appreciative of the imaginative aspect of theory generation, while at the same time offering a conceptualisation framework that is both valid and harmonious with the subject matter being researched. This methodology requires a familiarisation with the marketing literature on technological innovation. This overview of current explanations is undertaken so as to identify shortcomings or paradoxes within in-place explanations (within the context of *interesting* categories), which may then be used to stimulate the development of plausible alternative explanations.

3.2 Mainstream marketing's frameworks for technological innovation research

Most analysis, whether theoretical or empirical, must start somewhere, and have some stocks of historical material such as theories, methods, hypotheses, and data on which to draw. Within explanatory framework construction this material is construed as the 'ecology' of a discipline. It identifies what is considered as 'known' about a particular phenomenon. Familiarity with this material is an essential platform for both challenging in-place explanations and associated theoretical assumptions, and developing plausible alternatives (Davis, 1971). While familiarising oneself with the

technological innovation literature, its sheer volume and diversity could easily result in an epistemological tangle. That such a voluminous body of material exists is readily apparent within the work of Rogers (1995), and although much of this material is based within the broader sociological perspective, marketing-orientated research on technological innovation ranks second in terms of volume of publications. Given that such a large body of literature pertaining to technological innovation exists within the marketing discipline, some method of selectivity is required so as to identify dominant frameworks and commonly held theoretical assumptions.

By familiarising oneself with the literature, one can identify and examine the broad paradigms and associated metaphorical representations that underpin research by mainstream marketing into the phenomenon of technological innovation (Merton, 1968; Weick, 1974; Pinder and Moore, 1980). This level of analysis is necessary as it identifies commonly-accepted explanation(s) of a phenomenon, along with the inherent theoretical assumptions that support the propositions that guide lower level theoretical/empirical inquiry (Lawson, 1989). A relatively high level of consensus with respect to these aspects is what constitutes the currently accepted 'truths' within mainstream marketing literature. Although there are explicit notions about 'what' should be of concern within the familiarisation process (ie. *interesting* categories), suggestions as to how far back such familiarisation should go and whom to include, are not so explicit. This is a particularly thorny dilemma, for the marketing discipline has a somewhat longer and ill-defined history than that commonly portrayed. Although there is little doubt that marketing-orientated research into technological innovation was apparent at the turn of the century, the emergence of a coherent body of innovation literature did not occur until the late 1950s (Sheth, Gardner and Garrett,

1988). The surge in innovation research during this period is quite noticeable, and as such, can provide the temporal starting point for the exploration of theory. With respect to whom to include, Merton's (1968) suggestion to read the 'masters' in the field of inquiry seems appropriate, though what constitutes a 'master' is open to interpretation. Achieving the required level of familiarity is possible through an exploration of those researchers who have not only published extensively in the area, but more importantly, whose research into technological innovation forms the basis for other research endeavors.

In this regard, the work of Rogers (1962, 1971, 1983, 1995) chronicling innovation research from a number of disciplines, provides a fertile ground for exploration. His work has had an explicit and profound influence, one readily apparent in many marketing journal articles and texts. In addition to Rogers, a number of other researchers are deemed to have had a profound influence on marketing thought with respect to the phenomenon of technological innovation. Those selected to include in this familiarisation process are Booz, Allen and Hamilton (1960, 1968, 1982), Bass (1969; 2004), Midgley (1976, 1977), Crawford (1983, 1991), Saren (1984), Granovetter (1985, 1992, 1995), Mahajan, Muller and Bass (1990), Wind and Mahajan, (1988, 1997), Snelson and Hart (1991), and Archol (1991,1997). While the choice of this limited group of 'masters' is open to criticism, the aforementioned authors have been selected because their work has been the catalyst for the majority of marketing's research into technological innovation. Furthermore, without such a narrowing of the field, the familiarity process could easily become a disjointed and irrelevant morass. Through an examination of the literature, three dominant explanatory frameworks have been identified: encapsulated within the metaphorical

representations of ‘diffusion’, ‘new product development’ and ‘network’. The following material explores these frameworks, examines their particular essential characteristics and identifies deemed shortcomings with respect to theoretical explanation and current realities.

3.2.1 Diffusion Theory

The utilisation of diffusion theory to both explain and examine aspects associated with technological innovation has both a long history and a diversity of (sub)discipline contributions. Up to the late 1950’s the bulk of innovation research was undertaken by the Anthropology and Sociology disciplines, with both focussing on diffusionism, that is, the introduction of innovations from outside a particular society as an explanation for change(s) within said society (Griliches, 1957). Subsequent diffusion research tended to dispense with the ‘outside’ distinction, equating innovation to the diffusion of any idea, product, process or practice among members of a social system (Midgley, 1977). The sheer volume of diffusion research is chronicled in the work of Rogers (1962, 1971, 1983, 1995), a body of thought that has been influential in directing marketing’s research into innovation from the early 1960's to the present day (see Table 3.1). Diffusion theory, as applied to much of the early innovation research within mainstream marketing, is essentially a model of communication. This fact is readily apparent in Roger’s (1962:12) widely accepted definition of ‘diffusion’ as “the process by which an innovation is communicated through certain channels over time among members of a social system.” This definition pays homage to the research of Ryan and Goss (1943) that conceptualised innovation as an adoption process driven by information sharing within a population.

Table 3.1 Traditions of research on Diffusion of Innovations

TRADITION	PUBLICATION NUMBER	TYPICAL INNOVATIONS STUDIED	METHODOLOGY	UNIT OF ANALYSIS	FINDINGS
Anthropology	141	Technological ideas (steel axe, horse)	Observation/Case study	Tribes/villages	Consequences/Relative success of change agents
Early sociology	10	City manager government, Postage stamps, ham radio	Secondary sources/ Statistical analysis	Communities/ Individuals	S-shaped adopter distribution/ Adopter characteristics
Rural sociology	845	Agricultural ideas (weed sprays, hybrid seed)	Survey interviews/ Statistical analysis	Individuals in rural communities	S-shaped adopter distribution/ Adopter characteristics/ Attributes of innovations and rates of adoption/Communication channels
Education	359	Teaching and learning Innovations	Survey interviews/ Statistical analysis	School systems/ Teachers/Admin	S-shaped adopters distribution/ Adopter characteristics
Public health/ Medicine	277	Medical and health ideas (drugs, CAT scan)	Survey interviews/ Statistical analysis	Individual/hospitals	Opinion leadership/Adopter characteristics/Communication
Communication	484	News events, Technological Innovations	Survey interviews/ Statistical analysis	Individuals/ Organisations	Opinion leadership/Adopter characteristics/Communication/ Diffusion networks
Marketing/Management	585	New products (coffee, fashions)	Survey interviews/ Statistical analysis/ Field experiments	Individual consumer	Adopter characteristics/Opinion leadership
Geography	160	Technological innovations	Secondary records/ Statistical analysis	Individuals/ Organisations	Role of spatial distance
General sociology	322	New ideas	Survey interviews/ Statistical analysis	Individuals	Adopter characteristics
General economics	144	Technological innovations	Economic analysis	Individual/ Organisations	Economics of technological innovations
Other traditions	563	____	____	____	____
TOTAL	3,890				

Source: adapted from Rogers,E.M. (1995) *Diffusion of Innovations* (4ed) New York:The Free Press

In modelling this process of diffusion, much of the early research applied the mathematics of epidemiology, and in doing so, depicted the process as an S-shaped cumulative distribution over time. Such a distribution is based on the assumption of cumulatively increasing influence and/or pressure upon an individual to adopt or reject an innovation as a result of the activation of peer networks (Montgomery and Silk, 1971). The 'bell-curve' explanation of innovation diffusion, and its pictorial representation (Figure 3.1), dominates much of the current research conducted by marketing into aspects of innovation (Gatignon and Xuereb, 1997; Bass 2004). The 'bell-curve' thesis is a broad paradigmatic theme within the marketing discipline and has provided the basic explanatory framework for a large body of research into aspects of technological innovation. The majority of this research can be grouped into three interrelated areas of enquiry.

Figure 3.1 Symmetrical diffusion of an innovation based on adopter categories

Figure removed due to copyright restrictions

Source: Rogers (1995:263)

The first area of enquiry (which could be termed 'the innovation-decision process') focuses on the internal mental processes that can lead an individual to adopt/not adopt an innovation. Such a process is also deemed to be applicable to aggregated individuals and will therefore have a determining effect on the rate and speed of a technological innovation's diffusion through a population (Baker et al; 1998). Though there are variations on this 'hierarchy of effects' model of decision- making, most marketing research adopts the innovation-decision process proposed by Rogers and Shoemaker (1971) which identified the following cognitive stages;

- Stage 1 *Knowledge*: the individual is exposed to the innovation's existence and gains some understanding of how it functions
- Stage 2 *Persuasion*: the individual forms a favourable or unfavourable attitude toward the innovation
- Stage 3 *Decision*: the individual engages in activities that lead to a choice to adopt or reject the innovation
- Stage 4 *Confirmation*: the individual seeks reinforcement for the innovation decision they have made, but may reverse previous decision if exposed to conflicting messages about the innovation.

The 'innovation-decision process' model is based on the assumption that adoption/non adoption of an innovation results from the cumulatively increasing influence on an individual's cognitive processes due to the activation of peer networks, and as such, can be depicted as a normal distribution curve (Rogers 1995; Bass, 2004). In essence, this particular model is concerned not so much with the diffusion of a technological innovation *per se*, but rather the diffusion of information *about* such an innovation within a social system. This is readily apparent in the research, which concerns itself largely with the influence(s) of mass advertising, word-of-mouth and opinion leaders on cognitive processes, and by extension, on the diffusion rate of a technological innovation into a population (Mahajan, Muller and Bass, 1990; Sheth and Sisodia, 1999).

The second area of research could be termed ‘adopter categorisation’ and focuses on the characteristics of individuals as major determinants of the rate of diffusion of an innovation. The premise for much of this research is the basic adopter categorisation scheme initially proposed by Rogers’ (1962), and identified in Figure 3.1 above. In this scheme the ‘innovativeness’ of a population, that is, the willingness and ability to adopt technological innovations, can be represented by five basic categories (ie. innovators, early adopters, early majority, late majority, laggards). Qualification or fit into these categories is primarily assumed to be the result of social factors, which are scaled on dimensions such as socioeconomic indices (eg. wealth, education, social status), inner-directed personality traits (eg. empathy, logic, rational) and communication behaviours (eg. social participation, interpersonal networks, exposure to mass media).

In depicting the rate of diffusion as a normal distribution curve, assumptions are made about the cumulative effects of information flow. However, also inherent within much of the research is the notion of ‘imitation’ which refers to the assumption of social status, and in particular, the idea that *innovators* are a group to which others in the population aspire to belong. The ‘adopter categorisation’ model is fertile ground for marketing to research technological innovation, with the majority of papers focusing on the identification of additional socio-economic factors which explain ‘innovativeness’ and its influence(s) on information flows, and by default, rates of technological generation and diffusion (Donnelly and Ivancevich, 1974; Lilien, Rao, and Kalish, 1981; Gatignon and Robertson, 1989).

The third major area of enquiry based on the ‘bell-curve’ thesis could be termed ‘product characteristics’. It focuses on the relationship(s) between a technological innovation’s attributes and the rate of its diffusion. Much of the research in this area is based on the work of Rogers and Shoemaker (1971) that viewed a technological innovation’s attributes as essentially product information. A major aspect of this work was the concept of tacticity, that is, the notion that the ease with which information pertaining to an innovation is assimilated, will have an influence on benefit determination, acceptance and communication. Given that a large number of attributes could be associated with a single technological innovation, the authors prescribed a number of selected characteristics. These are;

- *Relative advantage*: the degree to which an innovation is perceived as being better than the idea it supersedes
- *Compatibility*: the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters
- *Complexity*: the degree to which an innovation is perceived as relatively difficult to understand and use
- *Trialability*: the degree to which an innovation may be experimented with on a limited basis
- *Observability*: the degree to which the results of an innovation are visible to others.

As for the communication effects identified in the ‘innovation-decision process’ and ‘adopter categorisation’ models, product attributes are thought to induce a normal distribution diffusion effect within a population. The less tacit the information pertaining to a technological innovation, the greater the flow of information about such, and therefore the greater likelihood of cumulative effects. Although this particular area of diffusion research is not as common in the literature, an acceptance of the classification scheme proposed by Rogers and Shoemaker (1971) is apparent in research predicting diffusion rates and/or identifying additional classification

dimensions (Mahajan and Muller, 1979; Lancaster and Taylor, 1986; Rao and Yamada 1988).

There is little doubt that diffusion theory is the dominant influence on mainstream marketing thought with respect to explanations of the technological innovation process (Rogers, 1995; Bass 2004). Given that the marketing discipline is concerned principally with market behaviour(s), this is hardly surprising. However, there is a sound basis from which to challenge the validity and usefulness of diffusion theory, both in itself, and as an explanatory framework for research into the processes of technological innovation. Most models of diffusion are reliant on over-simplified concepts and heterogenous samples to test their validity and usefulness. Such simplification is erroneous due to the diverse variety of forms, capabilities and economic effects that come into play during the metamorphosis of even mildly complex technological innovation (Gold 1990; Becker and Knudsen, 2005).

Problems with diffusion theory *per se* can be best exemplified by the Bass (1969) forecasting model, a model that has been the basis for upwards of 120 studies within the marketing area (Bass, 2004). It is used as an explanatory approach to test specific diffusion hypotheses, or as an analytical approach to predict the spread within a market of a technological innovation. Basically, the Bass model accepts that diffusion within a social system is a symmetrical process (ie. a bell-shaped curve), which is essentially the result of two types of information flow, mass media and interpersonal word-of-mouth. The workings of the model are very similar to that used to explain diffusion within epidemiology, the basic structure of diffusion being characterised by point of inflection (ie. mean) and symmetry (ie. normal standard deviation).

Notwithstanding the fact that a bell-shaped distribution is an ‘ideal’ that is very rarely achieved in reality (Midgley, 1976; Rink and Swan, 1979), the Bass model actually adopts such an 'ideal' as reality;

> The noncumulative adopter distribution peaks at time T*, which is the point of inflection of the S-shaped cumulative adoption curve. Furthermore, the adopter distribution assumes that an initial pm (a constant) level of adopters buy the product at the beginning of the diffusion process. Once initiated, the adoption process is symmetric with respect to time around the peak time T* up to 2T*. That is, the shape of the adoption curve from T* to 2T* is the mirror image of the shape of the beginning of the diffusion process up to T* (Mahajan, Muller and Bass, 1990:2-3).

While such a curve offers desirable statistical properties, its empirical application requires a number of theoretical assumptions (Bass, 2004) that are based on analytical parsimony, rather than on any close approximation to reality. These assumptions (and the current thesis’ challenges based on the *interesting* categories previously identified) include;

- The market potential of technological innovation(s) remains constant over time (*stabilisation A*)
- The diffusion of a technological innovation is independent of all other innovations (*separation B*)
- The nature of a technological innovation does not change over time (s*tabilisation A*)
- The geographical boundaries of the social system do not change over the diffusion process (*stabilisation A*)
- The diffusion process is binary (*form B*)
- Product and market characteristics do not influence diffusion patterns (*causation A*)
- There are no supply restrictions (*supply B*)
- There is only one adoption by an adopting unit (*abstraction A*) .

Perhaps the most problematic issue with diffusion theory when applied as an explanatory framework for technological innovation research is its treatment of information. As stated earlier, diffusion theory is essentially a theory of communication that has changed little since Shannon and Weaver’s (1949) *The Mathematical Theory of Information*, which attempted to quantitatively define and

measure information as a probability function incorporating a reduction in uncertainty. In marketing research, innovative behaviour and level of uncertainty are supposedly synonymous. As such, it is commonly proposed that the degree of innovation diffusion can be ascertained through the aggregation of individual decisions of system actors about whether the value of collecting additional information is greater than the cost of obtaining it (Mahajan, Muller and Bass, 1990). Leaving aside the fact that this proposition relates more to the level of risk than to uncertainty, it explicitly suggests that every system actor is not only a recipient of the same information, but also understands it in the same manner. While it is possible in some circumstances to consider information as uniform data, once it is within the realm of the human mind it becomes subject to influences such as contextual meaning, learning, experiences, and so forth which give rise to information flow asymmetry (Lave, 1993). These influences suggest that diffusion theory's treatment of information can be challenged on the *interesting* categories of *values A* and *supply A*.

While the previous comments relate to problematic issues that arise with respect to 'information flows *about* an innovation', there are even more problems when a technological innovation itself is conceptualised as information. This (re)conceptualisation of technological innovation is indicated by a shift from its depiction as an idea, practice or object to one that views 'innovation' as synonymous with 'technology'; "technology is information and transfer is a communication process, and so technology transfer is the communication of information" (Rogers, 1995:12). While it is accepted that 'technology' and 'information' should be considered as largely inseparable concepts in technological innovation research,

much of the research fails to make a conceptual distinction between the ‘practical utility’ that is technology, and the ‘intellectual understanding’ that can arise from information (Galbraith, 1967; Nelson and Winter, 1982; Mokyr, 1990; Vincenti, 1991; Mort, 1994). Of principal concern is the direct transference to technological innovation of the ‘common pool’ depiction of information. The result of such transference is that much of the diffusion-based research into technological innovation views the innovation itself as a ‘black box’, the contents of which can be assumed to be common information knowable by all population members. However, to considered information, even that supposedly ‘objective’, as uniform understanding is nothing more than situational determinism (Nonaka, 1990; Glazer, 1991; Moorman and Miner, 1997). To do this is to dismiss the different interpretive schemas, heuristics, motivations, learning (sub)systems, and so forth, that are used to assign meaning(s) to information (Burns and Stalker, 1961; Cyert and March, 1963; Argyris and Schon, 1978), and as such, is open to challenge on the same *interesting* categories offered above.

In conclusion, diffusion theory is beset with theoretical problems, particularly when used as an explanatory framework for technological innovation research. Quite simply it fails the ‘truth in logic’ test that underpins the challenges of the *interesting* categories. The theory is based on simplistic assumptions that perceive a reality of *constancy* and *homogeneity*, a perspective that discounts the complexities associated with technological innovation, and indeed with all innovative activity. Most models of diffusion are based on the erroneous conception that the process is akin to filling a bottle. They presuppose that a ‘given’ and ‘unchanging’ technological innovation is progressively adopted by a ‘given’ and ‘homogeneous’ population (Gold, 1990;

Knott, 2003). This conception is supported within the marketing discipline by the overwhelming desire for mathematical ease, as amply demonstrated by Midgley's (1976:34) simply formulae depicting diffusion as a constant linear proportion (ie. dx/dT=JX, where J is a constant), and the subsequent proviso that; "Undoubtedly this is too simplistic an approach but it was thought desirable to reduce mathematical complexities." However, such a conception promotes atomism and reductionism at the expense of system interdependency, and over-emphasises determinism, gradualism and mechanism by promoting analytical tractability at the expense of useful explanation. As a result, much of the research within marketing is lop-sided, with bias towards an organised and stable representation of the technological innovation process.

The lack of questioning of the perspective, concepts and associated theoretical assumptions of the diffusion framework has led to a self-serving situation, where the dominant ideals of 'scientific empiricism' have become synonymous with 'truth'. Such a situation is insightfully captured within Boulding's (1987:115) observation that "the principle that nothing fails like success is a key to understanding human epistemology, simply because success does away with the need for learning." The 'success' of diffusion theory has done little to increase understanding of the technological innovation process within the marketing discipline (Knott, 2003). In fact, it is argued that by adopting a research agenda that focuses on the prediction of diffusion rates, there is a lessening of understanding. This is the paradox of models of prediction, for the less explanation contained within the model, the more precise the model's predictive results. However, it is a moot point whether such simplistic predictive models are more precise than pure guesswork (Dubin 1978; Hodgson,

1998). An explanatory framework that is seemingly directed towards a 'better' understanding of technological innovation, and which has wide application within the marketing area, is that associated with new product development.

3.2.2 New Product Development Theory

While not as dominant as diffusion theory, models arising from 'new product development' (NPD) research have had a major influence on marketing thought with respect to explaining the process of technological innovation (Kennedy, 1983; Craig and Hart, 1992; Wind and Mahajan, 1997; Bhuiyan, Gerwin and Thompson, 2004). As for most, if not all of the explanatory frameworks utilised within marketing, NPD research is a composite of theoretical ideas and empirical research 'abducted' from other discourses. Of particular influence are early management ideas on 'instrumentality' as an explanation for organisational development, and in particular, the notion of pre-specified ends, these ends being expressed as goals, with the means to achieve them regarded largely as rational and purposeful behaviour (Luthans, 1973). The adoption of the 'instrumentality' metaphor within marketing was cemented by the work of McCarthy (1960) and Kotler (1972), with both championing the cause of market behaviour as a rational endeavour based on clearly articulated and understood needs and/or end states.

In concert with the utilisation of management theory, marketing research into NPD has also 'abducted' heavily from research examining the reason(s) for inter-industry growth variations. The major conclusion of this work was that the accepted factors within the standard production function model (ie. capital, labour, and/or shifts in

productivity function) only explained about one-eighth of economic growth. While research identified a number of exogenous factors (including increased education, growing employment and capital output levels, knowledge advancement and economies of scale) the dominant explanation of economic growth was held to be differences in R&D expenditure (Solow, 1957; Schmookler, 1966; Mansfield, 1968). Similar to the subsequent research direction taken by management theorists, much of the NPD-orientated research in marketing attempts to identify the prime mover(s) of this expenditure, debating whether the motivation stems from market-forces (demand pull) or from the very essence of scientific discovery (technology push) itself (Witcher, 1985; Sourey, 1989; Hamel and Prahalad, 1994). It is strange that such a debate should occur, as many of the often-cited studies in support of one argument or the other, either acknowledge the need for a balance of both supply and demand factors, or qualify their findings through the identification of research biases that impacted on causality explanations (Langrish, Gibbons, Evans and Jevons, 1972; Downs and Mohr, 1976). Notwithstanding this 'push/pull' debate, research associated with new product development is somewhat more fragmented than that associated with diffusion theory. This is reflected in Nijssen and Lieshout's (1995) observation that if one considers all possible versions and modifications of NPD models and methods, over 600 different types can be identified. A somewhat more manageable classification is that proposed by Saren (1984) which identifies five distinct conceptual models within the literature;

- *Departmental stage model*: views the process in terms of the departments or functions that hold responsibility for tasks to be carried out
- *Activity stage model*: views the process as series of activities carried out by various departments or functions
- *Decision stage model*: views the process as a series of information evaluation points that attempt to reduce uncertainty
- *Conversion model*: views the process as a 'black box' transformation of inputs into outputs

- *Response model*: views the process as one of acceptance or rejection of the change bought about by internal and/or external stimulus.

Within mainstream marketing the activity stage model appears to exhibit the highest appeal and utilisation, with Booz, Allen and Hamilton's (1960, 1968, 1982) model cited most frequently (see Table 3.2). This particular model explains technological innovation as a formal system of managed key core activities revolving around the stages of idea generation, screening, business analysis, development, testing, and commercialisation. Within the marketing literature the process is usually represented as a 'means-end rationality' process (Figure 3.2).

Figure 3.2 Stages in the New Product Development Process within Organisations

Figure removed due to copyright restrictions

Source: Kotler, Armstrong, Brown, and Adam (1998:390)

Table 3.2 An analysis of the NPD process based on Booz, Allen and Hamilton (1982)

Figure removed due to copyright restrictions

Source: Hart and Snelson (1989)

While the somewhat simplistic depiction of the NPD process as a neat, linear, and positivist progression dominates this particular area of technological innovation research within the marketing literature, a number of researchers have offered models that show more awareness of the complex 'realities' of the process (Poole, 1981; Crawford, 1983; Cooper, 1988; Achrol, 1991; Day, 1994; Gatignon and Xuereb, 1997; Gerwin and Barrowman, 2002). In particular, these researchers have argued that NPD should be considered as a process involving both continuous (ie. known) and discontinuous (ie. unknown) aspects, for as Snelson and Hart (1991:203) point out, "each stage or phase of development is capable of producing numerous outputs which implicate both previous development work and future development progress." The aforementioned authors also point out that the complexity of the NPD process is further compounded by the existence of related strands of development. These related strands of development refer to possible parallel activities occurring simultaneously within a number of functional areas as the NPD process unfolds.

Utilising 'new product development' as an explanatory framework for technological innovation research has wide support within the marketing discipline, based largely on a belief that the approach offers a 'better' understanding of the underlying process. To some extent this is true and especially so in those models representing NPD as parallel streams of activity, rather than a unitary sequence (Gerwin and Barrowman, 2002; Bhuiyan, Gerwin and Thompson, 2004). Also, the NPD framework incorporates a greater appreciation of the nexus between the generation and diffusion elements of technological innovation than that offered by diffusion theory. However, as for the diffusion framework, the NPD approach has problems in both its theoretical basis and empirical application.

It was argued earlier that NPD owes much to early management theory, and in particular, theoretical contributions based on symbolic constructs drawn from the 'instrumentality' metaphor. The central tenet of this metaphor is 'means-end rationality', which manifests as the theoretical assumption that a structured connection between desired ends and appropriate means of attainment can be determined *a priori* through rational thought. The notion of 'instrumentality' is open to challenge on the *interesting* categories of *organisation B, form B, assertion A, values A, organization B* and *co-relation A* as highlighted by Simon's (1957:264) argument that;

> the means-end hierarchy is seldom an integrated, completely connected chain. Often the connection between organization activities and ultimate objectives is obscure, or these ultimate objectives are incompletely formulated or there are internal conflicts and contradictions among the ultimate objectives, or among the means selected to attain them (Simon, 1957:264).

Despite the tensions associated with 'means-end rationality' as a theoretical concept, it is at the fore in most empirical research into the NPD process, primarily as a result of the focus within this research area on 'successful' technological innovations for which research data is readily available. Such a focus however, leads inevitably to numerical cause and effect modelling, the aim being to predict such success based on the influence (or otherwise) of perceived causality factors such as product champions, resource expenditure, efficiency of evaluation and screening systems, and methods and sources of idea generation. The predictive ability of numerical cause and effect models is quite limited, for they are constructed from essentially fixed causal relations (ie. model parameters) that exist between 'given' system elements at a 'given' time (Allen, 1990). In this situation any prediction(s) are questionable because there can be little confidence that the computations traced from the initial 'given' system elements are precise enough, or that these initial conditions

themselves have been defined/identified with sufficient clarity or precision (Prigogine and Stengers, 1984; Braun, 1992; Hodgson, 1993). There is also the broader issue of mathematical cause and effect models as generators of explanation;

> The use of mathematical models as an aid to causal explanation is inevitably problematic because, as a language, mathematics is acausal and astructural. It lacks the categories of 'producing', 'generating' or 'forcing' which we take to indicate causality. Mathematical functions such as $y = f(x)$ say nothing about what makes y or x, only that quantitative variation in y is formally (not substantially) related in some way to quantitative variation in x. The = sign in an equation does not, of course, mean that the so-called 'independent variable' is the cause of the changes in the 'dependent variable', but merely that the quantities on either side are equal! (Sayer, 1992:179).

The underlying theme of the majority of NPD research is a story of winners, a singularly positive representation that suggests the history of technological development has followed an orderly and rational path. Such a suggestion is ludicrous, because by extension, it implies that today's human realities were the goal toward which all decisions, made since the beginning of history, were consciously directed.

Although the NPD literature exhibits a strong theoretical rhetoric aimed at broadening the process of technological innovation to explicitly include both generation and diffusion aspects, this seldom happens in empirical research. In a review of NPD research within marketing, Wind and Mahajan (1997) argue that much of it has a lopsided focus on internal organisational aspects, with particular emphasis on technological innovation generation through technology push that occurs ostensibly within a single organisation due to increased R&D expenditure. The authors also highlight another dichotomy between theory and empirical research;

> The traditional stage gate process, despite the disclaimers that it is not designed to be linear, often turns out to be just that, in effect serving as a funnel that screens out new product ideas, concepts, and products that do not meet some a priori criteria (or that seem too risky) (Wind and Mahajan, 1997:7).

This is perhaps the central problem with the NPD explanatory framework; it represents technological innovation, whether market pull or technology push, as a structured process of orderly, rational and logical sequences that ultimately produce a ‘successful’ conclusion. Such a representation is hardly surprising given that most of the research is retrospective and positivist in nature. The former aspect raises three shortcomings in research. Firstly, the studies depend entirely upon either the availability of documentation or the recollection of participants in the NPD process. Secondly, due to this dependence upon limited or ‘fuzzy’ data sources, the studies tend to focus on just one step, usually that associated with research and development. Thirdly, due to the nature of the data sources, the studies give the impression that the steps are deterministic because serendipitous and/or accidental aspects are unlikely to be fully documented or acknowledged by participants. The latter aspect, positivism, refers to the emphasis within NPD research on 'successful' technological innovations due to the ready availability of research data. Adopting a retrospective and positivist approach in research is fraught with danger, for as Rogers (1983) points out, there is a strong tendency for results to become little more than self-fulfilling models dreamed up in the researcher’s mind.

The present thesis argues that as the NPD process may be ongoing without any definable beginning, middle and end, and with a number of possible outcomes, this brings into question the ‘classic’ task-by-task, function-by-function models commonly accepted and promoted within mainstream marketing. These models, in attempting to prescribe the necessary steps to ‘successful’ technological innovation, are akin to ‘looking in a dark room for a black cat that isn’t there’. Such futility is highlighted by Jewkes, Sawers and Stillerman’s (1958) whose simple conclusion is

that the process of technological innovation is always thorny, and as such, there are no short cuts to success, no infallible formulae. Echoing this view, Snelson and Hart (1991:143) argue that while the literature on NPD makes interesting reading, the growing consensus that technological innovation is a dynamic and complex process makes it difficult to "reconcile the traditional task-stage gate models… with these newer findings." While these models highlight key process activities to be accomplished in technological innovation, the theoretical assumption of an underlying structured process of pre-determined, rational and logical sequences appears invalid with respect to current known realities of the technological innovation process (Odagiri, 1997; Nelson, 2003; Hodgson and Knudsen, 2004).

Perhaps the most problematic issue with NPD models is boundary specification. While the models show appreciation of the influence of external entities on the process of technological innovation through information links with other entities in the value chain, the level of analysis is basically that of the firm. Theoretical and empirical insights into the phenomenon of technological innovation can be gained at the individual organisation level, but the underlying assumption within much marketing research is that the firm is basically an island of self-supporting innovative activity, a view that is considered no longer relevant, if indeed it ever was (Nelson and Winter, 1974; Pavitt, 1984; Allen, 1988; Van de Ven and Garud, 1994; Vromen, 2001).

While the call to move beyond the level of the firm so as to gain a better understanding of technological innovation has been apparent for some time in the literature (Alchian, 1950), a resurgence is currently occurring. There is an increased

(re)appreciation that competitive success through innovative activity is a function of an organisation's ability to perceive itself as part of an evolving industrial system, and to realign its strategic intent as a result of such a perception (Chesnais, 1986; Garud and Van de Ven, 1989; Porter, 1990; Carlsson and Jacobsson, 1991; 1994). Many product markets, and in particular those of a technological nature, are experiencing a form of dynamism that requires a shift in strategic focus from reacting to change, to one of proactive flexibility. Within such environments competitive advantage through technological innovation is largely determined by the strategic management of information, not only within the organisation, but also more importantly, between the organisation and other entities within its technological system. The boundary of this system needs to be broader than the buyer-seller relationships depicted in NPD models (Carlsson and Stankiewicz, 1991), and the context should include entities that interact in the innovation process to provide instrumental (ie. suppliers of applied R&D, manufacturing, marketing and distribution services), resource (ie. basic scientific or technological research, financing, venture capital and human resources) and institutional support (ie. organisation of industrial R&D, academic infrastructure, government agencies, trade associations). It is improbable that the continuous-discontinuous interrelationships of information generation, accumulation, transformation and transfer occurring within such a system could be incorporated successfully within the current framework of NPD.

In conclusion, the NPD models commonly found within mainstream marketing literature, while identifying some of the important tasks/activities and required information inputs associated with technological innovation, are far too simplistic

with respect to their explanations of the underlying process. To compound the problems associated with this organised and stable view of the process of technological innovation, the models are basically framed within an atomistic context of the individual firm. While interdependency between organisations is apparent in the models, the focus is placed only on those relationships between the individual firm and others with whom it has direct contact. Such an approach treats the environment not as a complexity of interdependence, but rather as a faceless whole, with the firm in relationship to this whole. An attempt to overcome the limitations of socio-economic rationalism and system decontextualisation inherent in NPD models is apparent within a small section of the marketing literature, specifically that using the network framework (Achrol, 1991, 1997; Anderson, Hakansson and Johanson, 1994; Hart and Baker, 1994: Gatignon and Xuereb, 1997; Rodan and Galunic, 2004). While not a dominant framework for technological innovation research in the marketing discipline as yet, the influence of these core researchers (together with the appeal and application of the network approach within a variety of disciplines) suggests that marketing's research into technological innovation will broaden to focus more on this area.

3.2.3 Network Theory

As for the two explanatory frameworks already discussed, the marketing discipline has 'abducted' many of the theoretical assumptions and research methods associated with network theory. The latter evolved out of early anthropological, descriptive studies into communities, particularly those examining the diffusion of cultural norms, values, and so forth through communication contact (Bott, 1957). Due to the small size of the social groups being examined, these early studies exhibited a high

level of explanatory detail with respect to both the complexities of social patterns (ie. relational form) and communication exchange (ie. relational content). While descriptive empirical research provides a level of richness, it can become quite cumbersome, disjointed and indecipherable when applied to situations where relationships cut across bounded groups or categories. As a means of defining these larger social systems, the metaphor 'networks' was used. In conjunction with this new metaphorical representation of relatively larger social systems, the emphasis of subsequent research shifted from a focus on narrative description to mathematical representations. In doing so, the research adopted the theoretical assumption of homophily. Within the context of network theory the inference is made that the identification of similar patterns of ties among actors within a social system (ie. relational form) is indicative of similar information exchange behaviour (ie. relational content). The use of network theory as an explanatory framework for technological innovation research is not surprising given its appeal and application across a number of research areas and across a range of (sub)disciplines (Table 3.3).

Table 3.3 (Sub)discipline areas associated with network research

Discipline/subdiscipline	**Major focus**
Economics:	
* industrial economics	economies in production costs (ie. scale, scope, specialisation, experience)
* organisational economics	predictors of network formation (ie. asset specificity, uncertainty and frequency of transactions, measurability of performance, risk aversion)
* organisational perspective	marrying a prescriptive concern for what is effective with a descriptive concern for what actually happens (ie. reaching and stabilising agreements, choosing effective power distribution)
* organisational studies	organisation of inter-firm alliances such as joint ventures, franchising, etc. (ie. differentiation between units, complementarity of resources, intensity of inter-firm interdependence, number of units)
* negotiation analysis	understanding of exchange regulation within networks (ie game structure as a predictor of network foundation and shape, effects of processes in reaching agreement)

Table 3.3 continued

Discipline/subdiscipline	Major focus
* resource dependency	strategic manipulation of transactions and games so as to change the network relationship to one's advantage (ie. types of dependence, breath of relationships, resource pooling)
* neo-institutional approach	dependence (ie. material resources or transactions) and legitimation through social linkages (ie. personal friendship, formal relationship, institutional embeddedness)
* organisational sociology	social and cultural embeddedness (ie. network formation through social coordination)
* radical and Marxian studies	power mechanism and class dominance (ie. interlocking directorates, clubs, business institutions)
Social psychology	
* social network theory	emergence and change of informal structures (ie. network boundaries, corporate cooptation, structural equivalence)
Combination of disciplines	
* business policy	strategic alliances as an approach to enhance position (ie. manipulation of network members)
* industrial marketing	dynamics of networks (ie. social exchange, individual skills, entrepreneurship)
* economic policy/law	negative externalities that networks may generate (ie. competitiveness, effectiveness and fairness of networks)
* population ecology	potential for survival of networks (ie. economic effectiveness and efficiency, legitimation)

Source: Adapted from the review by Grandori and Soda (1995)

While the multiple perspectives of various disciplines makes integration of theoretical aspects associated with network theory a difficult proposition, attempts have been made by some authors to draw the material together (Thompson et al, 1991; Axelsson and Easton, 1992; Grabher, 1993), identifying the following as the basic focuses within the literature;

- *Relationships and/or interactions* based on mutuality, level of perceived dependence different types of bonds, and the investment each has made to the relationship
- *Structure* as a consequence of interdependence
- *Position* of actors and the connections formed as a result of function performed, expectations, relative importance, and relationships to individual actors and the network of actors
- *Process coordination* as a result of the interaction of competition and cooperation.

What these attempts at integration reflect is the increased utilisation of ideas from the broad field of sociology, in particular, the notion of organisations belonging to

networks of 'social communities of information exchange', and the belief that network formation is not solely influenced and/or directed by economic competition and/or imperatives, but also by social contact.

The theoretical appeal of network theory stems from the two inter-related concepts of 'social cohesion' (Lorrain and White, 1971; White, Boorman and Breiger, 1976) and 'structural equivalence' (Burt, 1979). The 'social cohesion' explanation is derived from the theoretical assumption that "actors who maintain especially cohesive bonds among themselves are more likely to perform similarly" (Knoke and Kuklinski 1982:57). Consequently, there is an expectation of greater behavioural homogeneity among actors who have relatively frequent face-to-face contact than among actors who have less contact. The concept of 'social cohesion' is operationalised through the identification of networks within a social system based on specified properties such as the frequency, strength, and/or duration of the ties or links among actors. The alternate 'structural equivalence' explanation is based on the theoretical assumption that actors who occupy the same position within a social system exhibit similar behaviours. Positions do not infer roles *per se*, but rather arise from the similarity (ie. density, centrality, betweenness) in ties or links to other positioned actors in the social group. While the explanation of position and relations are mutually self-supporting within the two approaches, they usually yield different results (Figure 3.3).

Figure 3.3 Distinction between social cohesion and structural equivalence

Figure removed due to copyright restrictions

A social cohesion criterion identifies two distinct cliques, a small one involving just the two receptionists and a large one containing all three nurses and both physicians. But using structural equivalence criteria, four distinct positions would emerge, corresponding to the four roles labelled in the diagram. Nurses and doctors are no longer aggregated because they differ in their patterns of contacts with the other actors (ie. doctors are linked to the patients but the nurses are not) Knoke and Kuklinski (1982:20).

It is not surprising that the theoretical assumption of homophily has wide appeal within the marketing literature, for the role of interpersonal networks in influencing uncertainty reduction and subsequent adoption of innovations is well documented (Rogers, 1995). Research in other discipline areas directed specifically at innovation of a technological nature also shows some appreciation of the notion of member homogeneity as a basis for the explanation of an innovation system's structure. The 'social cohesion' explanation seems congruent with many assumptions within the literature, including; clustering of individuals or organisations around a technological innovation (Nelson and Winter, 1982); the narrow and idiosyncratic nature of technological trajectories (Dosi, 1988); and the low degree of technology appropriability (Silverberg, Dosi and Orsenigo, 1988). The 'structural equivalence' explanation has similar congruence with theoretical assumptions such as: technological innovation diffusion occuring in a positional patchwork fashion as distinct from a center-periphery flow (Burt, 1980); network position as a precursor to

power, control and resource attainment in the technological innovation process (Thorelli, 1986); and technological innovation within nation states and/or industrial systems being characterised by multiple network interaction (Johanson and Mattsson, 1991).

As well as having theoretical appeal, the network explanatory framework also exhibits empirical appeal. The research design is based on the theoretical assumption of homophily, such that identification of the various patterns of ties amongst those who populate a technological innovation system is merely a spatial or geometric property (eg. density, centrality, frequency, strength), which can be easily obtained through basic sociometric 'who-to-whom' questionnaires and Euclidean geometry techniques, such as block modelling. However, such simplicity in research design is due solely to the absence of asymmetry and discontinuity inherent in the homphily assumption. In fact, Rogers and Kincaid (1981:154) have suggested that empirical research should not incorporate relational contacts beyond the second link because of the "information distortion that may occur in such sequential interpersonal flows." Much of the research seems to have adopted this suggestion, thereby focussing on individual dyadic or triadic relationships in the innovation process, rather than on the technological network as a whole.

The theoretical underpinnings of network theory as an explanatory framework for technological innovation research is open to challenge. Of particular concern is the direct transference of the theoretical assumption of homophily. This assumption has value in ascertaining the structure of a social system (eg. organisational contact, functional linkages), and some use in aggregating a population into probable similar

characteristic groupings (eg. organization size, technical capabilities). However, to infer that homophilious relational contact denotes homophilious relational content is a misguided leap of logic, and can be readily challenged on the *interesting* categories of *composition B* and *causation B.* Furthermore, over-emphasising the value of communication as a way of achieving mutual understanding is at odds with what is known regarding the diversity inherent in information flows between individuals, and the assimilation of this information by said individuals (Simon, 1962; Blauwhof, 1994). As for diffusion theory, such an assumption within network theory is open to challenges on the *interesting* categories of *values A* and *supply A.* As Carlsson and Stankiewicz (1991:100) argue;

> Firms differ in the information they have, in the extent to which they use the knowledge they have, and in how they use it. They differ in the resources they devote to advancing their knowledge base and the effectiveness with which they conduct research. They also differ in their ability to learn from experience… differ in their ability to perceive opportunities and their willingness to take risks.

An associated concern is the question of what factors contribute to initial network formation. While there is general consensus within the network literature that the process of technological innovation is essentially a dialogue of information exchange, there is argument as to whether economic (ie. competitive) or social (ie. cooperative) forces bring about this exchange. The economic argument is framed within the notions of ‘resource dependency’ and ‘buyer-seller relationships’, and asserts that network formation occurs because the overall goal of an organisation is economic control of the environment in which it operates (Iacobucci and Hopkins, 1992). The social argument is based around theories of social exchange, with the assertion that network formation is a result of adherence to social customs, and in particular, factors such as trust, solidarity and commitment (Hakansson, 1988; Biemans, 1992). The shortcomings associated with research that attempts to explain human behaviour

through the adoption of a rigid ideology, whether this is economic or social, is identified by Granovetter (1985:484);

> But despite the apparent contrast between under-and oversocialized views, we should note an irony of great theoretical importance: both have in common a conception of action and decision carried out by atomized actors. In the undersocialized account, atomization results from narrow utilitarian pursuit of self-interest; in the oversocialized one, from the fact that behavioral patterns have been internalized and ongoing social relations thus have only peripheral effects on behavior. That the internalized rules of behavior are social in origin does not differentiate this argument decisively from a utilitarian one, in which the source of utility functions is left open, leaving room for behavior guided entirely by consensually determined norms and values - as in the oversocialized view. Under- and oversocialized resolutions of the problem of order thus merge in their atomization of actors from immediate social context.

Analytical expediency has been highlighted as the key problem in empirical research examining networks. Knoke and Kuklinski (1982) have noted that in order to 'fit' chosen analytical techniques, a number of researchers examining information exchange within networks have made their data symmetrical at the analysis stage, even though this data was asymmetrical at the collection stage. Analytical expediency is also recognised in Cook and Whitmeyer's assertion (1992) that relatively high proportions of researchers manipulate the direction of information exchanges to suit their data analysis method. While it may be argued that such data manipulation is uncommon, there is a tendency within marketing research to find comfort in analytical tractability, and as such, one needs to be cautious in interpreting the results of any network analysis. The need for caution of a more general nature with regard to network research is highlighted by a number of authors, who offer criticisms such as: 'overflowing with semantic ambiguity' (Baker, 1990); 'suffering the consequences of its growth in importance' (Oliver, 1990); and 'showing a multiplicity of interpretations' and 'lacking in substance' (Benz, 1993). The general lack of research integration within the literature drew the comment from Nohria (1992:3) that the

"indiscriminate proliferation of the network concept threatens to relegate it to the status of an evocative metaphor, applied so loosely that it ceases to mean anything."

To conclude, the utilisation of network theory as an explanatory framework for technological innovation research would seem to be a step in the right direction for the marketing discipline. Network theory offers a conceptualisation of the process that incorporates many aspects deemed to be representative of the current realities associated with technological innovation. The depiction of technological innovation as a process of informational exchange between actors in a broad system, mediated by economic and social forces, seems, on the surface at least, in step with research in other (sub)disciplines (Nelson and Winter, 1982; Pavitt, 1984; Freeman, 1991; Nelson, 2003; Becker and Knudsen, 2005). However, the network framework is similar to diffusion and NPD research in that it is steeped in 'scientific empiricist' ideals, and in particular, those of objective measurement, control and prediction. These ideals are largely achieved through the application of questionable theoretical assumptions that are challengeable across a number of the *interesting* categories. To assume that human behaviour, whether it be information exchange, decision-making, uncertainty reduction or group formation is subject solely to laws of an invariant kind is problematic in any research. In research attempting to explain the social context of technological innovation it is delusional. Most, if not all definitions of innovation, technological or otherwise, contain reference to the introduction of novelty, therefore, a theoretical appreciation of some measure of discontinuity is paramount (Boulding, 1982; Gowdy, 1985; Kauffman, 1993). The tendency within network theory-based research of technological innovation to treat the discontinuities inherent in relational context and content as irrelevant, is to dismiss new realities and experiences.

3.3 Conclusion

The purpose of this chapter has been a familiarisation with the dominant explanatory frameworks (and theoretical content) that marketing uses in research on technological innovation. In this way one may identify and explain perceived tensions or anomalies between these frameworks (and associated theoretical assumptions) and current realities and experiences through the use of *interesting* categories (Davis, 1971; Zaltman, Le Masters and Heffring, 1982; Poole and Van de Ven, 1989). In utilising the '*interesting*' aspect within the current methodology, the approach is somewhat distinct from theory construction in general, which requires a familiarity with data. The current approach is more concerned with initially developing a familiarity with marketing's widely-held assumptions with respect to that data (Davis, 1971).

The material in this chapter has examined the essential theoretical and empirical aspects of the dominant explanatory frameworks within mainstream marketing that encapsulate what is 'known' about the phenomenon of technological innovation. While this familiarisation process is to some extent subjective due to the abilities and prejudices of the researcher, a measure of objectivity was gained through an examination of the work of a number of major writers in the area. Two dominant explanatory frameworks associated with mainstream marketing's research into technological innovation were identified and examined, these being 'diffusion theory' and 'new product development theory'. As the 'network' approach is exhibiting small, but growing support within the marketing literature as a potential explanatory basis for technological innovation research, it was also explored so as to develop some level of familiarity. During this process of familiarisation, it was argued that a number of tensions were apparent between these explanatory frameworks and current

realities and experiences, and that all contained a number of flaws with respect to their theoretical and empirical treatment of technological innovation.

Each of the frameworks exhibited a number of tensions with current realities and experiences, not only with respect to their particular associated theoretical assumptions, but also among themselves. While the idea that tension(s) can occur between alternative explanations is central to a discipline's 'generative capacity', there is an expectation that these tensions arise from differing theoretical and/or empirical explanations of essentially the same phenomenon. While the two dominant explanatory frameworks used by marketing to examine research issues pertaining to technological innovation are founded on ‘scientific empiricism’, they use different theoretical and empirical approaches. What is not so explicitly recognised is that they are explaining different phenomenon. The diffusion framework is based within a deductive method that operates from a set of well-developed theoretical concepts and propositions that provide the basis for 'observational' research through data collection. The primary focus is on predicting technological diffusion (ie. adoption or rejection) due to the interaction of other concepts and propositions (eg. communication, social systems). The NPD approach is framed within an inductive method, offering a number of theoretical process models developed through empirical research. The primary focus is identifying the causal mechanism(s) that affect the generation of a successful technological innovation.

While it is accepted that both explanatory frameworks exhibit some appreciation of the inescapable inter-relationship(s) between the generation and diffusion of technological innovation, this connection is implicit rather than explicit. In essence

neither framework examines technological innovation *per se*. Instead, they isolate ‘behavioural bits’ and apply laws that are believed to be the underlying causalities of human behaviour in the technological innovation process. The notion that the social context of technological innovation can be considered as a collection of discrete elements, and that these elements can be examined in isolation, is a false belief. Human behaviour, irrespective of context, can never be considered as a ‘Newtonian clockwork’ because such behaviour is inherently messy, driven in part by forces such as self-interest, subjectivity, spontaneity and chance. As a result of these forces, any phenomenon touched by human endeavour “cannot (not even in theory) be deduced from the most complete knowledge of the components, taken separately or in other partial combinations” (Mayr (1985:58). The argument is that there is no discernible theoretical platform within either research area that would facilitate the linking together of generation and diffusion factors associated with technological innovation into a coherent explanatory whole. Even if there were, it is argued that the result would be an overly atomistic, reductionist, deterministic, gradualistic and mechanistic explanation due to the use of invalid, or at best, highly questionable theoretical assumptions.

It was argued that a number of theoretical assumptions associated with the diffusion literature are at odds with current realities and experiences, and therefore challengeable through the *interesting* categories. These tensions included: technological innovation as a 'common pool of information' into which all could dip; technological systems as a social network of homophilious actors; communication as a linear and symmetrical causation mechanism; technology adoption as a 'normal' bell-curve pattern; technology characteristics do not influence diffusion patterns; and

the diffusion of a technological innovation as independent of all other innovations. These tensions are raised very rarely in the literature, for to do so brings into question the validity of the widely-accepted diffusion theory itself, and the theoretical assumptions that hold it together. Theoretical assumptions can be considered as the scaffolding around an explanatory framework, and in 'theory', removal of part or all of this scaffolding will leave the basic premise(s) of the framework intact. This is not the case with respect to diffusion theory, for to remove even the theoretical assumption of information exchange as a constant, most, if not all the other commonly accepted theoretical assumptions would fall.

Although the NPD framework is different from that of diffusion, focussing as it does on the development of a number of explanatory process models rather than predictive ones, it too is beset by similar problems. This is particularly evident in the deterministic and mechanistic depiction of organisational decision-making with respect to technological innovation: deterministic in that this decision-making is considered as a somewhat pre-ordained path because a structured connection between desired ends and appropriate means occurs as a result of rational thought; mechanistic in that decision-making is usually empirically treated as a process of linear and rigid sequencing; This is not to deny certainty a place in the decision-making process, but to highlight the central importance of uncertainty in this process. As Hayek (1945:519) points out;

> The knowledge of the circumstances of which we must make use never exist in concentrated or integrated form, but solely as the dispersed bits of incomplete and frequently contradictory knowledge which all the separate individuals possess.

The NPD explanation also decontextualises the firm, for while the systemic aspect of technological innovation is considered through reference to informational inputs from

outside actors (eg. customers, suppliers), this interdependency is treated in an individualistic manner. It has more to do with the firm relating to the system (a result of quasi-mechanical adherence to social or economic norms) rather than considering the firm as a part of that technological system.

It was noted that this problematic issue of system context is being addressed by a growing body of literature within mainstream marketing that promotes the network approach as a valid and viable framework for explaining and examining technological innovation. However, this framework too is open to charges of being overly atomistic, reductionist, deterministic, gradualistic and mechanistic, due largely to the fact that much of the research tradition is steeped in the same theoretical assumptions as diffusion and NPD explanations. Examples include: technical information exchange between actors is symmetrical; group homogeneity with respect technological understanding occurs as result of this symmetry; and means-end rationality promotes purposeful behaviour in the technological innovation process. The overall thrust of the network explanation is that individual/organisational interdependency occurs so as to reduce, or even remove the disorganised and unstable aspects of information uncertainty within the technological innovation process. While it is doubtful that the level of information uncertainty could be reduced significantly (due to the nature of information itself, and to the fact that most firms have different needs, capabilities, and goals), to do so would be counterproductive if the goal is technological innovation. As pointed out by Boulding (1987), the uncertainty inherent within asymmetrical information exchange between system actors is at the heart of technological innovation generation and diffusion.

That all the identified explanatory frameworks adopt an *ex post* analytical methodology for evaluating their particular metaphorical representations of technological innovation is hardly surprising. Verbal/literary representations may be equivocal, lacking in explicitness and rigour, and the recourse to mathematical models is motivated in part by a desire to remove such imprecise ornamentation. However, taking sole recourse in mathematical models to explain the *process* of technological innovation is questionable, for the language of mathematics shows "an extraordinary paucity of verbs, it is hard to think of more than four: equals, is greater than, is less than, and is a fraction of" (Boulding, 1989:14). This is not to suggest that numerically-based modelling is inappropriate *per se*, but rather that analytical tractability should not be the starting point for marketing's research into technological innovation. The argument of the present thesis is not that of Brown (1996:260) who accuses marketing of embarking on a "self-abusive orgy of mathematical masturbation," but rather that of Montgomery and Srinivasan (1994) who argues that there are classes of problems that may or may not be amenable to numerical analysis. If the problem is well defined and the crucial issues are well understood and easily quantifiable, then it seems logical to resort to mathematical analysis so as to yield a viable explanation. However, it is the argument of the present thesis that the realities of technological innovation, particularly in the current complexities of socio-economic environments, are not well defined and understood, nor are they as amenable to quantification as is suggested by much of marketing research.

The general conclusion of this chapter is that the frameworks utilised by mainstream marketing to explain technological innovation are akin to 'houses of cards', which are not only held in place by a 'scaffolding' of theoretical expediency, but also by

empirical expediency as well. The theoretical assumptions of uniformity, linearity, rationality, symmetry and instrumentality (and their expression via statistical packages) dominate 'publishable' research within the marketing discipline. This omnipotence promotes conformity over dissidence and restricts vision, for as Galbraith (1973:8) commented;

> The good scholar is the man who sticks tightly to his last, declines any concern with the truth or error of the system of which his work is a part. And such concern, since it involves the difficult task of offering more satisfactory alternatives, can usually be attached as deficient in methodology or proof.

Marketing, like its economic and sociological parents, is steeped in the 'classical' orientation of ‘scientific empiricism’ and its inherent call for rationality, objectivity and measurement (Arndt, 1985; Hunt and Menon, 1995). It is therefore not surprising that much of marketing’s research into technological innovation assumes that the phenomenon can be generally treated in an atomistic, reductionist, deterministic, gradualistic and mechanistic manner. It is argued that such general treatment is inappropriate as the phenomenon of technological innovation exhibits characteristics that are inherently interdependent, indeterminate, unstable, and counter-intuitive (Metcalfe, 1994; Hodgson, 1998; Fonseca, 2002; Fleming and Sorenson, 2004). It is further argued that as a result of such treatment a number of theoretical assumptions are made within marketing’s explanatory frameworks for technological innovation that are little more than phenomenological pretence. Specifically, the diffusion framework can be challenged on the *interesting* categories of *stabilisation A, separation B, form B, causation A, supply B, abstraction A, values A* and *supply A*; the NPD framework on *organization B, form B, assertion A, values A, organisation B,* and *co-relation A*, and the network framework on *composition B, causation B, values A* and *supply A*.

The methodical approach adopted by the current thesis is based on the principle that a challenge to in-place explanations must be accompanied by a plausible alternative. A number of writers have argued that this plausible alternative should not alienate existing audiences through the assertion of a conflicting point of view based on a change as radical as a paradigm shift (Zaltman, Le Masters and Heffring, 1982; Foxall, 1993). While appreciating the need for some measure of audience acceptance, it is the assertion of the present thesis that such a paradigm shift is required. While the development of a 'better' theoretical explanation of technological innovation could possibly result by 'tinkering' with current explanatory frameworks, this approach would merely pander to what is largely uncontested dogma. The central argument of the present thesis is that a substantial change to the overall research orientation is required so as to generate an explanation that better models current realities and experiences.

Offering alternative explanations of social phenomenon is not common within the marketing discipline, with research being more focussed on defending in-place explanations or making *ad hoc* modifications (Day, 1990; Brown, Doherty and Clarke, 1998). However, the logic of discovery implies pluralism, rather than an attempt to forge a synthesis upon narrow conceptualisations (Brown, 1976; Arndt, 1985; Montgomery, 1994). Hunt (1994) concurs, arguing that marketing should adopt a philosophy that is more pluralistic; that is, “open, without being anarchic; critical without being nihilistic; tolerant without being relativistic; fallible without being subjectivistic.” The present research adopts this notion of pluralism, a condition that Holbrook (1998:251) argues is required by the discipline in general because;

> Some of the more traditional approaches to marketing research have devolved to a repetitive and obsessively literal-minded condition of inveterately blandness. As a remedy, I propose a need for greater imagination in what we think mentally, greater liveliness in what we write verbally, and greater vividness in what we represent visually.

In promoting pluralism the present thesis is not adopting the position that marketing's research into technological innovation is ill-served by the ‘scientific empiricist’ credo of 'what is, should be'. Rather, the notion 'what is, could be', is being put forward. There is a call for a more tolerant and open atmosphere so as to allow the development of rival alternative explanations of technological innovation within the marketing discipline. As Moore (1991:37) argues; "We find vitality in tension, learn from paradox, gather wisdom by straddling ambivalence, and gain confidence in trusting confusion that naturally arises from multiplicity."

The present research heeds the call for pluralism, and in doing so, argues that a plausible alternative explanation of technological innovation can be found in an 'evolutionary' orientation. That an evolutionary perspective has value as a rich source of ideas and approaches is canvassed by a number of authors (Witt, 1991; Meldrum, 1995; Nelson, 2001). A number of benefits are also highlighted by Hodgson (1993:32);

> The application of an evolutionary approach… seems to involve a number of advantages and improvements over the orthodox and mechanistic paradigm. For instance, it enhances a concern with irreversible and ongoing processes in time, with long-run development rather than short-run marginal adjustments, with qualitative as well as quantitative change, with variation and diversity, with non-equilibrium as well as equilibrium situations, and with the possibility of persistent and systematic error-making and thereby non-optimizing behaviour. In short, an evolutionary paradigm provides an alternative to the neoclassic 'hard core' idea of mechanistic maximization under static conditions.

In adopting an evolutionary orientation, the present thesis is not merely accepting a theoretical position, but is also using the process of evolution as a modality. As

Campbell (1974:421) argues, the epistemology of theory construction itself is evolutionary; “a blind-variation-and-selective-retention process is fundamental to all … achievements, to all genuine increases in knowledge…’

> May we not acknowledge the personal and subjective character of creativity, but still comprehend it as a mode of thinking that emphasizes or exaggerates capacities sufficiently common to all of us that we may at least understand if not hope to imitate (Gould, 1990:53).

4.0 AN EXPLANATION OF EVOLUTION

4.1 Introduction

Material presented in the previous chapter supports a central research tenet of the current thesis, that is, in challenging marketing's dominant in-place explanations of the phenomenon of innovation there must be an initial exploration of the research area. Such exploration is a form of 'familiarisation', identifying not only dominant explanatory frameworks, but also evaluating them so as to identify their strengths and weakness. Chapter Three specifically addressed this issue of familiarisation, identifying 'diffusion of innovation', 'new product development' and 'networks' as the dominant explanatory frameworks used by much of mainstream marketing's research into the phenomenon of technological innovation. While these frameworks exhibit differences with respect to broad research parameters, such as problem definition(s) and level(s) of analysis, there is similarity in that a number of the same underlying theoretical assumptions are widely used. In particular, they emphasis the market-place as economically efficient, decision-making as a rational 'means-end' process, the behaviour of system members as a homophilious pattern, information as a perfect good, and progression as an ordered linear sequence. Though these theoretical assumptions may be true representations of the 'realities' associated with technological innovation in general, it is argued that they only hold true in a very limited number of clearly defined circumstances. This distinction is rarely, if ever made, and as a result these theoretical assumptions have obtained the status of unquestioned dogma. In turn, this has led to a very narrow and often misleading appreciation of the 'realities' of technological innovation. This is evident in the explanatory frameworks that dominate marketing's

research into technological innovation, where both theoretical and empirical endeavours are largely atomistic, reductionistic, deterministic, gradualistic and mechanistic in nature. In the current thesis it is argued that this perspective is ill-conceived for it fails to successfully incorporate the systemic complexities that constitute the realities of technological innovation (Nelson, 1995; Saviotti, 1996; Vromen, 1997; Hodgson, 1998; Frenken, 2000).

Chapter Three also canvassed a possible reason as to why much of marketing's intellectual space adopts an atomistic, reductionistic, deterministic, gradualistic and/or mechanistic perspective when examining technological innovation. It was shown that marketing's dominant explanatory frameworks (like the discipline's theoretical development in general) are formulated on 'scientific empiricism'. While the logic of 'scientific empiricism' is a key to the success of the physical sciences, it is difficult to successfully transfer this approach to reasoning when examining aspects of social behaviour. This is because 'scientific empiricism' fails to acknowledge the existence of and/or to include unobservable entities and processes into the research agenda (Gidden, 1984, Lawson, 1985). Furthermore, the 'success' of 'scientific empiricism' is largely predicated on the discovery of generalisable laws, whereas any suggestion that invariant universal laws govern social behaviour is wishful thinking. Although research into social behaviour may desire a population marching to the beat of a single drum, human behaviour has enough heterogeneity to challenge the validity of such a claim (Braithwaite, 1956; Simon, 1962; Andresk, 1974; Outhwaite, 1987).

A number of conclusions have been drawn from material presented in the previous chapter. Firstly, the great majority of mainstream marketing's research into technological innovation perceives the phenomenon as a somewhat simplistic cause and effect process.

Secondly, this research, in some manner and measure, rests on theoretical assumptions that are invalid and/or over-simplified so as to be amenable to generalisation and/or predictive assessment through numerical manipulation. Thirdly, the basic research schema of scientific empiricism, with its inherent emphasis on objectivity, exactitude, accuracy, generalisability, replicability, and numerical manipulation should not be the dominant methodology at this juncture due to incomplete and/or unknown conceptual issues associated with the process of innovation in general, and that of technological innovation in particular. These conclusions, and the arguments on which they are based, highlight and support not only the need to challenge marketing's in-place assumptions with regard to technological innovation research, but also the need to do so from a different orthodoxy. In essence, the research area needs to exhibit more eclecticism in its choice of research ideology, for the goal should be the development of a larger set of possible alternative explanations of the phenomenon of technological innovation, rather than a competition for overall supremacy or intellectual monopoly.

It has been argued that the research methodology underpinning the present thesis exhibits a measure of eclecticism by incorporating philosophical, epistemological, methodological and design elements somewhat different from those currently used in marketing research in general, and technological innovation research specifically. Of particular importance is the adoption of the postmodern philosophical position that is predicated on the notion that there is 'no one best way' for understanding social phenomena (Feyerabend, 1987). This position is different from the 'truth out there' goal of 'scientific empiricism', and has as its aim greater understanding of 'the world out there' (Rorty, 1980). This is not to infer that the 'truth of reality' is an inappropriate research goal, but to recognise that within the social sciences such a goal is problematic given that most (if not all) human behaviour is complex, due to its fluid, elusive and

opaque nature (Andresk, 1974). These aspects of social reality are reflected within the ontological stance of postmodernism that directs research thought to the transient and ephemeral nature of social phenomena, and in particular, to its emergent, fluctuating and transformation features (Clegg, 1990; Chia, 1995). Given the growing belief that these features are essential aspects of the technological innovation process (Nelson and Winter, 1982; Leydesdorff, 1994; Frenken, 2000), the methodological ontology is considered to be a highly appropriate approach for the current thesis.

As outlined in Chapter Two, the current thesis should not only challenge marketing's in-place explanatory frameworks for technological innovation research, but also needs to offer an interesting alternative representation that is not only plausible, but has some measure of theoretical acceptance to the discipline. It is suggested in the literature that the 'generative capacity' of marketing might be better served through modifications to in-place frameworks (Zaltman, LeMasters and Heffring, 1982). However, such 'tinkering' would do little to advance understanding of the phenomenon of technological innovation. As identified in Chapter Three, the in-place explanatory frameworks are based on foundation assumptions that can be easily challenged on a number of *interesting* categories. In addition, this approach also runs counter to the growing call to inject a healthy dose of theoretical pluralism into the marketing discipline (Hunt and Menon, 1995; Brown, 1997; Brownlie, 1997; O'Shaughnessy, 1997; Miller, 1998). Material in the remainder of this chapter heeds this call, offering a perspective of the evolution process that is somewhat different from that commonly held within mainstream marketing.

The following section offers a brief examination of the meaning ascribed to the term 'evolution' in mainstream social sciences, with particular reference to the small body of

literature within the marketing discipline that explores the evolutionary perspective. Perceived flaws within the dominant perspective on evolution within the social sciences are also examined. Subsequent sections of the chapter are the 'logical' development of an explanation of evolution based on a particular perspective gleaned from a range of (sub)disciplinary sources. This schema identifies the general principles deemed to be essential when interpreting the process of evolution, and the conceptual expansion of these principles so as to furnish an explanation of the underlying process of evolution. It should be noted that the overall aim of the chapter is not to present a literal portrayal of the evolutionary process, but rather to develop an explanatory device that may offer support in the formulation of knowledge about the process of technological innovation. As consistently argued within this thesis, explanations of social phenomenon should always be predicated on 'as-if', as distinct from an 'as-is' perspective, for most, if not all social reality is elusive and far too complex for any single explanation. As Kaplan (1964:288) warns;

> the view that scientific achievement is marked only by our ability to formulate the truth about any subject matter in a single comprehensive model - postulationally, and even formally, developed - is no more than a prejudice.

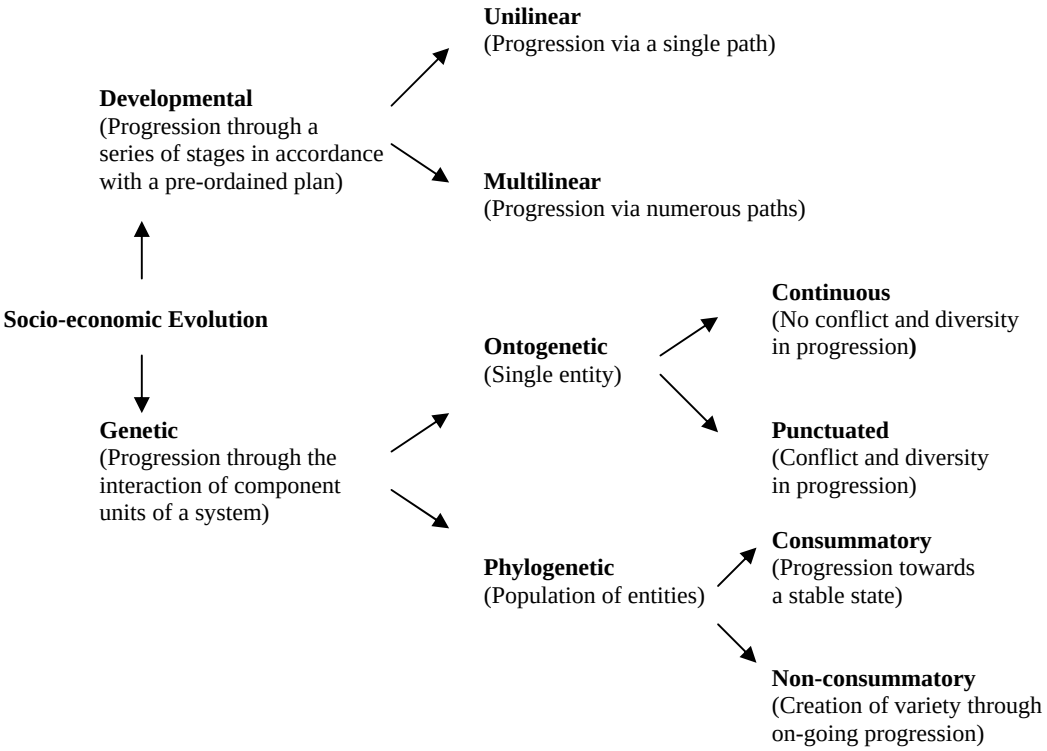
4.2 The meaning of 'evolution' within mainstream social science literature

It has become quite fashionable of late for research in the social sciences to represent social phenomena through analogies to biological metaphors, and in particular, via the root metaphor of 'evolution'. The term 'evolution' was initially derived from the Latin verb *volvere*, and while this strictly refers to 'unrolling', its meaning in Latin is often expanded to incorporate the broader idea of 'motion' (Hodgson, 1993). Increased usage of the term 'evolution' occurred during the 17th and 18th centuries, and while there were a number of meanings initially applied, the term became synonymous with the notion of 'development of a system over time' (Bogen and Woodward, 1988). Evolution as

‘development’ took on new meaning in 19th century biology, the term ‘evolution’ being used to denote ‘directional progression’, and in particular, progression in a positive direction due to the ‘pure objectivity’ presupposed in the world of nature (Hull, 1988). The notion of evolution as a (near)optimising progression through the forces of natural selection, whether that be random mutation or heritable traits, became embodied in the frequently used phrase; ‘survival of the fittest’.

This particular conception of ‘evolution’ has been transferred quite readily to the social sciences, though with varying degrees of explicit pronouncement. Within sociology the term ‘evolution’ is used to describe a particular logic of positive development, that is, social progress as a succession of developmental stages exhibiting increasing superiority and/or sophistication. An example is the development of the human collective from primitive hunter-gathers through various stages to post-industrial societies (Van Parijs, 1981). In economics, the term is used in a similar manner, with economic growth seen as the progressive development of increasing levels of efficiency in production, as shown by the shift from Guilds to the factory system (Grabher and Stark, 1997). This preoccupation of the social sciences with a ‘progressional’ perspective of evolution is apparent in the taxonomy offered by Hodgson (1993) that attempts to disentangle the different meanings of evolution that are caught up in the net of ‘evolutionary theory’ (see Figure 4.1). Notwithstanding these different meanings, the driving force of evolution is generally accepted as some form of competitive interaction with respect to diminishing resources. This notion, in concert with the assumption of ‘optimal progression’, has directed the dominant research focus within the social sciences towards the consequences of evolution, rather than towards any in-depth (re)examination of process itself (Ho, 1988; Hodgson, 2001).

Figure 4.1 Different conceptions of 'evolutionary theory' within the social sciences



Source: Adapted from Hodgson (1993)

The almost universal belief within the social sciences of the (near)optimal consequences of evolution is misguided, for a most cursory of glances at the background literature associated with evolution theory reveals no evidence that evolution is in fact a progression to some positive or superior end-point. Indeed, Darwin himself did not champion the notion of evolution as a progression towards the optimal, arguing that Nature provided no independent criterion of the ideal (Gould, 1977). Furthermore, for Darwin the outcome of 'natural selection' was *relative* success or failure, as distinct from the *absolute* success denoted by Spencer's phrase; 'survival of the fittest' (Depew and Weber, 1997). Perhaps the most problematic aspect is the linking of these two (mis) representations for mutual support via the argument that survival of some natural or competitive selection process is itself proof of a positive progression. This is nothing more than a tautology (Gowdy, 1992). In essence, much of the mainstream social

sciences' literature adopts a literal and somewhat simplistic interpretation of (neo)Darwinian theories of evolution, an approach that offers little in the way of explanation, but rather 'a mechanical description in which evolution appears as a museum, in which only the best is conserved' (Prigogine, 1987).

Reference to evolutionary terminology can be found within early marketing literature (Alderson, 1957, Thorelli, 1967), with perhaps the first comprehensive examination of the potential applicability of the evolutionary perspective to marketing issues undertaken by Tellis and Crawford (1981). The genesis for their research was the realisation that the product lifecycle concept (PLC) offered little relevance as an explanatory framework for investigating the development, growth and proliferation of products and/or markets. In particular, the authors argued against the deterministic, gradualistic and mechanistic assumptions that are inevitable in the PLC's representation of a product/market's birth-growth-death cycle. As an alternative they proposed the product evolutionary cycle (PEC), an explanatory framework that viewed product/market progression as a dynamic and open-ended evolutionary process. Although the PEC framework lacks detail, it does suggest that product/market innovation is a more complex process than marketing's in-place explanations conveyed. More importantly, while indicating that biological evolution provides an alternative perspective from which to explain innovation processes, the inclusion of human mediation as a selection mechanism suggested that an explicit analogy to (neo)Darwinian biological processes might not be entirely appropriate, or at very least requires some additional thought.

This problem was overlooked by the small body of subsequent marketing research that worked within an evolutionary perspective (Henderson, 1983; Lambkin and Day, 1989; Holak and Tang, 1990; Katsanis and Pitta, 1995). All of this research links

(neo)Darwinian biological metaphors (eg. natural selection/fitness) to marketing metaphors (eg. market sovereignty/competitive advantage). Similarly, Massey (1999) argues that marketing research adopting an evolutionary theme should do so from a Lamarckian rather than Darwinian perspective. In this case the theoretical linkage is between Lamarckian 'learned adjustment' and the 'marketing concept', a fundamental tenet of marketing thought that advocates that one ascertain market needs before taking any action. Irrespective of the particular theoretical stance taken with respect to evolution, the marketing literature has adopted analogies akin to the 'drunken man leaning on the lamppost', utilising theoretical ideas within evolutionary theory to support in-place marketing thought rather than to illuminate any new ideas.

The marketing discipline's limited foray into the evolutionary perspective largely began with the optimistic possibilities raised by Tellis and Crawford (1981). Sadly, the research area has degenerated into the relabelling of existing marketing knowledge with evolutionary terminology and/or the transfer of ill-formed ideas to bolster, rather than replace, questionable in-place theoretical assumptions. This has been a wasted research opportunity for the marketing discipline, as it has for social sciences as a whole. The research area has been intellectually seduced by (neo)Darwinian perspectives, and as a result, has not examined inconsistencies and ambiguities within these perspectives nor considered other perspectives of evolution. As to why much of the social sciences persists with the (neo)Darwinian view of evolution is open to conjecture. However, the opinion offered by Gould (1990) is interesting in that it points the finger at frailties in human nature, suggesting that this view promotes and maintains our two deepest prejudices, that is, our need for an inherently purposeful and progressive existence, and our belief that effort will be rewarded.

To conclude, it is argued that there is an overwhelming tendency within the social sciences to assume that ‘evolution’ has a common and obvious meaning, and that this meaning is encapsulated within the (neo)Darwinian notion of ‘positive progression’ through the optimising forces of competitive natural selection. This assumption is ill-founded, for not only are there a diversity of ‘meanings’ within the evolution literature (Foss, 1997), but also a number of the theoretical concepts underpinning the (neo)Darwinian perspective are questionable at best (Allen, 1990; Gowdy, 1992). While there is no doubt that biology, like any other discipline, provides a rich source of ideas and approaches on which the social sciences can draw, it is common for research directly ‘abducting’ metaphors from one discipline to another to (dis)miss problems at the source, and thereby impose similar problems on the destination (Campbell, 1969). It is argued that such a situation occurs in the transfer from biology to the social sciences of aspects associated with the root metaphor ‘evolution’. In particular, there is a tendency for social science research to see evolutionary theory through the narrow perspective of (neo)Darwinism, and to subsequently make explicit analogies between the social behaviour under examination and the development of an organism or species in the natural world. It is argued that a more appropriate research agenda is to employ the broad research field of ‘evolutionary theory’ as a prompt to reflect on the many meanings and ambiguities inherent within the term ‘evolution’. Such reflection can then be used to draw implicit analogies between the natural, physical, chemical and/or social worlds (Lakoff, 1987). The following section embraces such an approach, developing an explanation of evolution based on the ‘abduction’ of ‘plausible’ ideas that have a relatively high degree of ‘acceptability’ in a number of (sub)disciplines.

4.3 An explanation of ‘evolution’

‘Explanation’, whether as terminology or methodology, is quite an elastic research tool, covering a wide variety of cases. In the current context the terminology of ‘explanation’ is that suggested by Greer (1969:124); “an enlightenment concerning the order of our various experiences.” As such, ‘explanation’ is a means of making something intelligible and/or comprehensible through the identification and conceptualisation of underlying mechanisms, together with recognition of the necessary relationships these elements may have with each other (Appleyard, 1992). It should be appreciated that an ‘explanation’ is tentative. It is somewhat open as all the factors of that being explained cannot be seen, will not be fully understood, nor included in the explanation. This partiality is not a shortcoming, for “finality is a mark of runic explanations, not scientific ones; the road to inquiry is always open, and it reaches beyond the horizon” (Kaplan, 1964:341). The methodology adopted in the current thesis is that suggested by Dubin (1978), that is, the development of an ‘textual explanation’ through a *why*, *what*, *how*, *when* and *where* format that attempts to identify the underlying pattern(s) of the phenomenon in question. Identification of such a pattern rarely occurs in a knowledge vacuum, for most explanations are based on what is already known or understood; “Knowledge normally develops in a multiplicity of theories, each with its limited utility” (Quinne, 1960:251).

While much of the research in the social sciences’ area ‘patterns’ evolution solely through direct analogies to the mainstream (neo)Darwinian biological perspective, the current thesis offers a pattern that is emerging in research across a number of (sub)disciplines. This research does not profess to ‘know’ the pattern of evolution as yet. Rather it proposes that there are common threads intertwining among the conceptualisations of the principles deemed to be essential in any explanation of evolution. Principles are the fundamental properties or characteristics of a phenomenon,

what Spilbury (1974) refers to as the ‘sacrosanct conditions’ that must be addressed in any research. These principles are not so much generalisations or laws, but rather “ways of treating subject-matter that have been found to be so determinative of sound conclusions in the past that they are taken to regulate further inquiry until definite grounds are found for questioning them” (Dewey, 1938:13). Principles are in essence the starting points of research into phenomena, the ‘illuminating metaphors’ that acquire meaning through the process of (re)conceptualisation (Habermas, 1971; Bohman, 1991). The following material identifies the principles of evolution that have a measure of support within a broad range of literature in the ‘hard’ sciences area. Conceptualisation of these principles is undertaken through the process of ‘abduction’, and developing a ‘textual explanation’ via a *why*, *what*, *how*, *when* and *where* approach, with validation based on the ‘plausibility’ and ‘acceptance’ criteria identified in the methodology section.

Any explanation of evolution, and therefore of the principles involved, must start from the ontological assumption that what is being discussed is an open dissipative system of interdependent relationships. All systems, even the simplest, are open dissipative structures that not only result from the generation of energy, but also have such generation as their primary goal so as to overcome the forces of entropy. There is a high level of consensus about this concept in a number of research areas within physics, chemistry and molecular biology (Prigogine and Stengers, 1984; Field and Gyorgy, 1993; Kauffman, 1993). However, this is a contrary view to the dominant theoretical stance in much of the social sciences’ literature whereby all systems are treated as closed, and their ultimate goal (conscious or otherwise) being the suppression of on-going instability so as to achieve a static state of (near)equilibrium. It has been argued previously that such a perception may have more to do with the human desire for order

than with reality (Hodgson, 1997). In itself a pragmatic suspension of temporal and spatial aspects so as to facilitate empirical examination is of little concern, however, problems arise when this is taken as a research position that implies theoretical substance and/or the truth of reality itself. In accepting the ontological assumption of systems as constantly open and dissipative, it can be generalised that both *when* and *where* explanatory aspects are constants across all the principles to be discussed. Evolution is a process of variation, selection and preservation, and while it may sometimes appear stationary or static, the *when* of this process is invariably 'always'. To generalise about *where* is to appreciate that evolution is not a linear sequence of three discrete events containing identifiable cause and effect relationships, but rather a cumulative progression of interrelated acts of variation, selection and preservation;

> The beautiful spiral patterns in conch shells, the rhythmic change of color in oscillating chemical reactions, the biorhythms that order human life, including the beating of the heart, are all consequences of the countless unseen processes without which the observed effect would be absent (West and Salk, 1987:117).

4.3.1 The Principle of 'variation'

Gould (1996:64) commented; "We cannot grasp the irony of life's little joke until we recognize the primacy of variation within complete systems, and the derivative nature of abstractions or exemplars chosen to represent this varied totality." The current orthodoxy in most disciplines shows little appreciation of this irony, as it sees the primacy of order as the central purpose of systems. As Western thought is predicated on the belief that knowledge about a particular situation arises when one imposes some sense of order, it is not surprising that 'order' is attributed as a system's very purpose (Nagel, 1961). Such a prejudice is implicit in the common conceptualisation of the principle of 'variation', which views the diversity that constitutes the known Universe as the result of chance, and therefore subject to the 'forces of order' operating within a shifting probability function. This mathematical treatment of 'variation' is nothing more

than shabby research, for it not only summarily dismisses the defining aspect of evolutionary theory, but also down plays what is perhaps the central purpose or characteristic of all systems (Eigen, 1971; Prigogine, 1980; Gleick, 1987).

Taking recourse in the notion of 'chance' to explain the 'variation' inherent within a system has a long research history. Darwin himself offered 'random mutation' as the mechanism by which the gene pool generated 'variation' within, and across species (Hodgson, 2001). It should be realised however, that Darwin took recourse in 'chance' because of difficulties he encountered in formalising variation as a theoretical construct. As Depew and Weber (1997:113) observe; "What we call chance is for Darwin… a matter of our ignorance of causes, as is our reliance on probabilistic judgements to compensate for that ignorance." This treatment of 'variation' as chance (ie. random mutation) is perhaps the one undisputable objection to (neo)Darwinian and Lamarckian theories of evolution, for they both lack a valid explanation for the existence of the very raw material of evolution (Hodgson, 1993). Furthermore, attempting to hide conceptual ignorance beneath probabilistic judgements with respect to evolution in Nature, places a strain on the mathematics of statistical probability given the immensity of 'variation' within and between species, and the relatively short time frame involved. As Hough (1997:27) has pointed out; "The probability of creating the eye as a result of random mutation is about as likely as tossing ten tons of scrap metal in the air and hoping it comes down as an aero-engine."

If it is accepted that all systems are open dissipative structures, then explaining *why* 'variation' occurs (and its central place in any explanation of the evolutionary process) is a relatively simple exercise. Without initial 'variation', either as a result of self-renewal or importation from outside sources, a system could not begin to function.

Furthermore, any functioning system subjected to 'variation' depletion would be subject to entropy, and would therefore eventually cease to exist (Prigogine, 1980). 'Variation' is indeed the 'irony of life's little joke', for while it may seem that all natural systems have as their central goal the attainment of a final destination, the reality is the opposite. The purpose or *why* of all systems, whether biological, physical or chemical, is to continually increase levels of 'variation' through the generation of inherent diversity or novelty, and it is these variant conditions that provide both the spark and fuel for the evolution process (Mayr, 1982; Ridley, 1985; Hahlweg, 1991; Kauffman, 1993).

In providing a *what* within an explanation the overall goal is to offer a loose term that suggests some guidance in formulating meaning, one that does not set strict limits on admissible modes of conceptualisation (Kaplan, 1964). The common definition of 'variation' within the biological literature is 'gene pool', that is, a collection of individual gene-controlled characteristics operating at the species level. In an attempt to broaden the interpretive scope of evolutionary theory, a number of authors within various disciplines have defined 'variation' as a 'multi-dimensional possibility space' (Gleick, 1987; Allen, 1988; Cramer, 1993; Fonseca, 2002). While 'multi-dimensionality' is usually used to denote temporal and spatial aspects of a system, it has been pointed out that there may well be a number of additional and context-specific dimensional aspects (Allen, 1994). This idea is reinforced through the notion of 'possibility space' and refers to known and unknown sources of 'variation' inherent within systems (McKelvey, 1995). To define 'variation' as a 'multi-dimensional possibility space' is not to claim that a system can feed its evolutionary process through limitless variation renewal and/or importation. Research in the chaos theory area suggests that all systems have constraints on the amount of variety that can be contained

within their boundaries, for there is a “limited tolerance that complex structures have of deviation, and beyond which they lose their functional integrity” (Plotkin, 1995:43).

As alluded to earlier, the modern (neo)Darwinian synthesis posits the view that *how* ‘variation’ arises is solely the result of random mutation, in essence the ‘faulty reproduction of old types’. On this view, ‘variation’ is only initiated when a (sub)population is subjected to some form of competitive stress triggered by its environment (Spilbury, 1974; Hodgson, 1993). Notwithstanding the theoretical vagaries inherent within the term ‘random’, the notion that ‘variation’ results solely from random mutation(s) is highly improbable, given the diversity inherent within a particular species, or even (sub)population (Hough, 1997). This improbability expands even beyond imagination when coupled with the odds of such a randomly generated ‘variation’ fitting into its new, competitively defined, system environment. Also questionable is the assumption that environmental pressures act as the sole trigger for the initiation of variation. As Ridley (1985) has argued, it is difficult to reconcile such an assumption with the many real life instances of an abundance of different species occupying the same uniform environment. Darwin’s recourse to a utilitarian depiction of how ‘variation’ arises is hardly surprising given that his “quest to become the Newton of biology depended on his ability to shift the causal and explanatory accent of evolutionary theory from inner drives to outer forces” (Depew and Weber, 1997:115). It has been argued that there should be little surprise that much current research on evolution is in the grip of utilitarian philosophy. To view the world as essentially competitive is an understandable, though not necessarily correct reflection of many a researcher’s views of his/her own world (Watkins, 1998).

A number of researchers in the biology area have suggested that while ‘variation’ within and across species may result from random mutation, such variation may also be the result of purposeful mutation. Drawing on the theoretical contributions made by Waddington (1969) and Lewontin (1970) to self-developing aspects in biological entities, research in the molecular genetics field has shown that ‘variation’ in the gene pool can occur due to purposeful molecular restructuring (Plotkin, 1995). This restructuring can be undertaken by a single gene as a specific self-development process and/or as the result of a broader self-developmental process undertaken by the genome system. An example of the first type of restructuring is a gene in the immune system subdividing into subtle variations of itself so as to create a host of possible solutions to an as yet unspecified bacterial attack. The latter restructuring process refers to the numerous individual variations undertaken by the genome to change overall form or design, as shown by the long neck of the giraffe requiring a powerful heart to pump blood to the brain (Hough, 1997). Research is also indicating that the evolution of design, that is, a transformation of the qualitative form of a species, may be due not only to purposeful gene and/or genome restructuring, but also to self-development at the protein and nucleic acid levels (Depew and Weber, 1997).

Similar conclusions are also apparent in physics and chemistry, particularly in studies examining chaotic behaviour, nonlinear dynamics and self-organisation within systems. This research is based on the explicit assumption that all systems are dissipative and open, and that ‘variation’ within a system can arise as a result of purposeful internal activity and/or importation. The belief is that ‘variation’ within a system can be generated through the amplification of in-place energy force fluctuations, the on-going recombination of existing energy forces, and the importation of energy forces from surrounding systems. ‘Variation’ can be further generated by the feedback activities

occurring as the aforementioned new variation(s) enter into the existing variation mix (Prigogine and Stengers, 1984). Importantly, the research makes little distinction *per se* between population, any inherent subpopulations, and environment, arguing that all are, in some measure and manner, providing a contribution to the macro 'pool of variation' through the generation of micro diversity (McKelvey, 1995). This is perhaps the central aspect of this new paradigm, which perceives 'variation' as the result of the relationship(s) between systems and/or components that constitute a system, rather than the components themselves or their particular properties (Misheva, 1997). In essence, 'variation' is, and results from, a multitude of cumulative interactions that occur within and between micro and/or macro levels, and these interactions may not have a definable beginning, completion or limit.

In conclusion, to conceptualise the principle of 'variation' the current thesis has abducted ideas from a number of sources. In doing so it has become apparent that mainstream orthodoxy about 'variation' is open to challenge across a number of areas. First and foremost is the issue of placing of arbitrary boundaries on the system under investigation, for while this may lessen the difficulty of research, it also has the tendency to close the mind to the broader question of *why* something occurs. Such a limitation has occurred in much of the literature pertaining to evolution. As a consequence, this research has (dis)missed the central purpose of all systems, which is, the creation of variety so as to provide the initial catalyst and fuel for an on-going evolutionary process (Arrow, 1986). Secondly, to define 'variation' as some sort of random activity is to provide little insight into *what* the term actually mean. The suggestion is that evolution is little more than the probability of a change in some quantitative aspect(s) of a system. A better approach is the 'multi-dimensional possibility space' definition which is more suggestive of 'variation' as the energy for

qualitative change. On this view, ‘variation’ is the source material that allows systems to continually experiment with their structure or design. Thirdly, while *how* ‘variation’ arises is a matter for conjecture, there is growing support in a number of research areas for the notion that while ‘variation’ may arise from random mutation, it can also result from behaviour that is driven by intent. In fact, there is a suggestion in some of the literature that no system generates ‘variation’ through random processes because all systems are inherently deterministic (Gleick, 1987; Allen, 1990). What is theoretically and/or empirically treated as a ‘random variation’ is in reality an unforeseen consequence of multiple cause and effect relationships, in essence, Lorenz’s (1993) ‘butterfly effect’. Furthermore, all on-going evolving systems, in some measure and manner, exhibit an ability to learn, and to show some level of adaptability that will in itself contribute to ‘variation’. This is perhaps the major point (dis)missed by those proposing ‘intelligent design’ as an argument to support a biblical representation of creationism. While a god may indeed be a reality, the fact that much of what we see and know exhibits a logic in intelligent design is not proof of god’s existence *per se*, but merely a reflection of the intricate complexities inherent within *all* of ‘god’s creatures’. Although there is a need for researchers to assume a level of objective indeterminacy due to an inability to see all the interconnected relationships within the system being investigated, it should not imply a total narrowing of one’s view nor should it force one to take recourse in mathematical probability. Rather, the emphasis should be on bringing to light as many as possible of the sources of ‘variation’ (and any symbiotic interaction(s) between these variations), for it is these aspects that are at the very heart of a system’s evolutionary process. As Popper (1990) has argued, the very nature of a system and its ongoing evolution is a function of the variation arising from realised, being realised, and yet to be realised possibilities.

4.3.2 The Principle of 'selection'

While the principle of 'variation' has been somewhat neglected with respect to conceptual expansion, that of 'selection' is perhaps the most widely-discussed concept ever formulated and used. While the initial conceptualisation of the principle of 'selection' is clouded, Depew and Webber (1997) suggest that Newton's model of celestial motion, and in particular, gravitational forces acting upon (ie. selecting) the trajectory of orbiting bodies, provided the catalyst for discussion across a broad range of disciplines. The notion that outside forces determine the behaviour of individual entities was taken up by classical economics. It resonates in Malthus's *Essay on the Principles of Population* (1850), where it is argued that population behaviours are determined (ie. selected) by resource scarcity (Gould, 1990). Taking recourse in Malthus's thesis, Darwin hypothesised in *On the Origin of Species by Means of Natural Selection or the Preservation of Favoured Races in the Struggle for Life* (1859) that transmutation within Nature is the result of competitive pressures (ie. selectivity) arising as populations increase at a rate beyond resource availability and/or replenishment (Hodge and Kohn, 1985). Given such an esteemed intellectual lineage, it is hardly surprising that current mainstream thinking in most disciplines denotes the principle of 'selection' largely as a struggle for survival in the face of environmental forces. Nor is it surprising that survival is framed as an optimal point in design, or put another way; a state of (near)equilibrium is constantly being restored between an environment and those that constitute its (sub)populations.

Notwithstanding such intellectual weight and intuitive appeal, this conceptualisation of the principle of 'selection' is being challenged on a number of grounds. Firstly, current orthodoxy views the environment and the entities that inhabit it as mutually exclusive classes, and in doing so, discounts the reality of system interdependence (Levins, 1979;

Ho, 1988; Hodgson and Screpanti, 1991). Secondly, the basic conceptualisation of 'selection' offers a force that works on what is already in existence, and as such is not a sound description of a mechanism for overall progression (Hahlweg, 1991; Kauffman, 1993). Thirdly, to assume that 'selection', however defined, is a strong optimising force is highly problematic, for evolution in any context can bring about suboptimal and/or disastrous outcomes (Hodgson, 1993). Lastly, and while not directly related to the conceptualisation process *per se*, there is a tendency within the literature to promote a 'mechanical materialism' view of 'selection' to support other agendas (Ho, 1988; Hough, 1997). In particular, Spilsbury (1974:21) has argued that such promotion is a;

> fundamental and indispensable stratagem of scientific empiricism, which assumes or hopes that the world is comprehensible uncryptically, without resort to such non-empirical conceptions as purpose direction, or to non-empirical sources of information. The history of scientific empiricism shows repeatedly; as a recurring motif, the invocation of selection principles to protect the tenets of empiricism, to make the world safe for positivism, and to fend off 'mysticism'.

The following material, using the *why*, *what* and *how* format, will offer an explanation of the principle of 'selection' which better reflects current knowledge, understandings and experiences.

It was argued earlier that mainstream thinking assumes that 'selection', however defined, is an optimising force, weeding out the 'fit' from the 'unfit'. Such thinking has no explanatory merit because it is little more than a tautology. If 'fitness' is by definition being successful in the selection process "the idea can have no empirical content, for it will not be verified or falsified by reference to any facts that might have been otherwise" (Depew and Weber, 1997:327). It is difficult to understand how this reasoning as to *why* selection occurs became dogma, for Darwin argued that 'selection' does not lead to a single optimal solution, but to an increase in adaptable solutions (Hodgson, 1993). It may well be that the Spencerian phrase 'survival of the fittest' has become so ingrained in the human psyche that it warrants no examination of its

theoretical merit. Whatever the reason, to suggest, as many authors are wont to do, that ‘selection’ occurs to bring about an optimal outcome or state of (near)equilibrium is spurious.

In attempting to explain the *why* of ‘selection’ one needs to also make explicit reference(s) to that of ‘variation’, for the principles of evolution are not discrete aspects, void of any conceptual harmony. Given that the preceding section argued that all systems are open, dissipative structures that generate ‘variation’ as a means of overcoming entropy, it is counter-intuitive to suggest that ‘selection’ occurs to bring a system, and/or those that constitute its population, to an optimal point (or (near)equilibrium state) by diminishing ‘variation’. Evolution requires that there must always be a variety of forms from which to select, a situation that would not occur if ‘selection’ were an optimising force. It should not be inferred however, that these comments dismiss the notion that the underlying *why* of ‘selection’ is regulatory. As previously discussed, without some form of constraining mechanism to act upon the continual generation of ‘variation’, there would be a loss of internal integrity. In this sense, ‘selection’, at least in a broad interpretation, is a mechanism that occurs so as to prevent a system from becoming totally unstable. This view has support within areas of the physics and chemistry literature, where ‘selection’ is seen as a mechanism(s) that manages physical and/or chemical energies so that they do not expand beyond a critical level. An often cited example is the ‘strange attractors’ that bind physical and chemical reactions to a broad pattern of behaviour (Allen, 1990; Kauffman, 1993). In essence, the *why* aspect of the principle of ‘selection’ denotes a universal characteristic of all systems which seeks to dampen inherent variation rampancy so as to maintain structural and/or functional integrity.

‘Selection’ within mainstream (neo)Darwinism is considered to be a natural force, that is, environmental pressures acting on the gene pool. The effect of such pressures is the increase or decrease of particular genes through reproductive success rates, thereby changing the average characteristic(s) within a population (Hough, 1997). This conceptualisation of ‘selection’ as a matter of relative success rates has been encapsulated in the commonly used terminology, ‘survival of the fittest’. On this view, ‘selection’ is a mechanism of competitive struggle, where the ‘fit’ prosper, the ‘unfit’ do not, and where evolution is seen as a quantitative alteration in system entity numbers (Gould, 1977). This depiction of ‘selection’ as an optimising force, weeding out the weak from the strong, has been abducted by a host of (sub)disciplines and used as an analogical reasoning tool in countless literary and research endeavours. However, this commonly evoked *what* (or meaning) of ‘selection’ is questionable on a number of major theoretical grounds. Firstly, the common meaning ascribed to ‘selection’ offers no statement with respect to the evolution or general progress of a system (Hahlweg, 1991; Kauffman, 1993). Secondly, the idea that ‘selection’ is an optimising force is not reflected in the reality of most, if not all systems, irrespective of whether they are biological, physical, chemical or socio-economic. As Gould (1990:12 points out “the proof of evolution lies in imperfections that reveal history.” Thirdly, in treating ‘selection’ as a natural force there is little or no scope to consider purposeful behaviour as a selection mechanism (Hodgson, 1998). Lastly, to suggest that systems are largely competitive landscapes, and that ‘selection’ is driven solely by inherent competitive pressure(s), is absurd. All systems have relatively high levels of interaction, interdependence and/or complementary behaviours, and as such, competition might be a special case of ‘selection’, rather than a defining characteristic (Lewontin, 1978).

A meaning that addresses the aforementioned problematic issues, and one with more interpretive scope, is the idea that 'selection' is a mechanism that promotes, yet places constraints, on ongoing adaptive emergence (Allen 1990; de la Mothe and Paquet, 1996). 'Selection' may be seen to promote adaptive emergence in the sense that both the environment and those that constitute its population(s) undergo intended and/or unintended selective renewal as a result of their interaction and interdependence under constantly changing conditions (Spilbury, 1979; Boulding, 1982; Cramer, 1993). On the other hand, adaptive emergence is constrained in the sense that 'selection' is, in some measure and manner, conditioned by and dependent upon, both its historical contingencies and the properties of that which is selected (Gould, 1977; Hough, 1997). This interpretation of 'selection' sees the process as simultaneous and associative co-selection, incorporating both competitive and cooperative pressures, which consciously and/or unconsciously change the structural and functional aspects of the system in some way (Allen, 1994; Mckelvey, 1995). In adopting a meaning of 'selection' as 'constrained ongoing adaptive emergence' the explanatory focus is placed on adaptation(s) in quality, as distinct from alterations in quantity (Hodgson and Screpanti, 1991; Gould, 1996).

As touched upon previously, within mainstream (neo)Darwinist biology (and in the other (sub)disciplines that have abducted explicit analogues from the area) the conceptualisation of *how* the mechanism(s) of 'selection' operate is usually one of 'competitive conditions, brought about by environmental pressures, impacting in a random fashion on the relative survival rates of individual entities that inhabit a particular environment' (Gowdy, 1985; Hodgson, 1993). That such fortuitous 'fitting' could lead to the evolution of something as complicated as a human being, never mind a complete ecosystem, is mathematically at least, highly improbable (Waddington, 1969;

Levins, 1979; Maturana and Varela, 1980; Hough, 1997). This is not to suggest that the concept of natural selection should be dismissed, but rather to highlight the proposition that there must be more to *how* the selection process works. As Gould (1990:12) commented; "evolutionary theory is fruitfully undeveloped enough to provide a treasure of mysteries… it provides a home for all styles and propensities."

It was stated earlier that the separation of the environment and its inhabitants into mutually exclusive classes is common practice within much of the research into 'selection'. While an atomistic view may facilitate analytical expediency, such separation has no foundation in reality. Evolution is not the transformation of a single population through various stages of development, but rather a process of simultaneous renewal across a number of system areas (McKelvey, 1995; Gould, 1996). Complex systems do not just spontaneously appear; they are the result of cumulative interaction and resultant adaptation. This means that 'selection' must impact on 'within and between' aspects of a system, and that within relatively simple systems such co-selection might operate on all aspects simultaneously (Hughes, 1983; Vromen, 2001). However, as systems become more complex there is a tendency for co-selection forces to localise, a notion apparent within the 'path-dependency' thesis. The underlying assumption here is that 'selection' is not only constrained by historical interconnections and interdependencies, but also by the tendency for systems and/or populations to shelter themselves from future chaotic conditions that may occur due to the exponential increase in such relationships which arise from increasing system complexity (Popper, 1974; Kauffman, 1993; Plotkin, 1995). Though additional and/or different 'selection' mechanisms could be employed, it is argued that even these would have to contract to a more manageable location within the system, or perhaps shift to a new system itself, given a significant rise in complexity (Perez, 1983: Hahlweg, 1991).

It has been argued by Sober (1981:100) that “competition is a familiar way of thinking about natural selection; yet curiously the familiar cases of natural selection that serve as text book examples do not involve competition.” While these may be examples of poor argument, they also reflect the common tendency of many researchers to view any system through a purely capitalistic market-place perspective (Gowdy, 1992). However, if systems do contain varying levels of interconnectedness, then the ‘competitive selection’ effects often assumed to be the drivers of survival, are questionable. In fact it may well be, as previously commented, that ‘selection’ due to competitive pressure(s) is an aberration within an evolution process, for a competitive selection force, by common definition, will not only restrict the quantity of variation, but also the quality of variation. Restriction of the latter runs counter to the central tenant of evolution, speciation, which is concerned with the filling of different environmental niches (Lewontin, 1978). Support for the notion that ‘selection’ is not necessarily a competitive pressure, and more likely to be a complementary or cooperative mechanism, is readily apparent in the human body itself. Sapp (1994:13) notes that “we evolved from, and are comprised of, a merger of two or more different kinds of organisms living together. Symbiosis is at the root of our very being.” Within current physics and chemistry research examining and/or utilising the principles of evolution, ‘selection’ is rarely, if ever, treated as a competitive force. Instead the perspective is symbiotic, viewing evolution (and therefore selection) as a contemporaneous process. The alteration in or of a system is considered to be brought about largely through co-selection forces that result from numerous complimentary and/or cooperative interactions (Prigogine, 1987; Cramer, 1993; Kauffman, 1993).

If it is accepted that ‘selection’ can be a mechanism driven by contemporaneous interdependencies, positing that it is a random force becomes highly problematic. Even

if one takes a contrary view of 'selection', the notion that it operates in a random fashion is illogical. Hodgson (1998:43), argues that "for selection to operate consistently in favour of some characteristics rather than others, behaviour cannot be purely accidental". As argued previously invoking the notion of 'chance' is a case of inappropriate semantics, and using the term 'random' when selection mechanisms are not known and/or fully understood, is less meaningful as a description of 'selection' than using the term 'indeterminate' (Andresk, 1974). On this view 'selection' is not considered as a randomly generated force, but one which occurs as a result of the interdependencies that accumulate as a system becomes more structurally and/or functionally complex (Simon, 1962; Koestler, 1967; Emery, 1969). As such 'selection' is not a random process *per se*, but rather one of default, the result of 'uncaused' (ie. indirectly produced), unintended sequelae or side consequences (Gould, 1996). While the very nature of 'selection by default' makes practical observation a difficult, if not impossible proposition, modelling in the physics and chemistry fields (ie. evolutionary/adaptive landscapes) shows that 'selection' does indeed occur in this manner (Prigogine and Nikolis, 1989; Allen, 1990/1994; Kauffman, 1993; McKelvey, 1995).

However, 'selection by default' cannot be the sole or dominant mechanism, as there must also be a high degree of coordination due to the coevolutionary imperative. As previously argued, evolution should never be considered as the transformation of the individual (whether that be gene, entity or species) because of the complex interdependencies that exist in even the simplest of systems. Furthermore, 'selection' is not just a force emanating from the environment, for population(s), whether biological, physical and/or chemical, may select particular environmental niches that fit their particular needs (Levins, 1979; Kauffman, 1993; Hough, 1997). This means that

‘selection’ can be a conscious force, a mechanism driven by purposeful behaviour based on some level of foresight and/or intent. That ‘selection by design’ may occur is readily apparent in the literature pertaining to self-developing genes (as discussed in Section 4.3.1). ‘Selection’ is a constant experiment with form, and while such experimentation may not be directed at a specific gene, species or population *per se*, there is an intentional selection mechanism at work that tempers the overall direction of this experimentation (Gould, 1977; Hull, 1988). The concept of ‘selection by design’ is also apparent within some areas of physics and chemistry, where systems are viewed as autopoietic in nature, that is, the interactions of the dissipative structures that constitute a system are held in check by intentionally selected constraints (Allen, 1988; Prigogine and Nikolis, 1989; Kauffman, 1993). As noted previously, these self-imposed constraints are not applied to a particular aspect *per se*, but operate instead as a loose selection mechanism that (re)allocates energy so as to provide a broad direction for a system’s evolutionary path (Prigogine and Stengers, 1984).

To conclude, much of the mainstream literature conceptualises ‘selection’ as a mechanism of chance. On this view, random events within an environment create competitive conditions, with the survival of a particular entity (ie. optimal outcome) under such conditions the result of random fortuitous mutation(s). While it is acknowledged that natural selection is one of the most useful concepts ever formulated, its common (mis)conceptualisation offers limited value as a principle for explaining the evolution of even relatively simple systems. By adopting a *why*, *what* and *how* approach, the material presented in this section has offered a conceptualisation of the principle of ‘selection’ that allows for the development of more realistic understandings of its underlying mechanism(s). In accepting that evolution is not a staged process towards a state of (near)equilibrium the reference point for *why* moves closer to that

which provides a regulatory role. The *why* is regulatory in the sense that 'selection' occurs to maintain the structural and/or functional integrity of a system, and to promote and support on-going evolution rather than the achievement of some optimal outcome. In this role 'selection' is a mechanism for the stimulation of ongoing adaptive emergence, regulating the overall design of a system rather than the specifics of its inherent properties. Given that the regulatory focus is on overall design, the mechanism must be one of co-selection, which occurs simultaneously, which emanates from both the environment and population(s), and which also involves 'within' and 'between' system aspects. This is not to imply that the co-selection mechanism operates across a whole system, for it has a tendency to become localised due to the imposition of previous selection behaviour(s), the properties of the variation being selected upon, and any significant increases in system interdependence. Furthermore, given these notions of co-selection and interdependence, it is highly likely that a defining characteristic of 'selection' will be a cooperative or complimentary nature, as distinct from one driven solely by competitive concerns. It follows too that a 'selection' mechanism must operate with a degree of purposeful intention, though such internationality may dissipate into unintentional consequence as it resonates through complex structural and/or functional interdependencies. Taken in concert, the concepts identified in this section move beyond the somewhat simplistic interpretation of Darwin's intellectual legacy that is generally found in the literature. As a result a deeper appreciation of the subtlety inherent within the evolution of even the simplest of systems is possible.

4.3.3 The Principle of 'preservation'

Within much of the current literature examining evolutionary processes, the principle of 'preservation' is usually given short shrift. This happens not so much because of conceptual complexity, as is the case with the principle of 'variation', but because of the

almost universal beliefs in the ability of natural selection to adapt biological forms to optimally fit their environment, and that any adaptation is directly inheritable. Such beliefs have been termed the 'Panglossian paradigm', a somewhat rationalist mechanistic perspective that conceptualises all things as serving a specific purpose or function in what is at present, and will be in the future, the best of all possible worlds (Gould and Lewontin, 1979). The implication of such a perspective is that what is preserved forms a 'perfect match' with its environment, and therefore requires little in the way of explanation. In this sense, all adaptations and inheritances are (near)optimal and there for a reason (Hahlweg, 1991; Hough, 1997). However, the contention that all living things are a (near)optimal adaptation to environmental conditions, brought about by the forces of natural selection, is little more than a mechanical cause and effect description of the current characteristics and/or behaviours of entities, and as such, offers little real enlightenment;

> one cannot get a good explanation of an organism's traits merely from what would, *a priori*, be the most efficient, most desirable way for an organism to function. One cannot do this for roughly the same reasons that one cannot get a good historical narrative, or even a good fictional one, merely by mentioning what an agent intends to do, tacitly supposing that it will be done. Life just is not like that. Just-so stories in biology are, in this respect, like hero worship in history: neither can produce a convincing, or even real, narrative (Depew and Weber, 1997:389-390).

Compounding the conceptual problem associated with the 'evolution through optimal adaptation and direct inheritance' thesis are a number of inherent theoretical assumptions that do not ring true in the face of known reality. These include: treating an environment's overall population as a collection of discrete and distinct (sub)populations, and considering such to have little or no adaptive interaction (Hull, 1988); treating these individual groups as passive, undergoing specific adaptation(s) merely as a reactive response to random and quite narrow environmental forces (with no consideration of proactive response), whether that be by (sub)populations or by the environment itself (Plotkin, 1995); treating the inheritance of selected adaptation(s) as a

symmetrical transmission, with no consideration of the differences (whether inherent or as a result of transmission) between the sender and receiver of such a transmission (Depew and Weber, 1997); and finally, treating adaptation(s) as a final response, with little or no regard as to the impact such adaptation(s) might have on the on-going evolutionary process (Gould, 1996). The following material adopts an explanatory format similar to the previous sections and offers a conceptualisation of the principle of 'preservation' that addresses the criticisms levelled at the 'optimal adaptation' thesis and the fallacious assumptions which it spawns and harbours.

As previously argued, any discussion on the principles of evolution, whether individually or in combination, should operate from a basis of underlying conceptual congruency. While a number of theoretical differences have been raised with respect to the principles of 'variation' and 'selection', both explanations have been developed from the same conceptual foundation; that is, all living things, whether they are big or small, simple or complex, are open dissipative systems that cycle internal and external interdependent relationships in an effort to maintain their structural and/or functional integrity in the face of entropy. Given this, it would seem logical to suggest that the *why* of 'preservation' is survival. While the current thesis accepts that survival is the ultimate purpose of evolution, and therefore central to the evolution process, the common conceptualisation of 'survival' is challenged. In particular, the notion that 'preservation' embodies an individual's defining moment, when a randomly generated and/or inherited trait facilitates a perfect 'fit' with current environmental conditions is questionable. This notion which manifests itself in the terms 'optimal adaptation' and 'heritable fitness', has drawn criticism due to its depiction of evolution as a somewhat static process, suggestive of little more than short-term gain or progress. As Jantsch (1980:273) argued, "In the dynamics of dissipative biological, socio biological and

socio cultural processes… there are no problems which may be solved once and for all. There is only a dynamic, evolving *problematique…"*. The implication is that it may be more appropriate to consider more deeply the *why* of 'preservation', and the inherent notion of survival, and in doing so, to move beyond terminology that serves merely as a mouthpiece for abstract mathematical models that treat evolution as an alteration in quantity, with little regard for changes to quality.

As previously discussed (Section 4.3.1), research at the genetic biological level shows that survival and inheritance are not solely accomplished through adaptation(s) to environmental conditions that initially result from random mutation. Research has shown that genetic restructuring can occur as a result of an internal self-organisational or generational process that is not triggered by external conditions (Plotkin, 1995; Hough, 1997). Furthermore, it has been shown that at the molecular biological level, the bulk of DNA within most species is comprised primarily of 'preaptive' or 'nonapted' features, readily available, either individually or in a combinational compound, if required in the future (Gowdy, 1992). This suggests, that at these biological levels at least, 'preservation' has more to do with future flexibility than immediate survival *per se*. The notion of future flexibility is also apparent at the species level, and is encapsulated in the concept of 'exaptation'. This concept is based on the premise that the vast majority of a species' characteristics are unrelated to pressures emanating from the current environment, though these characteristics may be consciously coopted as a dominant trait in the future to counter new environmental circumstances (Gould and Vrba, 1982; Depew and Weber, 1997).

The idea that the *why* of 'preservation' has more to do with 'ongoing resilience' than 'immediate survival' is also apparent in the areas of physics and chemistry which utilise

an evolutionary perspective. This is particularly so in research adopting the view that systems are autopoietic in nature (Luhmann, 1982; Gleick, 1987; Laszlo, 1987; Allen, 1990). Systems are autopoietic in the sense that they will constantly redirect internal energy and draw upon external energy sources in an effort to overcome the second law of thermodynamics. The point should be made that this autopoietic nature is not merely concerned with the development of a specific solution to a particular entropic problem, but is also focussed on a range of possible solutions that may be adaptable to future entropic forces, what Lewontin (1987) termed a 'typology of accessibility'. It has been suggested by some authors that this notion of an autopoietic nature should be further expanded, such that it also denotes an ability to both construct a new dissipative system and to pass on this ability (Prigogine, 1987; Kauffman, 1993).

While it is accepted that the *why* of 'preservation' is ultimately about survival, to conceptualise the principle in terms of 'optimal adaptation' and 'symmetrical inheritance' is too neat. The process of evolution (and therefore any explanatory principles) cannot be conceptualised within a maximisation explanation, for there is no specific pre-existent form or ideal that adaptation(s) should attain. This is not to imply that evolution lacks foresight, for there must be some reason for system durability, but rather to suggest that this foresight is implicit, rather than explicit. While evolution is a process incorporating the replication of what seems to work, its fundamental purpose is directed towards the emergent reproduction and renewal of what could possibly work so as to ensure a system's on-going structural and/or functional integrity. In a sense, the *why* of 'preservation' has more to do with resilience than survival, more to do with flexibility than optimality, more to do with the future than the present.

Within mainstream literature the meaning (or *what*) ascribed to the principle of 'preservation' is usually denoted as optimal adaptation through heritable fitness. Within such a denotation, adaptation is deemed to be an entity's unconscious response, via random mutation, to environmental pressures. Any response that facilitates a better match to environmental circumstances necessarily becomes a selected heritable characteristic that increases the 'fitness' (ie. reproductive success) of said entity's offspring or lineage. While this definition has logical appeal, particularly for those who see success in terms of sheer weight of numbers, it is based on a number of questionable assumptions. Firstly, the definition implies quite explicitly that the environment is either static or changing at a rate that is gradual enough to allow an entity's successful adaptation to be passed on to the population as a whole, and then to successive generations (Ho, 1988). While the 'punctuated equilibrium' thesis attempts to modify this view by suggesting that an environment is subjected to "long periods of little change punctuated by short periods of rapid change" (Wollin, 1995:54), the very assumption that change in environmental conditions is largely gradual "is a culturally conditioned prejudice, not a fact of nature" (Gould, 1990:163). Secondly, the focus of the adaptionist theory is on the individual, considering only the contribution an adaptation makes to their particular fitness, with little or no reference to any relational impact, whether that be on other genetic characteristics, (sub)populations and/or environments (Plotkin, 1995). And thirdly, the common depiction of adaptive fitness implicitly assumes that any adaptation that is inherited must be necessarily functional and (near)optimal. Given that the majority of research focuses on a single specific adaptation that can be relatively easily explained by environmental usefulness, such an assumption seems defensible. It is not supported however, by the fact that the majority of a population's broad range of characteristics, inherited or otherwise, have no

relationship(s) with their success, their often overlooked failure, and their current environmental circumstances (Hahlweg, 1991; Hough, 1997).

To counter the shortcomings associated with ascribing the ‘evolution through adaptation’ meaning to the principle of ‘preservation’, the current thesis suggests that it is more appropriate to adopt the subtle, yet distinctly different meaning, ‘evolvability through adaptability’. Employing the term ‘evolvability’ is an explicit recognition of the on-going nature of evolution, and in particular, of the fact that a system has the ability to operate in a dynamic range of conditions, fluctuating between order and chaos (Campbell, 1987; Lewin, 1992). Using the term ‘adaptability’ broadens the descriptive focus such that inheritance may involve replication, reproduction and/or renewal. On this view, evolution concerns not only the direct inheritance of ‘environmentally selected’ adaptations, but also the ability to interpret and overcome the constraints imposed by environmental pressures via ‘internally selected’ adaptive responses (Hough, 1997). Sole reliance on an ‘adaptation’ descriptive makes it difficult, if not impossible, to reconcile the heterogeneous nature of evolution, for it suggests a tendency towards homogenisation, with a population all bearing the same, or very similar characteristics. By contrast, ‘adaptability’ allows for the incorporation of a broader notion of evolution as a phenomenon of on-going emergence, where ‘self-consistent sets of (sub)populations constantly pose and solve the problems and opportunities associated with mutual existence’ (Allen 1990). Furthermore, by proposing an ‘evolvability through adaptability’ meaning, the principle of ‘preservation’ is broadened to include more than the discrete (whether that be a specific (sub)population, adaptive response and/or inheritable trait). ‘Preservation’ is ultimately about the on-going evolvability of the system as a whole; it is concerned with maintaining structural and/or functional integrity within the fluid phase space bounded

by order and chaos, for it is here, and particularly so at the ‘edge of chaos’ that the greatest opportunities for further evolution exist (Prigogine, 1987; Kauffman, 1993).

Within mainstream literature the depiction of *how* ‘preservation’ occurs is commonly incorporated within the notion of ‘replication’, that is, the duplication and direct inheritance of randomly generated (though naturally selected) adaptations, which fit environmental conditions. The underlying logic is that in a struggle for survival (near)optimal adaptations will not only confer greater reproductive success, but also the direct inheritance of said adaptations will ensure on-going reproductive success, and therefore continual survival. This depiction of the *how* of ‘preservation’ as a simple numbers game is inappropriate *per se* and furthermore, it is based on two highly questionable theoretical assumptions, which pervade research in the area of evolution theory. Firstly, to assume that adaptation is a specific, discrete and sequential event shows a total disregard of the coevolutionary imperative and associated relational character that binds all living systems. Jantsch (1980:75) notes that “it is not adaptation to a given environment that signals a unified overall evolution, but the co-evolution of system and environment at all levels”. Secondly, the common depiction of ‘preservation’ as a (near)optimal outcome, whether in the guise of a particular adapted trait and/or the symmetrical inheritance of that trait, is indefensible;

> ideal design is a lousy argument for evolution, for it mimics the postulated action of an omnipotent creator. Odd arrangements and funny solutions are the proof of evolution-paths that a sensible God would never tread (Gould, 1990:20).

To evoke these assumptions makes for neat, relatively simple research into the phenomenon of evolution. However, to do so glosses over the fact that the evolution of any system is a messy and complex process, a process that should be reflected in any explanation (West and Salk, 1987; Appleyard, 1992).

As stated earlier, most explanations within mainstream biology of *how* 'preservation' operates, view it as the direct replication and inheritance of (near)optimal adaptations that allow a (sub)population to 'fit' their current environmental circumstances. In accepting that there is a measure of validity in such an explanation, this only holds true if the adaptation, the aspect of the system environment to which the adaptation is 'fitted', and any inherent interdependencies, remain relatively stable. All systems attempt to maintain a measure of stable or ordered energy (state?) in an effort to preserve structural and/or functional integrity. However, such integrity would ultimately dissipate if this ordered energy reach a level such that the importation and/or self-development of diverse energy stopped. As previously argued, all evolving systems must contain a mix of fixity and freedom, that is, a sufficient level of order to allow (sub)populations to hold and exchange information, but also a significant level of flexibility so that the creation and exchange of new and diverse information can occur unabated (Prigogine, 1987; Kauffman, 1993). It is this latter aspect that has the greatest influence on system evolvability, for it is not the preservation of a particular adaptation *per se* that is at the heart of evolution, but rather the preservation of 'adaptability'. Of critical interest is the ability to survive in a system that is fluid enough to allow further evolution;

> The notion of 'adaptability' has two different, albeit related, meanings. On the one hand we may call it 'adaptiveness', meaning the actual capacity a population of organisms exerts in its normal heterogeneous habitat. On the other hand, it denotes the potential to adapt to future environmental circumstances (Hahlweg, 1991:440).

The notion that on-going evolution is the result of both adaptation and adaptability is apparent within the molecular biology literature (Hull, 1980; Dawkins, 1989, Depew and Weber, 1997). Research into the structure and function of genes has identified three distinct DNA mechanisms that are apparent, to varying degrees, within the genetic make-up of most, if not all biological populations. The first mechanism is termed 'replicators', denoting that DNA has a *replicating* function that preserves and passes on

fixed information with a high degree of fidelity. The second is termed ‘interactors’, denoting that DNA has a *reproduction* function that produces, preserves and passes on modified information (ie. differential replication) that has been attained through direct interaction with the environment. The third is termed ‘instructors’, denoting that DNA has a *renewal* function that produces, preserves and passes on novel information pertaining to the construction of new and diverse dissipative structures. These different mechanisms of ‘preservation’ are explicit in Depew and Weber’s (1997:470) basic depiction of biological evolution;

> We assume that the properties required for the emergence of life will be maintained by living systems…. That is why we view living things as *informed* autocatalytic systems that sustain themselves by efficient environmental energy exchanges, yet vary under the drive to configurational randomness in such a way that new information, guiding new catalytic functions, can be selected from this variation.

That ‘preservation’ occurs through the aforementioned functions is implicitly apparent in some of the general biological literature which suggests that what is preserved and passed on is not a single elementary trait, but a structural configuration of much higher ‘design dimensions of preservation’ in which such traits may be nested (Hodgson, 1993; Plotkin, 1995). It is further argued that the extent to which these ‘preservation’ mechanisms of replication, reproduction and renewal are apparent within (sub)populations is largely path dependent. As such, the opportunities and motivations for a population to improve in adaptability are also a function of historical contingencies, and in particular, of the level of environment heterogeneity (Hahlweg, 1991).

The capacity of systems to replicate, reproduce and renew is also apparent within some research areas in physics and chemistry research, particularly in the complexity and chaos theory fields (Prigogine, 1987; Cramer, 1993; Kauffman, 1993; Misheva, 1997). It has been suggested previously that physical and chemical systems exhibit a certain

degree of order at the macro level, such an ordered state being brought about by the replication of accumulated system interactions and historical constraints. At lower levels the state of the system is more chaotic, with internal fluctuations and amplifications depicted as a sort of 'imaginative and creative force' which explores around whatever presently exists (Allen, 1990). This force reflects the autopoietic and autocatalytic characteristics associated with all evolving systems. They are autopoietic in the sense that there is an inherent ability within systems to continuously reproduce and renew themselves in such a way that the integrity of their structure is maintained (Laszlo, 1987; Hodgson, 1993). They are autocatalytic in the recognition of the inherent ability of systems to feed back into themselves positive and/or negative outcomes of the autopoietic process (Jantsch, 1980; Johannessen, 1998). As with biological systems, research utilising the 'adaptive landscapes' perspective has shown that a physical and/or chemical system's level of adaptability is also path dependent, and as such a function of past experiential challenges (Koestler, 1980; Cramer, 1993; Kauffman, 1993; Allen, 1994).

In conclusion, much of the mainstream literature adopts the 'adaptionist thesis' when attempting to explain the principle of 'preservation' as it applies to evolutionary theory. The 'adaptionist thesis' perceives 'preservation' as an optimal utilitarian adaptation forged by random generation and natural selection forces, which is then passed on to successive populations through direct inheritance and/or reproduction. This common depiction of evolution within a maximisation model is inappropriate given that most (sub)populations carry an excess baggage of nonaptive features (Gowdy, 1992). The *why* of 'preservation' has little to do with a defining result, with one specific adaptation that stands out above all others as the sole means to survival. By definition, evolution is a continual process fuelled by system variation. Therefore, 'preservation' occurs not

merely to replicate adaptations that have worked in the past, but also to reproduce and renew adaptations that could possibly work in a future *milieu* of on-going novelty. This emphasis on future flexibility suggests that the *what* of 'preservation' is ill-served by the notion of 'evolution through adaptation', and in particular, by its common conception as a heritable characteristic that increases the fitness (ie. success) of a given entity in a given environment. A notion of 'preservation' that is considered to better reflect our developing knowledge and understanding, and to offer greater conceptual scope, is 'evolvability through adaptability'. Such a meaning suggests that 'preservation' is not an end in itself but rather an on-going process of system emergence within the dynamics of an environment comprised of constantly changing parameters and interdependencies. Given such environmental flux the *how* of 'preservation' must necessarily be more than mere replication of a randomly generated characteristic that seems to 'fit' current circumstances. By incorporating replication and renewal mechanisms the adaptability aspect of 'preservation' is highlighted. This is a purposive, yet constrained response that utilises a diversity of mechanisms in an effort to maintain and enhance structural and/or functional integrity in an evolving environment. Such integrity however, is not achieved through the 'preservation' of a final (near)optimal adaptive response, but through the 'preservation' of the ability to offer a variety of responses. Furthermore, 'preservation' (in conjunction with 'selection') continually expands 'variation' through feedback and experimentation, a form of perpetual progression driven by the simple proposition that a really good idea is created through many ideas. Irrespective of the system, this fact holds true, "for in evolution variation is the defining (and concrete earthly) reality" (Gould, 1996:41).

4.4 Conclusion

Evolutionary theory is in a constant state of flux, due to its broad disciplinary appeal, associated philosophical and methodological foundations, and the researcher's powers of perception and conceptualisation. Notwithstanding the theoretical dominance of (neo)Darwinian thought, there is no single meaning (and inherent conceptualisation) of evolution that is accepted as proof positive of an underlying set of generalisations and/or predictive laws (Depew and Weber, 1997). What does hold true however, is that any explanation of evolution must incorporate the principles of 'variation', 'selection' and 'preservation' (Leydesdorff, 1994; Saviotti, 1996; Hodgson, 1997). As previously discussed, principles are 'illuminating metaphors', conditions if you will, that have to be included so as to provide not only a direction for inquiry, but also to help establish the explanatory 'facts' of the phenomenon under investigation (Spilbury, 1974; Hodgson, 1993). While the aforementioned principles are sacrosanct, they are nevertheless open to explanatory conceptualisation(s). To be of benefit these explanations must exhibit a level of generality so as to allow broader contextual appeal and application (Kaplan, 1964). The explanation of 'evolution' provided by the current thesis has abided by these stipulations, adopting a *why*, *what*, *how*, *when* and *where* approach to the conceptualisation of the principles of evolution. This conceptualisation is based on a diversity of general theoretical ideas drawn from a range of (sub)disciplinary areas. Although these ideas come from a diversity of sources, they are all bound by one overarching ontological assumption. Systems that undergo evolution, irrespective of their nature and composition, are open and dissipative process structures that exhibit varying levels of instability. This constant unstable or disequilibrium state is the result of system energy generation, either through internal and/or external sources, in an effort to overcome the entropy of resource depletion, however defined.

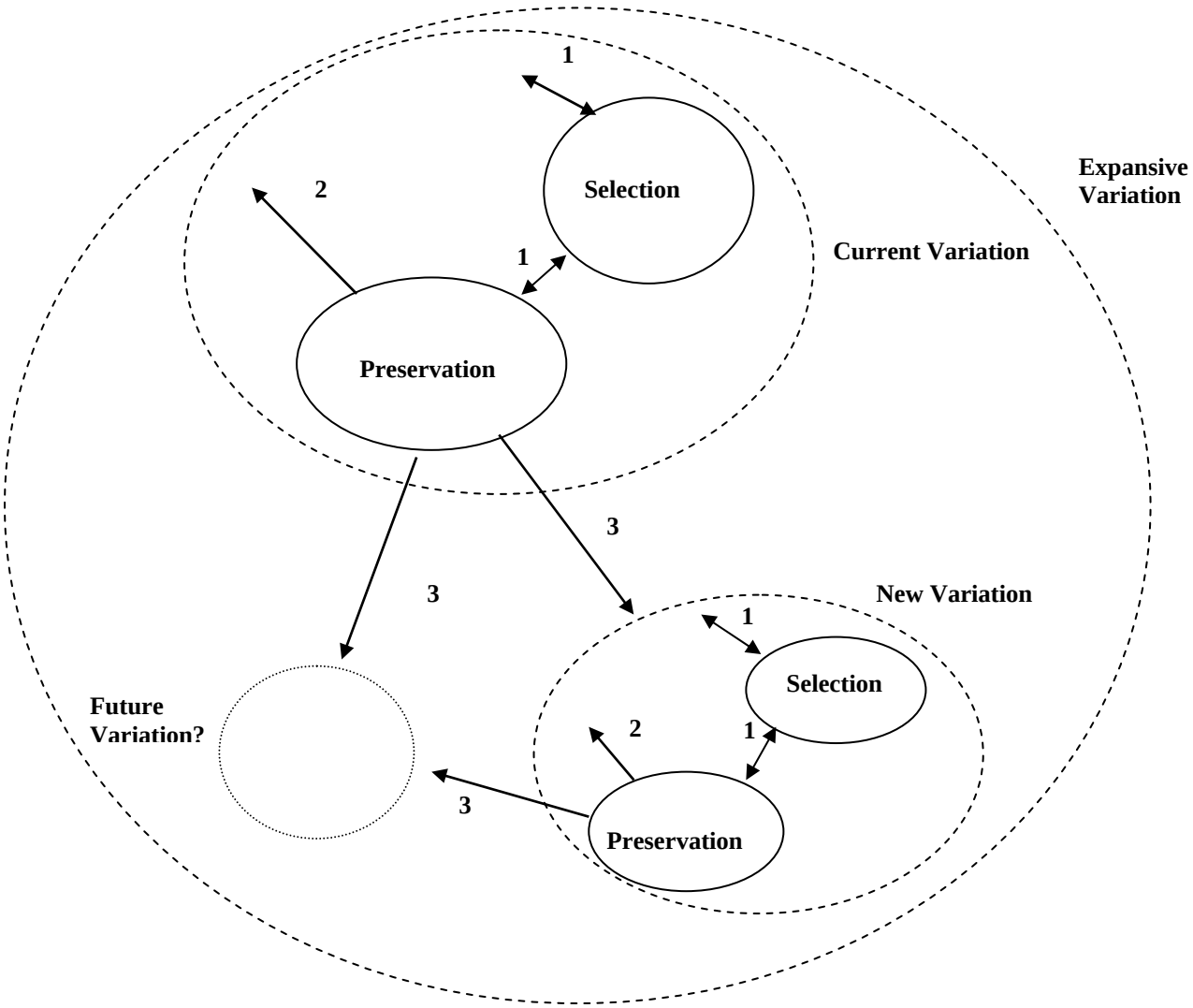
Such an assumption requires the explicit recognition that at the very heart of the evolutionary process is the production of ‘variation’, for without such diversity there is no evolutionary progression. Any movement, motion or change can occur only through the possibilities afforded by individual difference, and while the process of evolution may increase or decrease the complexity of a system, it always acts to increase ‘variation’. In essence ‘variation’ is the fuel of evolution, a ‘multidimensional possibility space’ that is at once the embodiment of a system’s past, present and future. This is not to suggest that an evolving system has limitless possibilities, for the historical contingencies of the past and present place constraints on future potential. The ‘variation’ that constitutes this possibility space arises as a result of: nondeterministic responses (ie. complexity of relational interdependencies) to broader system forces; purposeful self–developmental responses (ie. autopoiesis) to current and potential system forces; and/or feedback loops (ie. autocatalytic) associated with such responses and inherent to the structural complexity of the system itself.

To maintain a level of structural and/or functional integrity an evolving system will attempt to regulate ‘variation’, in both the level of generation and internal interaction(s). Such regulation is accomplished through ‘selection’, a process that attempts to keep a system in a fluctuating state between fixity and freedom so as to facilitate its on-going ‘adaptive emergence’. This process of ‘selection’ occurs simultaneously across different levels within a system, bringing together a number of variational energies into an overall design that offers some measure of structural and/or functional integrity. There are limits to this design however, for that which selects and that which is selected are path dependent, a function of previously employed ‘selection’ mechanisms and historical system interdependencies. While such interdependencies, in concert with outside environmental pressures, mean that ‘selection’ can occur in an unintended

manner, the process is strongly conditioned by purposeful intent. The structural and/or functional properties of a design emerge, rather than appear fully formed, and are a function of the associative nature inherent within the evolutionary process. While simple designs may result through ‘accidental’ or random selection, relatively complex designs can only emerge through a measure of conscious determination and organisation driven by competitive and/or cooperative imperatives.

While ‘preservation’ is ultimately about survival, it must be achieved in an emerging evolutionary context that is a mix of stability and instability. In such a context, survival itself is largely a matter of on-going resilience, the achievement of such requiring a combination of specific adaptations that work in relatively stable, yet somewhat changeable conditions, and a level of adaptability that affords a range of possible responses to any future disordered conditions. This evocation of ‘preservation’ as largely a case of ‘evolvability through adaptability’ necessarily requires a shift in emphasis with respect to its underlying mechanisms. While resilience may arise through the ‘replication’ of random and/or intended adaptations, such survival would be short-lived in anything but a stable environment. Given that an evolving system is by definition beset by instability, the notion of ‘preservation’ must incorporate mechanisms akin to learning. ‘Reproduction’ and ‘renewal’ are such mechanisms, the former referring to the ability to undertake a range of limited responses to localised environmental conditions, and the latter denoting the ability to construct new dissipative structures. Like all learning systems, this ability to develop a range of adaptable responses is initiated and enhanced through frequent exposure, whether intended and/or unintended, to a diversity of environmental conditions. A pictorial representation of the central features of the explanation of evolution developed in this thesis may be found in Figure 4.2. It is offered as an aid to the representative process.

Figure 4.2 Evolution 'in and of' an open and dissipative system



VARIATION
Why: on-going internal self-renewal and/or importation of external energy so as to overcome the entropic forces of resource depletion
What: multidimensional possibility space
-known/unknown sources of variation
-variation limited so as to maintain structural/functional integrity
How: -unintended responses to/from environmental stimuli
-intended self-development (internal/external sources)
-positive/negative feedback from interdependent system activities
When: ongoing
Where: interrelational

SELECTION
Why: regulatory-to maintain structural/functional integrity
What: the 'adaptive emergence of evolution's direction
How: -simultaneous co-selection
-competitive and cooperative
-intended and unintended
-path dependent
When: on-going
Where: predominately localised

PRESERVATION
Why: on-going resilience
What: evolvability through adaptability
How: -replication
-reproduction
-renewal
When: on-going
Where: design level

Arrow 1 relational interdependence/feedback between mechanisms
2 'reproduction'/'renewal' feeding into 'variation'
3 'renewal' creating new 'multidimensional possibility space'

This somewhat simplistic diagram is not considered to be a ‘true’ depiction of the evolutionary process, for such a depiction will always be beyond the capabilities of any graphic design approach. Furthermore, the most sophisticated software packages will not only be overwhelmed by the sheer complexity of evolution, but also lack the ability to generate true novelty as it is governed by initial parameter setting. The research design elements of *interesting*, *plausible* and *acceptable* have been specifically developed as a measure of validity for both the ‘familiarisation’ of marketing’s current explanatory frameworks of technological innovation (Chapter Three) and for the proposed alternative framework (Chapter Five). These elements can also be used as a general measure of validity for the explanation of evolution in Figure 4.2. While the *interesting* categories cannot be used as explicit challenges to in-place assumptions associated with current explanations of evolution (such categories are more amenable as challenges to specific assumptions that underpin concise hypotheses construction), the general theme of this particular research design element is nevertheless appropriate. Much of current mainstream research into evolution uses a (neo)Darwinian perspective, and as such, is couched within an atomistic, reductionistic, deterministic, gradualistic and mechanistic framework. The latter has been challenged in this chapter through the development of theoretical assumptions such as open and dissipative systems; structural and/or functional emergence; relational interdependence; autopoietic consequence; and autocatalytical feedback. The *plausibility* and *acceptability* criteria are considered fulfilled because the explanation of evolution offered in the current thesis answers the conjecture tests satisfactorily (See 2.4.2). Furthermore, it is argued that the intellectual weight of the referenced sources used in developing the explanation of evolution also provides high levels of *plausibility* and *acceptability*.

These comments do not imply that the offered explanation is a ‘true’ representation of the evolution process, for it is little more than an incomplete approximation, and therefore contestable. Evolution, both as an *explanada* and *explanadum*, is always on the move, for as Jantsch (1980:8) observed; “Evolution is open not only with respect to its products, but also to the rules of the game it develops.” However, it is argued that the explanation offers the potential for a more insightful understanding of the realities of evolution than that proffered by mainstream (neo)Darwinian thought. In the following chapter this explanation of evolution will be used as a framework, a formal cognitive model if you will, highlighting what is perceived to be a strong similarity between the processes of evolution and technological innovation in terms of exhibited pattern or form. It will be argued that because of this similarity one may apply the principles and associated conceptualisations of evolution to that of technological innovation. In essence, the next chapter will address the question; *does evolutionary theory provide a good explanatory framework for examining the phenomenon of technological innovation?*

> Science is no miraculous creation out of nothing, no spontaneous generation of knowledge from ignorance. When presuppositions are denied logical status, we remain mired in scepticism: epistemic bootstraps give no more leverage than any other. The task is not to move from wholesale ignorance to knowledge, but from less knowledge to more, from knowledge of some things to knowledge of others, from the vague and uncertain to what is clear and warranted (Kaplan, 1964: 85).

5.0 EVOLUTION: A 'GOOD' EXPLANATORY FRAMEWORK FOR TECHNOLOGICAL INNOVATION RESEARCH?

5.1 Introduction

An explanatory framework, as distinct from an explanation, is the practical proposition that what is thought to be a special case resembles a more general one, at least in terms of form, though not necessarily content (Baithwaite, 1956; Quinne, 1960). As such, an explanatory framework is a formal cognitive model (based on a style of abducted thought as distinct from a style of presentation) which is used in an analogical sense to show that two distinct phenomena share the same underlying process pattern (Lakoff, 1987). Though this approach to research method is seldom explicitly acknowledged, Chapter Three identified such 'analogical abduction' underpinning marketing's dominant frameworks (ie. diffusion, NPD, networks) for researching issues associated with technological innovation. Notwithstanding the contributions these frameworks have made to our understanding of technological innovation, their current use as empirically-generated predictive models limits deeper understanding. As O'Shaughnessy (1997:677) argues, attempting to explain social phenomena through empirically-based generalisation not only "ignores the richness and variety of behaviour, but is also an argument that reason has nothing of its own in contributing to raising this veil of ignorance." That the marketing discipline exhibits a relatively high level of ignorance with respect to technological innovation has been noted by a number of authors, who argue that the research area has as yet no explanatory framework that satisfactorily interprets what is an uncertain and highly complex reality (Meldrum, 1995; Sheth and Sisodia, 1999; Fleming and Soreson, 2004).

To use evolutionary theory as an explanatory framework for technological innovation is to explicitly recognise that the process of both is uncertain, characterised by numerous unique individual events that have varying (and sometimes quite subtle degrees of interdependence) that are not as yet fully understood. This suggests that the most appropriate form of explanation at present is textual, because only language has the required vocabulary to acknowledge and represent a complex process in which the future, and even present course of events, cannot be fully anticipated (Sayer, 1992; Depew and Weber, 1997). While the transfer of theories from the natural to social world through a *textual explanation* might be considered as nothing more than pseudo-science, it is more appropriate in the current context than resorting to a numerically-based explanatory framework;

> Those who refuse to deal with important and interesting problems simply because the relevant factors cannot be measured, condemn the social sciences to sterility, because we cannot get very far with the study of measurable variables if these depend on, and are closely woven with, immensurable factors of whose nature and operation we know nothing (Andresk, 1974:130).

The approach adopted in the current thesis is not novel or unique, in that there is a large body of inter-discipline research attempting to highlight the similarities between the processes underlying evolution and technological innovation. However, this research area has been judged a confusion of incoherent messages (Hodgson, 1997; Vromen, 2001), lacking in research standards and techniques (Nelson, 1995), and little more than a criticism of neoclassical economic concepts (Witt, 1991). It has also been suggested that the research program is so deeply ingrained within (neo)Darwinian explanations that strict adherence to associated metaphors seems to be the dominant criterion for a theory to qualify as ‘evolutionary’ (Freeman, 1991; Gowdy, 1992; Foss, 1997). Despite these inherent problems within the research area, utilising evolutionary theory as an explanatory framework for technological innovation is considered to have merit. This judgement is based on a number of factors, and in particular, that evolutionary theory:

addresses the specific aspect of technological and/or environmental uncertainty (Dosi and Nelson, 1995; Meldrum, 1995); is a means to integrate the multiple streams of technological innovation research (Drazin and Schoonhoven, 1996); supports the pluralistic expansion of conceptual thinking with respect to technological innovation (Saviotti, 1996; O'Shaughnessy, 1997); and is a plausible alternative to the neoclassical economic approach that views technological innovation through a lens that is atomistic, reductionist, deterministic, gradualistic and mechanistic (Bohman, 1991; Silverberg and Verspagen, 1994; Hodgson, 1998). The following material will present a narrative explanatory framework, showing that the ontological stance, principles and associated conceptualisations of evolution identified in the previous chapter can be used as analogous representations of the technological innovation process. As consistently argued, such representations are not touted as 'truths' *per se*, but rather as a more plausible explanation of the 'realities' of technological innovation than those that currently dominate mainstream marketing thought.

5.2 Technological innovation 'as and of' an open and dissipative system

It was argued in Chapter Four that evolution can only occur to, and within, a system that is open and dissipative, that is, the process is one of adaptable interdependencies that generate novel internal and external energy so as to provide the means for overcoming the entropic forces of resource depletion. Within such an ontological proposition, both the entity under investigation and the system that bounds it must have an on-going measure of disequilibrium due to varying levels of asymmetric energy interdependencies. However, in much research the idea that evolving socio-economic systems are essentially 'measured states of disequilibrium' is largely ignored, a function of the basic desire to have, and therefore see, order and the preservation of the status quo as our salvation;

> The task is to preserve the institutions of society in their present structure, we hear from all sides. Governments are supposed to preserve the constitution, churches the religions, universities the 'objective' structure of science, and all of us the existing institutions. The values of society must not be touched, its structures not put in question (Jantsch 1980:270).

Intellectual commitment to this belief is readily apparent in General Equilibrium theory, an overarching, though seldom explicitly-acknowledged assumption within much of the social sciences literature, that views socio-economic activity as Newtonian in nature. In essence, it is seen in 'scientific empiricist' terms as a somewhat mechanistic activity reducible to a number of identifiable, passive, yet rational individual cause and effect responses that gradually shift the socio-economic context towards a determinable ordered state of equilibrium (Boulding, 1982; Awan, 1986). This is not to suggest that socio-economic research is devoid of any appreciation of disequilibrium dynamics within systems, for the area has a long history of theoretical and empirical research which models the discontinuities of economic processes (Schumpeter, 1939; Alchian, 1950; Goodwin, 1951). However, despite this history, and the on-going attempts at modelling the disequilibria of asymmetrical interdependencies within socio-economic systems (Nelson and Winter, 1982; Dosi, 1988; Allen, 1994; Mckelvey, 1995), most of the research still views system equilibrium as the dominant state and/or defining result of socio-economic progress. While such a perception is supported by a plethora of mathematical models, these models offer no proof of the equilibrium thesis. To reduce the discontinuities of a socio-economic system to a collection of differential equations is to be bound to a mechanistic determinism appreciation of gradual equilibrium. This is due not only to the inherent properties of the mathematical notations employed (Bullard and Butler, 1993), but also (as previously discussed) to the inability of mathematical models to generate variability beyond that imposed by initial parameter settings (Allen, 1990).

In much the same way, ‘proving’ through numerical modelling that disequilibrium is the central property of systems is a difficult proposition, and while the use of nonlinear approaches (eg. transitional probability, coupled map lattices, NK landscapes) is a welcome relief from the dogma of linearity, it too is mechanistic determinism in the sense that the structure of the equations, in concert with the nature of the mathematics used, will necessarily find disequilibrium (Boulding, 1987; Barton, 1994). Notwithstanding this lack of mathematical ‘proof’, that the nature of evolving socio-economic systems is open and dissipative (displaying on-going disequilibrium) is readily apparent in research associated with the ‘sociology of science’ (Kuhn, 1962; Bloor, 1973; Layton, 1974; ver Mulkay, 1979; Collins, 1983), the ‘sociology of translation’ (Callon, 1980; Callon and Latour, 1981), and the ‘social construction of technological’ (Pinch and Bijker, 1987). Furthermore, case studies specifically examining technological innovation, whether that be electricity (Hughes, 1983), artillery (Morison, 1988), aircraft (Vincenti, 1991), automobiles (Sanchez, 1996), or cochlear implants (Van de Ven and Garud, 1994), highlight the open and dissipative nature inherent within technological innovation, in terms of both the technology itself and the socio-economic system in which it was developed and diffused.

Another problematic aspect associated with current explanations of technological innovation is the theoretical and/or empirical treatment of system complexity and relational interdependencies, particularly so when the system is represented as a specific and ‘solid’ spatio-temporal hierarchical structure. With respect to system complexity, there is a tendency within the literature to accept Simon’s (1962) notion of ‘nearly decomposable systems’ in a literal sense. Such a literal interpretation is the basis for the assumption that the whole system, however defined, can be considered as a composition of many smaller systems, and that these systems are so simple so as to “block the

formation of generic ensemble properties, and even to screen them off from view'' (Depew and Weber, 1997:435). Notwithstanding that this literal interpretation is ill-founded, such an atomistic assumption is questionable at best, for research shows that even what is currently viewed as the simplest of component forms is connected, in some manner and measure, to other forms (Burian and Richardson, 1991; Lewontin, 1992). Within the complex context of technological innovation such an atomistic view should be considered as untenable (Kirman, 1989; Kwasnicki, 1996). However, as argued in Chapter Three, the research area is littered with this atomistic perception, whether it be the separation of technology production from market diffusion, the entrepreneurial individual from the firm, the firm from the industry, and/or the industry from the broader industrial complex.

Although not as insidious nor as widespread as atomism within technological innovation research, reductionism is also present and problematic. The basis of this ideology is the assumption that an explanation of a complete system can be achieved through an explanation of one of its hierarchical levels (Allen, 1990). While it is accepted that the broader system may be explained in terms of lower level system entities, the idea that macro system behaviour is largely micro system behaviour writ large is 'impossible, and nothing more than a philosophically dogmatic diversion' (Hodgson, 1997). As argued, evolving systems are 'alive' and beget such a life through not only the variation differentials that result from the diversity of entities that constitute the system, but also from the asymmetrical interdependent relationships within and between these entities and the system as a whole, what McKelvey (1995) termed, 'multi-coevolutionary complexity'. In such a system context, not only is the whole greater than the sum of its parts, but the whole determines to some extent the properties of these parts (Campbell, 1974). Within much of the technological innovation

literature however, the illogical premise of reductionism dominates. It is readily apparent in the decontextualised application of individual behaviour theories to the firm, industry and/or the broader socio-economic complex (Metcalfe, 1994; Drazin and Schoonhoven, 1996). This is inappropriate as;

> it is becoming increasingly clear that the distinction between micro-and-macro levels is at best an analytical one, marking a continuum of theoretical concepts that figure in an adequate explanation, rather than a dichotomy between distinct levels of social ontology (Bohman, 1991:149).

The explanatory framework offered in this thesis provides a plausible response to these problematic issues in the context of technological innovation research. The framework has as its ontological basis the notion of systems as open and dissipative structures. This requires one to let go of a pre-occupation with the 'goal of equilibrium', and the ideals of 'scientific empiricism' that support such a pre-occupation. While it may be difficult to 'prove' in a scientific sense that technological innovation can be characterised as an open and dissipative system, the explanatory framework of the current thesis invites an expansion of the mind's eye so as to see technological innovation in what is perhaps a truer light;

> Nothing can be more plain or even more trite commonsense than the proposition that innovation, as conceived by us, is at the center of practically all the phenomena, difficulties, and problems of economic life in capitalistic society and that they are, as well as the extreme sensitiveness of capitalism to disturbance, would be absent if productive resources flowed - either in unvarying or continuously increasing quantities - every year through substantially the same channels towards substantially the same goals, or were prevented from doing so only be external influences. And however difficult it may turn out to be to develop the simple idea so far as to fit for the task of coping with all the complex patterns with which it will have to be confronted, and however completely it may lose its simplicity on the way before us, it should never be forgotten that at the outset all we need to say to anyone who doubts is: Look around you! (Schumpeter 1939 quoted in Andersen, 1994:31).

The centrality of the notion of systems' as open and dissipative requires that careful consideration be made before treating any aspect of technological innovation in an atomistic, reductionist, deterministic, gradualistic and/or mechanistic manner.

Technological innovation is a complex ubiquitous process that cannot be 'truly' explained through a basic 'scientific empiricist' methodology. All technological innovations are essentially emergent complexity, therefore the notion of complexity in explanation has more to do with our descriptions than with the technological innovation itself (West and Salk, 1987). Through the explicit recognition and incorporation of technological innovation 'as and of' an open and dissipative system, the proposed explanatory framework not only provides a more plausible explanation of the process itself, but also reflects the new theoretical and methodological realities of research into systemic phenomena;

> The notion of system itself is no longer tied to a specific spatial or spatio-temporal structure, nor to a changing configuration of particular components, nor to a set of internal or external relations. Rather, a system now appears as a set of coherent, evolving, interactive processes which temporarily manifest in globally stable structures that have nothing to do with the equilibrium and the solidity of technological structures (Jantsch, 1980:6).

5.3 What is evolving?

In order to stay at the required level of generality, the explanation of evolution presented in Chapter Four offered the broad notion of 'system' (though applicable to biological, physical or chemical systems) as the evolving entity. However, in the current context, that is, using evolution as an explanatory framework for patterning the technological innovation process, the obvious answer to the question, 'What is evolving?' would seem to be 'technology'. However, the term 'technology' is considered to be too general, offering little scope for fleshing out the explanatory framework and providing practical application. In an attempt to broaden this scope, yet keep some boundaries, the current thesis proposes that it is 'information' which is evolving. That 'information' is a plausible answer is implicit in the evolutionary theory literature, particularly so in the self-development/self-organisation dynamics thesis of genetic and molecular biology;

> An organism's genes, to the extent that they influence what the organism does in its behaviour, physiology, and morphology are at the same time helping to construct an environment by allowing the organism to act on inherited information and to respond to new information on the basis of inherited capacities (Lewontin, 1992:112).

A number of authors in the general area of biology are more explicit, arguing that biological cells and their constituent DNA arrangements 'preserve' themselves, not only by conserving and transmitting symmetrical information (ie. replication), but also through active interpretive learning (ie. reproduction, renewal) of asymmetrical information carried by internal and external stimuli (Hull, 1981; Plotkin, 1988; Dawkins, 1989; Depew and Weber, 1997).

Specific to the socio-economic context, there is a long and widely-held belief that information production and dissemination are significant influences in the generation of economic peculiarities (Schumpter, 1939; Marshall, 1949; Arrow, 1962). Direct reference to technology as information has a similar history, with the theoretical link between the two becoming more pronounced over recent years (Nelson and Winter, 1982; Dosi, 1988; Saviotti, 1996; Mandeville, 1998). This theoretical linkage however, rarely evolves to be explicitly incorporated within explanations of technological innovation, but is consigned instead to either implicit consideration or as a supporting role in the process (Boisot, 1995). On the occasions that information is explicitly considered, as shown in the discussions on diffusion and network theories in Chapter Three, it is treated as a commonly understood 'good' that can/is dispersed as symmetrical 'bits'. This non-recognition of the asymmetrical nature of information, both of itself and in most subsequent transmissions, has stifled research attempts to move beyond simple linear cause and effect models as descriptions of the technological innovation process. The need for research to delve into the informational contents of technological innovation has not only wide support (see Bijker, Hughes and Pinch 1987 for a review), but has been canvassed for some time;

> What is needed is an understanding of technology from inside, both as a body of knowledge and as a social system. Instead, technology is often treated as a 'black box' whose contents and behaviour may be assumed to be common knowledge (Layton, 1974:198).

While this 'black box' treatment of technology as information is to some extent a reflection of the long controversy about human cognitive processes, it is argued that the emphasis within the technological innovation literature on the 'coupling' of different innovation elements has led to a preoccupation with the contextual organisation of information, rather than the contents of information *per se* (Faulkner, 1994). This is not to suggest however, a total lack of appreciation within the literature of the many conceptual underpinnings associated with the term 'information'. The work of Arrow (1962) and Polanyi (1967) on broad characteristics of information (formal versus informal, tacit versus articulated, practical versus theoretical, and specific versus general) has provided the background for research which examines the 'technology as information' thesis (Dosi, 1982; Metcalfe, 1986; von Hippel, 1988; Mokyr, 1990). However, such categorical and/or characteristic terminology has been criticised as being both too broad (compounding definitional differences) and as too amorphous (offering little in the way of enhanced understanding of mutuality, variability, selectability, and preservability aspects of information) (Dodgson, 1992). Notwithstanding the problems and criticisms associated with the 'technology as information' thesis, it does not necessarily follow that information (and any evolution it may undergo) is inherently difficult to research. Such difficulty has more to do with the somewhat opaque images of information that are commonly held, ones that lack a richness in representing what it actually is, and how it evolves to meet present and future requirements. What is needed is a different, though necessarily plausible and acceptable explanation of information and its evolution.

In suggesting the 'technology as information' thesis, there is an explicit recognition that within the offered explanatory framework the frame of reference is informational content. This is a different approach from the majority of technological innovation research, even that based in evolutionary theory, which takes its point of reference as context, whether that be the individual, firm, groups of firms and/or the broader industry structure (Pinch and Bijker, 1990). It is argued that to use this reference point is to 'put the cart before the horse', for there is ample evidence that the structural and/or functional arrangements of socio-economic systems are largely determined by the contents or meanings attached to information, and the transmission flows of such (Freese, 1988; Lave, 1993; Metcalfe and Boden, 1992; Boisot, 1995; Hodgson and Knudsen, 2004). The following material, while arguing the similarities between the offered explanation of evolution and technological innovation, will do so from a perspective of information evolution.

5.4 Variation: Possibilities of technological innovation

Variation (an explanation based on evolutionary theory)

***Why*:** on-going internal self-renewal and/or importation of external energy so as to overcome the entropic forces of resource depletion
***What*:** multidimensional possibility space
-known/unknown sources of variation
-variation limited so as to maintain structural/functional integrity
***How*:** -unintended responses to/from environmental stimuli
-intended self-development (internal/external sources)
-positive/negative feedback from interdependent system activities
***When*:** ongoing
***Where*:** interrelational

In developing an explanation of evolution, it was argued that 'variation', both of itself and as an on-going process, is the fuel that sustains the evolutionary process. That the on-going generation of variation, and in particular, variation in information, is the *why* behind technological innovation, is a central tenet of the explanatory framework

proposed in this thesis. This view is apparent within the literature, with a number of authors arguing that the entropic pressures that may act upon the on-going generation of new technologies are not only stifled by a (re)combination of stored information, but also on the discovery and subsequent transmission of novel information (Rosenberg, 1976; Constant 1984; Freese, 1988; Metcalfe, 1994; Mandeville, 1998). So as to better reflect the somewhat complete, yet uncertain nature of 'variation', material presented in Chapter Four assigned the meaning (*what)* 'multi-dimensional possibility space', representing such as the phase space between fixity and freedom within which evolution occurs. That technological innovation occurs within such a space is apparent in the literature, particularly so in research considering aspects associated with dominant designs (Abernathy and Utterback, 1975), technological frontiers (Binswanger and Ruttan, 1978), technological guideposts (Sahal, 1981), technological regimes (Nelson and Winter, 1982, Dosi, 1990), technological paradigms (Dosi, 1982, 1988; Saviotti, 1996) and technological trajectories (Dosi and Nelson, 1995). The majority of this research conceptualises technological innovation as an unfolding path within a spatial construct of possibilities, and while information is suggested as the natural 'matter' of this construct, there is little evidence of an explicit representation of information in any of the models. For example, Nelson and Winter (1982) offer vague references to economic and social dimensions, Dosi (1988) suggests a trade-off between economic and technology aspects, while Saviotti (1996) utilises technical and service characteristics.

That this 'multi-dimensional possibility space' of known and unknown 'variant information' exists (at least in theory) is apparent in the thesis that the Universe is a living system that embodies past, present and future understandings (Einstein, Podolsky and Rosen, 1935). That such an embodiment exists in a practical sense is also apparent

when one considers that early Greek science had produced all the information necessary to construct a steam engine. These theoretical and practical observations are eloquently depicted in Schumpter's (1954:4) comment that "a man's mind must be indeed sluggish if, standing back from the work of his time and beholding the wide mountain range of past thought, he does not experience a widening of his own horizon." In a general sense the source of this 'variant information' is generated both internally and externally, what Luhmann (1986) referred to as structurally and/or functionally linked normative and cognitive (sub)systems. The suggestion is that all socio-economic systems are autopoietic in the sense that it is possible to self-produce information and yet still maintain the capacity to import novel information from other sources. The normative (sub)system is that which formulates and maintains the information bases that set internal behavioural standards and expectations, and also that which acts upon external signals, with such activity subjected to the limitations imposed by in-place information bases. The cognitive (sub)system is less rigid, and is considered to be a form of awareness or learning link that attempts to assign meaning to aspects of the 'variant information' that constitute the broader external environment (Maturana and Varela, 1980; Orton and Weick, 1990; Johannessen, 1998). It is this combination of normative and cognitive (sub)systems (whether at the individual, organisation or industry level) that maintains a level of structural and/or functional integrity within the technological innovation process (Johannessen, 1998; Mandeville, 1998).

That information exhibits variability both in itself and when interpreted, is not generally appreciated within the literature. Much of the research into technological innovation not only treats information as a uniform body of truth, but also as a common good, and usually supports such treatment through reference to Arrow's (1962) 'pool of information into which one dips'. Both this treatment and referencing is spurious, for

Arrow (1962) never argued that information is universally understood and/or available (Ansoff, 1982). Nonetheless, there is a tendency within much of the literature to consider information as a constant given, and therefore treatable in a mechanically deterministic fashion. This consideration and treatment is illogical, for the information that ignites and fuels technological innovation must exhibit variation because;

> The peculiar character of the problem… is determined precisely by the fact that the knowledge of the circumstances of which we must make use never exists in concentrated or integrated form, but solely as the dispersed bits of incomplete and frequently contradictory knowledge…. The economic problem of society is thus not merely a problem of how to allocate 'given' resources - if 'given' is taken to mean given to a single mind which deliberately solves the problem set by the 'data'. It is rather a problem of how to secure the best use of resources known to any of the members of society, for ends whose relative importance only these individuals know (Hayek, 1945:519-520).

It was suggested earlier that the lack of an explicit representation of the *how*, *when* and *where* of information within technological innovation models was due largely to unresolved conceptual issues associated with the term 'information'. That this is the case is highlighted by Blackler's (1995) review of the major 'images' of information within the organisational learning literature. He identifies five conventional 'images' of information: *embrained* information: (ie. dependent on abstract conceptual skills and cognitive abilities); *embodied* information (ie. dependent upon people's physical presence, sensory information, physical cues and face-to-face discussion); *encultured* information (ie. dependent upon the process of achieving shared understanding); *embedded* information (ie. dependent upon the mix of interpersonal, technological and socio-structural factors which reside in systemic routines); and *encoded* information (ie. conveyed by signs and symbols). Drawing the material together Blackler (1995) argues that while these 'images' are more helpful than traditional 'characteristic' representations of information (eg. tacit versus articulated, formal versus informal), they are still quite nebulous in nature, and provide little scope for theoretical expansion and/or practical application.

A similar line of reasoning was adopted by Star (1992) and Lave (1993), both arguing that current mainstream images of information are unrealistic, not only in a theoretical sense, but also in an empirical sense due to the pragmatics associated with including all conceptions into a research framework. Their most strident criticism is directed towards the tendency for much of the research to assume that information can be divorced from context and transferred either as abstract data or as universally applicable approaches to problem-solving. Lave (1993:12-13) suggests that such an assumption implies uniformity of information and learning passivity, and in doing so "does not acknowledge the fundamental imprint of interested parties, multiple activities, and different goals and circumstances, what constitutes 'knowing' on a given occasion or across a multitude of interrelated events." Star (1992:398) further clarifies this argument by pointing out that research into the use of mathematics (ie. a perceived uniform body of information) shows people to have different ways of utilising numerical information depending upon the context in which it is used;

> in supermarkets, bowling alleys, and Weight Watchers meetings, people are inventive and sufficient, perfectly able to use numbers for their own purpose. But in testing situations and classrooms, those same people fail the test, and appear dull and incompetent.

The above comments suggest, at the individual level at least, that the 'invariant information' within a 'multidimensional possibility space' is generated in a similar manner to the *how*, *when* and *where* of evolutionary 'variation'. Such conceptual similarity is also apparent within the technological innovation literature. Grilichez's (1994) research into 'R&D spillovers' suggests that much of the pool of 'invariant information' that fuels and drives the technological innovation process is generated by unintended consequence(s) emanating from the broader socio-economic environment. That this 'pool' is feed by purposeful self-development (internal/external sources) and feedback is readily apparent in research highlighting the contribution that training, conference attendance, and informal/formal links to customers and competitors makes

to the overall technological information base (Sweeny, 1987; Von Hippel, 1988; Rothwell, 1991). This generation of a multidimensional possibility space' of 'invariant information' is ongoing and relational as seen in the notion of 'ecologies of representations', which views the genesis of technological innovation as the dynamic interdependencies of information, individuals, symbols, technical communities and the objects as their technological activities (Engestrom, 1989; Dodgson, 1992).

The material presented thus far suggests that there are similarities between the principle (and associated conceptualisations) of evolutionary 'variation' and the 'technology as information' thesis. However, problems still persist with the concept of 'technology as information' due to epistemological vagueness. As a solution the current thesis suggests more specificity with respect to the 'variant information' content of a 'multidimensional possibility space' as it applies to technological innovation. That particular technological innovation endeavours have a measure of informational content specificity is well documented (Lundgren, 1993), however, research into this aspect has been pushed aside due to an 'intellectual culture of generalisation' (Thompson, et al, 1991). An approach that offers a more practical conceptualisation of 'variant information' requires a shift from abstract generalisations about information that someone might possibly *have*, to depictions of information that could possibly be used in *doing* technological innovation. Conceptualising information as an activity has implicit support within the technological innovation literature (Constant, 1984; Valentin, 1989; Henderson and Clark, 1990; Metcalfe and Boden, 1993; Hodgson and Knudsen, 2004), and is explicit in Faulkner's (1994) distinction between scientific and technical information used in the technological innovation process. Drawing on a review of the literature and her own research, Faulkner (1994) developed a composite typology of information types used in the broad sphere of industrial technological innovation (Table 5.1).

Table 5.1 Composite Typology of Information Used in Technological Innovation

Related to natural world
Scientific and engineering theory
"laws' of nature; theoretical tools
Properties of materials
Natural and artificial materials
Related to design practice
Design criteria and specifications
Understanding of user requirements
Demands of company and technology
Specifications of components
Design concepts
Fundamental operating principles
Normal configurations
Creative ideas
Design instrumentalities [a]
Design competence [a]
General design competence
Competence in specific product area
Practical experience
Related to experimental R&D [b]
Experimental and test procedures
Research instrumentalities [a]
Ability to utilise experimental techniques and equipment
Ability to interpret test and experimental results
Research competence [a]
General research competence
Competence in particular specialism
Experimental and test data
Related to final product
New product ideas
Operating performance
Performance of components or materials
Pilot production, field trials, and so on
User experience
Production competence [a]
Design requirements for manufacture
Competence in pilot production/scale-up
Related to knowledge
Knowledge of knowledge
Location of particular knowledge
Availability of equipment, materials, specialist facilities, or services

a. Indicates knowledge that is heavily skill based
b. Research and Development

(*Source*: Faulkner 1994:447)

The typology is based on a 'practical-artifactual' orientation, and focuses on the actual information used in the design, development and bringing together of the component

parts of a technological innovation. The degree of overlap and fluidity between the categories within the typology is indicative of the complexity of the multi-dimensional nature of technological innovation. Faulkner (1994) tentatively suggests that a better understanding of this complexity can be achieved through the application of additional taxonomic axes which cut across the specific categories identified within the information typology. Three taxonomic dimensions are offered: specific types of information; the objectives or activities with which these specific types are associated; and broad distinctions in the character of information (Table 5.2).

Table 5.2 Suggested taxonomic axes to cut across information typology

(i) Specific types of information

- The natural world
- Design practice
- Experimental R&D
- Final product
- Information itself

(ii) Broad character of information

- Understanding-information-skills
- Tacit articulated
- Complex-simple
- Local-universal
- Specific/contingent-general/metalevel

(iii) Objective or activities with which these types of information are associated

- Research, development and design of offering
- Technology development, engineering and prototyping
- Manufacture of components, provision of technological services
- Assembly/conversion to a consumer product
- Marketing

(Source: Adapted from Faulkner 1994)

Although Faulkner's (1994) proposed typology is based to a large extent on research into information flows between public sector research organisations and industry, it is argued that this approach to the conceptualisation of 'invariant information' fits neatly into the theoretical considerations of 'variation' within the proposed explanatory framework, and also provides an empirical foothold. In effect, 'information as activity' defines the 'multidimensional possibility space' of 'variant information' that has potential value (whether realised or not) during the emergence of a technological innovation.

To conclude, it has been shown that the principle of ‘variation’ and its conceptualisation within an explanation of evolution has a high level of analogical transfer to an explanation of the process of technological innovation. That ‘variation’, and in the current context, that the *why* of ‘variant information’ generation is central to the on-going evolution of technological innovation is beyond doubt (Galbraith, 1967; Mokyr, 1990; Leydesdorff, 1994; Granberg, 1995). That the meaning or *what* of ‘variant information’ can be represented as a ‘multidimensional possibility space’ has support within the literature, evidenced by Dosi’s (1982, 1988) depiction of technological innovation as a trajectory within a possibility of technological directions, and Debresson’s (1989) discussion on absolute and technical frontiers of technological space. While much of the research suggests that ‘variation’ is essentially informational, the tendency in the literature has been to adopt non-informational dimensions, or offer conceptualisations that have more to do with the characteristics and/or location of information. To a large extent these conceptualisations stem from a belief that information within the technological innovation process is largely tacit, that is, difficult to articulate and/or appreciate. While true for many technological innovation endeavours, this does not necessarily imply that information is necessarily opaque to research, nor does it mean that explanations need to resort to some form of instrumental convenience. In highlighting the similarities between the generative *how*, *when* and *where* of the principle of evolutionary ‘variation’ and the ‘invariant information’ that fuels and drives technological innovation, there is a suggestion that the latter could be considered and treated as the *doing* of technological innovation. That ‘variant information’ could be conceptualised and treated via a *doing* notion is evidenced by Nelson and Winter’s (1982) proposition that ‘technological innovation occurs within a set of physical possible activities rather than a known production function’. As a practical example, an information typology (in concert with three taxonomic

dimensions) was offered. This typology exhibits contextual appreciation with respect to the realities of technological innovation. While the material presented in this section provides a reasonable rich and rounded analogical transfer of the principle (and associated conceptualisation) of evolutionary 'variation' into the proposed explanatory framework of technological innovation, on its own this abduction does little to expand understanding of its alleged 'evolutionary' nature. The 'variant information' that constitutes a 'multidimensional possibility space' cannot speak for itself. The possibilities offered by the on-going generation of 'variant information' must be acted upon before any opportunity can be realised, and in the current context, such action is construed to be 'selection'.

5.5 Selection: Opportunities for technological innovation

Selection (an explanation based on evolutionary theory)

***Why*:** regulatory-maintain structural and functional integrity
***What*:** the **'**adaptive emergence' of evolution's direction
***How*:** -simultaneous co-selection
-competitive and cooperative
-intended and unintended
-path dependent
When: on-going
***Where*:** predominately localised

In the previous chapter the principle of 'selection' was depicted as a regulatory or constraining mechanism, dampening the effects of 'variation' rampancy in an effort to maintain the integrity of a system. In effect, *why* 'selection' operates is because it acts as a release valve, promoting and facilitating the adaptive emergence of structurally and functionally sound patterns from the milieu of 'variation' that constitutes the 'multidimensional possibility space'. 'Selection' is in effect, a paradox, constraining the 'multiplicity' of progress inherent within such a space so that actual progress can occur. In the context of the current explanatory framework, the *why* of 'selection' is considered to be the constraints that pattern the (re)discovery and (re)utilisation of novel

information. It is the means by which the ‘tyranny of combinational explosion’ is overcome (Metcalfe and De Liso, 1996); it limits the questions that are asked of the multitude of informational ideas that constitute the ‘multidimensional possibility space’ of ‘invariant information’ that fuel and drive technological innovation (Van de Ven and Garaud, 1994; Hodgson and Knudsen, 2004).

The meaning or *what* of ‘selection’ offered in the explanation of evolution (ie. adaptive emergence) is conceptually similar to Kuhn’s (1962) thesis on the evolution of science. Within this thesis the diversity of existing and/or novel information is ‘selectively adapted’ by paradigmatic frameworks or learning systems that offer a level of emergent coordination via the *ex ante* existence of expectations and intentions. Specific to the current context, there is a level of analogical similarity in that ‘selection’ could be considered as the mechanism(s) that provide: a measure of structural and functional integrity to the broad trajectory of technological evolution; the direction of particular technological regimes within this trajectory; (and) the means by which the core foundations, methods and standards of a specific technological design are fashioned. Within such a consideration, ‘selection’ is ‘adaptive emergence’ in that it is neither immediate, nor directed towards a final technological outcome. The diversity inherent within evolving technological systems will always negate immediacy, and finality is always elusive because ‘selection’ is an ‘open-ended, provisional and necessarily fallible mechanism’ (Hodgson, 1998). In effect, ‘selection’ maintains the structural and/or functional integrity within an evolving technological system. It imposes balance, not order, by allowing the system to work within the bounds of fixity and freedom, and by keeping the evolution of technology at a point where ‘variant information’ can still arise, without over-whelming this evolutionary process.

This similarity in the *why* and *what* of evolutionary 'selection' to the paradigmatic frameworks or learning systems that initiate and shape the evolution of technological innovation is readily apparent in the extensive research undertaken by Nelson and Winter (1974; 1977; 1982; 1984). Specifically, the authors argue that 'selection' should be treated as largely behavioural in nature, so as to better reflect the purposive but emergent activities of firms as they attempt technological innovation. The basic premise is that a firm undertaking technological innovation operates according to a set of previously selected decision rules (ie. patterns of learnt behaviour) that apply only to a selective set of environmental conditions. In a sense these rules pertain to a firm's standard operating procedures, investment decisions, and deliberate problem-solving approaches when undertaking 'routine' technological innovation. Any changes to existing environmental and technical conditions require that the firm undertakes search and problem-solving activities in an effort to select new rules that can be applied to these different circumstances;

> When the concern is with the evolution of productive technique, we may… identify rules with vectors of technical coefficients. The set of possible rules then bears a superficial resemblance to a production set-superficial because the production set characterises *known* techniques whereas we are concerned with the set of (physically) *possible* techniques (Nelson and Winter, 1974:903).

Conceptual similarity is explicitly apparent in Dosi's (1982; 1988) research into the emergence of technological innovation, where paradigmatic frameworks are seen as both an *exemplar* and *heuristic*, defining (selecting?) not only the technological puzzle within a particular existing context, but also the emergence of a pattern of inquiry that seeks to find possible solutions to this puzzle;

> The 'solution' of technological problems involves the use of information drawn from previous experiences and formal knowledge (eg. from the natural sciences); however, it also involves specific and *uncodified* capabilities on the part of the inventors. Following Nelson and Winter (1983) and Winter (1984), I use the term *knowledge base* for the set of informational inputs, knowledge, and the capabilities that inventors draw on when looking for innovative solutions (Dosi, 1988:113).

This view is supported by Metcalfe and Diliso (1996:72) who argued that a 'selection paradigm' is indicative of "the fruitful directions for technological change, defines concepts of progress, establishes tests to judge performance and has a powerful exclusion effect on the collective thinking".

That 'selection' can be considered as adaptive emergence is also implicit in the hierarchy notion, for a specific 'selection paradigm' is but a part of a larger 'selection paradigm'. Gowdy (1992) argues that these various levels of 'selection' should be seen as causal influences on each other. Instead, higher-level selection is often used as a descriptor of the consequences of technological innovation. That a particular selection mechanism could be a constituent part of broader selection mechanisms is readily apparent in the research of Perez (1985:444);

> …let us now look at the exhausted techno-economic paradigm. It came together in the 1920s and 1930s and underlays the present mode of growth established after World War II. It was based on low-cost oil and energy intensive materials, especially petrochemicals. The model for efficient productive organization at the plant level was the continuous flow process or assembly-line for the mass production of identical products. The ideal type of firm was the 'corporation' run by a separate, professional, managerial and administrative hierarchy; it included in-house R&D and operated in oligolistic markets. Growth was led by giant oil, chemicals, automobile and other producers of durable goods for the defence or consumer markets. The growth and interplay of these core branches, induced the proliferation of the service sector (from gasoline stations and supermarkets to the advertising industry and the diversified financial sector), as well as the growth of the construction industry. It demanded increasing amounts of middle range specialisation in both blue-and white-collar skills. It benefited from the economies of agglomeration and required an ever-expanding highway network, together with oil and electricity distribution systems for energy intensive production, transportation and lifestyles.

Depicting 'selection' as a paradigmatic framework, structurally and/or functionally embedded within macro socio-economic 'selection paradigms' (and one which itself may spawn macro and/or micro 'selection paradigms'), also suggests a level of conceptual transference of the *how*, *when* and *where* of evolutionary 'selection' to the process of technological innovation. That the *how* of 'selection' within technological innovation has a 'simultaneous co-selection' or associative element is implicit within

behavioural research, for it is argued that “human behaviour cannot be reduced to the choices and decisions of isolated individuals alone. Circumstances are in part a consequence of individual actions, but also individuals are moulded by circumstances, including their interactions with others” (Hodgson and Screpanti, 1991:13). That the *how* of technological innovation is reliant on the same process of ‘simultaneous co-selection’, involving the cumulative accretion of information by a number of interdependent actors, is explicitly supported within the innovation literature (Rosenberg, 1982; Henderson and Clarke, 1990; Becattini, 1991; Van de Ven, 1992). Research by Rosenkopf and Tushman (1994) into relatively complex technological innovations has shown quite conclusively that their emergence occurs through co-selection, at both the overall system and subsystem levels (see Figure 5.1).

Figure 5.1 Co-selection components of radio systems

(*Source*: Rosenkopf and Tushman, 1994)

This case study highlighted the fact that a specific technological innovation can be considered as a collection of interlinked ‘selection paradigms’, its emergence the result of adapting information found and/or created at all levels. Such adaptive emergence results from co-selection mechanisms operating simultaneously on multiple, interdependent technical aspects. Research by Carlsson and Stankiewicz (1991) drew

similar conclusions when examining the broader socio-economic context of innovation. They argue that technological innovation emerged as a result of co-selection occurring between and within: *instrumental* (ie. suppliers of applied R&D, manufacturing, marketing and distribution services); *resource* (ie. basic scientific or technological research, financing, insurance, venture capital, human resources); and *institutional* (ie. organisation of industrial R&D, academic infrastructure, government agencies, trade associations) aspects.

The notion that technological innovation evolves from simultaneous co-selection is not prevalent in mainstream marketing literature (see Chapter Three), which usually takes as its point of departure a single technology, firm and/or industry, and shows little concern for broader relational interdependencies (Hodgson, 2001). Even within research that has provided the foundation for the evolutionary perspective of technological innovation (Nelson and Winter, 1974; 1977; 1982; 1984), the *how* of 'selection' has been treated at a firm-specific level. Such treatment cannot be justified by appealing to 'analytical reasons' and 'conformable sub-theories' (Nelson and Winter, 1982). Futhermore, to do so is to dialectically oppose the long history of 'co-selection' aspects of innovation highlighted within the broader field of socio-economic theory (Schumpeter, 1939; Usher, 1954; Burns and Stalker, 1961; Lawerence and Lorsch, 1967; Cohen, March and Olsen, 1972; Mintzberg and Waters, 1985).

It has been suggested that the long history of methodological atomism has led to a certain blindness with regard to the importance of co-selection interdependencies (Freeman, 1991). It is the contention of the current thesis that the real culprit is evolutionary theory itself. As argued in the previous chapter, Darwin's theory of evolution was cut from the very fabric of Victorian England, a society which believed

that the economic success or failure, irrespective of social position, was the consequence(s) of 'individual struggle' in a highly competitive environment. This belief was transferred into biology as the metaphor 'natural selection', a metaphor which has subsequently found its way back into the socio-economic (sub)disciplines. However, during this abductive transfer the origin(s) of the metaphor has been largely forgotten. Because it is now seen as having originated in the supposedly politically neutral realm of the natural sciences, it is considered to be a credible analogy when explaining evolution within socio-economic contexts (Ho, 1988).

It was argued in Chapter Four that the *how* depiction of 'selection' as a purely natural or competitive mechanism has been challenged within the biology discipline. The suggestion was that there is a growing consensus that while 'selection' can be initiated and sustained by individual competitive responses, the 'symbiotic' or 'co-selective' nature inherent within most evolution necessarily requires a 'cooperative' aspect to be the dominant element in any proposed 'selection' mechanism. This notion of 'cooperative co-selection' has been implicit in the organisational literature for some time, particularly in that examining how social ecology 'selects' particular organisational and/or industry structures (Schon, 1971; Ackoff and Emery, 1972; Aldrich, 1979; Sahal, 1981). However, most models of technological innovation, including those adopting an evolutionary perspective, see the *how* of 'selection' solely as a form of progressive competition, with the ultimate being 'individual competitive efficiency at the margin';

> In contemporary theories of economic change, from neoclassical growth theory to the evolutionary models of Nelson and Winter…, change is driven by competitive selection, a process analogous to natural selection in biology. By this view, economic change is gradual and progressive in the sense that competitive pressure generates alternatives in the form of new firms and new techniques, and selection among them leads to greater efficiency through time. Indeed, this view of how change takes place is so ingrained in our way of thinking that it is rarely stated explicitly (Gowdy, 1992:1).

Such a view is also readily apparent in the resource dependency (Blok, 1974) and transaction cost (Williamson, 1975, 1985) models that have been used as the underlying frameworks in much of the technological innovation research, particularly so within the marketing discipline (Pfeffer and Salancik, 1978; Levitt, 1983; Porter, 1990; Lazonick, 1991).

Treating the *how* of 'selection' as merely a natural mechanism, initiated and driven by competitive economic rationalism, is highly questionable, for it goes against the cooperative nature of organisational life that has been a central tenet of management theory for some time (Hawley, 1950; Blau, 1964; Emery and Trist, 1965). That 'selection' within a technological innovation context has a cooperative aspect is explicit in von Hippel's (1990) examination of the steel industry, which found that proprietary information pertaining to the construction of mini steel mills flowed freely between competitors on a regular basis. Similar results have been found in research investigating technological innovation aspects associated with the emergence of machine tooling (Noble, 1984), gas turbine motors (Constant, 1980), cochlear implants (Garud and Van de Ven, 1989), flat glass (Anderson and Tushman, 1990) and electronic data imaging (Ludgren, 1993). In an examination of the evolution of the computer industry in Silicon Valley, Saxenian (1990:91) identified "the region's diverse networks of social, professional, and commercial relationships, not simply unfetted markets" as the basis for its on-going resilience. Furthermore, "the process of solving problems and charting directions in a technological volatile environment is increasingly a cooperative effort… a process of complementary innovation between networks of autonomous but interdependent producers" (Saxenian, 1990:103). These comments do not suggest that a 'selection' mechanism lacks competitive aspects, but highlight the need for cooperation to be considered as central to the workings of technological innovation. The cooperative

(and sometimes quite complex) interdependencies that have been found between ostensibly competitive firms, challenges the notion that competitive selection determines not only technological success, but also firm survival and the design of industry structure itself (Mckelvey, 1995). While it is clear that organisations will attempt to gain competitive benefit during the emergence of technological innovation, such benefit will only arise through broad cooperative interdependencies (Henderson and Clark, 1990; Van de Ven, 1992; Teece, 1993).

Another questionable aspect associated with the common depiction of 'selection' as a mechanism of competitive economic rationalism is a misplaced belief in its efficiency. As with the (neo)Darwinian notion of 'natural selection', there is a tendency within the technological innovation literature to see 'selection' as a mechanism that puts forth a (near)optimal design. Such a perception stems from the lingering neoclassical assumption of the sanctity of the market-place, a 'space' populated by supposedly rational actors with a basically correct understanding of their actual choices, and of the consequences of these choices (Porter, 1990). To use rational choice as a specific mechanism of *how* 'selection' works is flawed. This is because the theoretical starting point has been widely acknowledged as problematic due to the false assumptions that actors act rationally, and that all rational actors act alike (Polanyi, 1967; Loasby, 1976). Such an assumption has no basis in reality, as "all normal humans are rational in the general sense of having the ability to reason. But though rational there is a large body of evidence that shows we are not very logical, consistent or informed in our reasoning abilities" (Plotkin, 1995:190). Even when rationality is considered as 'bounded' it does not adequately incorporate a mechanism of 'selection', for it still does not allow for the systemic mistakes, ignorance, fallibility and misunderstandings that beset the emergence of all technological innovations (Vromen, 2001).

These comments are in direct contrast to much of the technological innovation literature, even that purporting to be evolutionary, for most models treat 'selection' mechanisms as largely programmed or mechanically-governed behavioural responses (eg. routines) to the current environment circumstances (Loasby, 1991; Hodgson, 2001; Vromen, 2001). It has been argued that these appeals to economic rationalism are little more than "simple, instrumentally useful representation of a much more complex reality in which real decision-makers attempt purposive interventions in the world whilst grappling with orders of complexity well beyond the capabilities of theorist's formal models" (Witt, 1991:113). 'Selection' is emergent due to diversity. Such diversity not only a function of the variety of paradigmatic frameworks that might be utilised, the involvement of a broad spectrum of organisations, the miscellaneous interdependencies between these organisations, and the asymmetries of technological capabilities, but also the diversity of motivations that directly impact on the initiation and on-going aspects of the 'selection' process. As Keynes (1936:150) remarked, "If human nature felt no temptation to take a chance, no satisfaction (profit apart) in constructing a factory, a railway, a mine or a farm, there might not be much investment merely as a result of cold calculation." If the *how* of 'selection' is deemed to be behavioural, then identified motivational determinants such as creative self-expression, imagination, curiosity, and dissatisfaction (March and Simon, 1958; Shackle, 1983; Metcalfe, 1988; Comfort, 1994), must play a part in any explanation. As argued in the previous chapter, any explanation based on the evolutionary perspective will necessarily deny formalism. Indeed, the underlying *how* of 'selection' is fashioned by so many elements that identifying and predicting those that exercise a decisive influence is nigh impossible (Boschma and van der Knaap, 1997). This does not mean that researchers should not try, for to do so requires the expansion of one's possibility space to not only see the puzzle, but also to provide the means for solving this puzzle.

The puzzle of *how* 'selection' works is perhaps more complex than the comments thus far suggest, for the basic mechanism has been depicted as purposeful intent, its underlying paradigmatic framework a result of intentionally-defined interdependencies and chosen competitive and/or cooperative behaviours. However, while 'selection' may act purposefully on the 'variant information' content of a 'multidimensional possibility space', the mechanism is also unintentionally conditioned by what Nelson and Winter (1982) refer to as 'the inner logic all its own'. Similar to the 'invisible hand of the market' thesis, such 'inner logic' refers to the self-organisational aspects that impact on the evolution of a system. As discussed in Chapter Four, self-organisation is *how* the unintended or 'uncaused' emergence of a pattern occurs within a system through 'autopoietic' and 'autocatalytic' means (Allen, 1990; Hodgson, 1998). 'Autopoietic' refers to the complex structural and/or functional interdependencies operating within and between (sub)system entities, while 'autocatalytic' refers to the feedback-looping of consequences back into the system itself;

> Symptom, action, and solution are not isolated in a linear cause-to-effect relationship, but exist in a nest of circular and interlocking structures wherein an action can induce not only correction but also fluctuation, counterpressure, and even accentuation of the forces that produced the original symptom of distress (Forrestor, 1980:12).

That self-organisation is an influence on *how* technological innovations emerge is supported within the literature (Boulding, 1982; Dosi, 1988; Cramer, 1993; Barton, 1994; Mckelvey, 1995). The idea is captured in Blauwhof's (1994:154) comment that self-organisation denotes "the ways in which various forms of interaction between the generation and adoption of new technologies result in feedback loops, in self-amplification, and in nonlinear dynamics." It would seem logical to claim (at least as the theoretical level) that the *how* of 'self-organisation' has an influence on 'selection' with the context of technological innovation. A number of researchers have adopted such a theoretical assumption, suggesting that 'selection' may occur as the unintentional outcome(s) of the interdependent dynamics of the diversity of loosely coupled (ie.

structurally and/or functionally) organisations and their innovation activities (DeBresson and Amesse, 1991; DiMaggio, 1992; Carlsson, 1995; Vromen, 1997; Fonseca, 2002).

Notwithstanding the theoretical plausibility of 'self-organisation' as an unintended influence on the *how* of 'selection', it is a difficult, if not impossible proposition to identify this causal influence *a priori*. However, research examining the presence of 'increasing returns' and 'historical lock-in' within a technological innovation context shows an appreciation of the effects of 'self-organisational' aspects of 'selection';

> Where positive feedbacks are present, there are usually several possible outcomes or time-paths the economy can follow; which one the economy 'selects' often depends on chance historical events; there is no guarantee that the best outcome is 'selected'; and once economic forces 'select' an outcome, the economy may be locked in to it (Arthur, 1990).

The complementary nature of 'increasing returns' and 'historical lock-in' has been identified in a number of case studies which highlight the influence of feedback loops, both positive and negative, on the mechanism(s) of 'selection' (Bupp and Derian, 1978; David, 1985; David and Bunn, 1987). The basic premise is that 'increasing returns', (such as the development of a technical critical mass or increases in profitability) lock 'selection' (through autocatalytic pressures) into a particular, though not necessarily technologically superior, emergent technological path (Arthur, 1989; 1990). Similarly, (though directionally different) the autopoetic nature inherent within the 'stochastic idiosyncratic' interdependencies of an emergent technological innovation, have the ability to influence a shift in 'selection' towards a possibility space beyond that which might be termed local (Vincenti, 1990; Garud, 1994; Stacey, 1995). If nothing else, the idea that self-organisation may have an unintended or unconscious influence on 'selection' requires further research, and in particular an exploration of the notion that intrinsic nonlinearities may have cumulative effects on the emergent direction of technological innovation.

While the autopoetic aspect of ‘self-organisation’ suggests that ‘selection’ mechanisms have the capacity to range far and wide within a technological ‘multidimensional possibility space’, the dampening influence of autocatalytic feedback loops ensure that this is not always the case. Such a capacity is further eroded by the presence of historical contingencies, for ‘selection’ within a technological context is largely the ‘experience of particularity’, bound by previous accumulations of socio-economic structures, information, competencies, skills, and so forth (Foss, 1997). As a prisoner of its history, *how* ‘selection’ operates has a measure of ‘path dependency’ and as such has the tendency to not only limit the availability of particular selection mechanisms, but also the range of technological possibilities that may be selected (Dosi and Nelson, 1995; Janszen, 2000). The ‘localised’ nature of ‘selection’ is well documented within the literature (Hughes, 1983; Metcalfe, 1994; Saviotti, 1996; Hodgson, 1998), and results not only from historical contingencies, but also as a means of controlling the uncertainty associated with unfamiliar technologies, markets and competencies (Boschma and van der Knaap, 1997). Furthermore;

> ‘selection’ mechanisms depend to a certain degree on trust and confidence, and therefore on a host of cultural and sociological factors that have a tendency to be found mainly in localised networks and is more likely to emerge on a background of shared ideologies and experiences, regional loyalties or common language or background (Metcalfe and Diliso, 1996:61).

In conclusion, it is argued that the principle (and associated conceptual assumptions) of ‘selection’ within the developed explanation of evolution provides a plausible analogical explanation of the mechanisms that shape the emergent trajectory of technological innovation. In the current context, ‘selection’ has little to do with ‘fit’ or the survival of efficient technological innovations, but more to do with how technological complexity is moulded out of the ‘variant information’ that constitutes the ‘multidimensional possibility space’. Within the explanatory framework offered in the current thesis, ‘selection’ is seen as a paradigmatic framework, a learning system of

developmental and reconstitutive processes that coordinate the adaptive emergence of technological innovation. Such coordination is not centralised *per se*, but operates through a broad process of 'partisan mutual adjustment', a co-selection process that interprets and assigns meaning to both in-place and novel information through reference to previous experiences and learning systems. This adjustment is directed not only by the interdependencies inherent within the intended competitive and cooperative behaviours of technological system members, but also by the unintended consequences of interdependent behaviours. Given that such behaviours are largely conditioned by historically-accumulated interpretations and assigned meanings, 'selection' is path dependent. However, this does not imply an identifiable process of cumulative discovery, for each preceding stage is never fully understood. Because of this lack of full understanding, and in concert with the 'variant information' that is the 'multidimensional possibility space', 'selection' operates in an environmental context containing a high measure of uncertainty, and as such, tends to 'localise' around familiar patterns of technological innovation. However, such localisation not only restricts the evolution of technological innovation, but may also kill it off. Evolution is first and foremost about the creation of diversity, and as such, the on-going adaptive emergence of technological innovation cannot be sustained by replication and reproduction of 'familiarity' alone. There must also be some aspect of renewal. Such a notion explicitly implies that an evolutional view of technological innovation should not be merely concerned with the 'preservation' of in-place learning systems, but more importantly, the on-going 'preservation' of a system of learning.

5.6 Preservation: Prolonging technological innovation

Preservation (an explanation based on evolutionary theory)

***Why*:** on-going resilience
***What*:** evolvability through adaptability
***How*:** -replicate
-reproduce
-renew
When: ongoing
***Where*:** design level

It was argued in the previous chapter that a new theoretical perspective of 'preservation' is emerging, signifying a shift, in some quarters at least, in the basic 'why' of evolution itself. Notwithstanding that Darwin's central postulate was that Nature provided no independent criteria of fitness, it has been assumed, particularly within the 'adaptionist thesis', that evolution is essentially a 'positive progression' that leads invariably to a specific outcome. As a result of this assumption, every inherited adaptation, whether that be a feature, characteristic or behaviour, is considered to be (near)optimal in the sense that it has occurred to serve a required function (Ho, 1988). It is hardly surprising that in adopting this notion of 'progress in adaptation', evolution is seen by many as a process that leads to a primary and defining result, with this result ensuring the survival of that which underwent the adaptation. However, such an assumption not only lacks an appreciation of the interdependencies inherent within the evolution process, but also requires a high level of stability in the environment for the inherited adaptation to provide its presupposed survival benefit(s). While it is acknowledged that an open and dissipative system may contain some independent and/or stable aspects, interdependent discontinuity is the dominant state in all systems (Jantsch, 1980; Prigogine, 1987; Popper, 1990; Kauffman, 1993). Furthermore, all aspects of stability will eventually dissipate due to the basic process of evolution itself, that is, the on-going creation of diversity through both internally and externally-generated means (Laszlo, 1987; Allen, 1990). Within such an interdependent, discontinuous and diversity-enhancing

environmental context, it was argued that ‘preservation’ (ie. on-going survival) is not bestowed by specific adaptations *per se*, but rather adaptability at the higher design level. This latter notion refers to an ability to not only operate within a range of environmental conditions, but also to make a range of adaptations to itself whilst still maintaining structural and/or functional integrity (Hahlweg, 1991; Hodgson, 1998). In essence, the *why* of ‘preservation’ as an aspect of evolution is essentially about ongoing resilience, a state that can only be achieved through a combination of both stability and flexibility at the design level, rather than at the particular characteristic level. While stability, resulting from the direct inheritance of symmetrical and/or slightly modified adaptation, can offer an evolving system a measure of current structural and/or functional integrity, future structural and functional integrity (ie. on-going resilience) can only occur through system adaptability (Gould, 1996; Depew and Webster, 1997).

These conceptualisations of the *why* and *what* of evolutionary ‘preservation’ as ‘on-going resilience’ and évolvablity through adaptability’ are not part of the mainstream socio-economic mindset. As in (neo)Darwinian biology, much of the social science literature is formulated within an ‘adaptionist’ explanatory framework, which ostensibly examines cause and effect relationships. The focus is almost exclusively on the effect or consequence(s) of specific (and largely implied) linear relationships (Laurent and Nightingale, 2001). Similarly, the majority of research into technological innovation exhibits such an ‘adaptionist’ perspective, for the cause is considered to be the competitive (ie. natural) selection pressures of the market-place, with the effect being the successful birth (ie. fitness) of a particular technological innovation. Given that this research sees the sanctity of an (near)optimal marketplace as a given, the almost exclusive focus (both at the epistemological and contextual levels) is on the immediate effect of the innovation process, the technological adaptation itself, or its imitative

diffusion through the market-place. However, this focus is little more than mechanistic determinism, for it views technological innovation as either the logical consequence of a process (as distinct from something that is central and immanent to the process itself), or as a simple matter of bimodal choice, that is, adopt/nonadopt (Witt, 1991; Bullard and Butler, 1993; Barton, 1994).

The current focus of mainstream research, with its emphasis on continuity and stability, both with respect to the environment and the technological innovation process, is fixated on the theoretical and empirical approaches of early innovation research (Burns and Stalker, 1961; Mansfield, 1968; Abernathy and Utterback, 1975). While this research had a profound and positive effect on the research area, it was based on data from a few select industries that had little need and/or desire to promote innovative activities. Given this, and the fact that most explanatory models where built around aggregated data and linear mathematical procedures, the notion of technological innovation as a stable, continuous, and linear cause and effect process has been accepted as 'reality'. It is questionable that such a 'reality' was indeed the norm during this early research, for any system that incorporates human activities is fraught with subjectivity and imperfections, and will therefore always experience a measure of turbulent discontinuity (Boulding, 1991; Allen, 1994; Boisot, 1995). Within the current technological climate(s) discontinuity is quite high. This reflects a multitude of discontinuous aspects inherent within current, broad, market-place conditions such as globalisation, the centralisation/decentralisation flux, and technological intensification (Lynn, Morone and Paulson, 1996; Vromen, 2001). Taken in concert with the discontinuities inherent within the relational interdependencies required for even the simplest of technological innovation, it is argued that;

> economic competence refers not so much to the set of maximizing or optimizing skills normally attributed to the firm in static theory as to the qualities which make for good

> performance in the long run: to generate opportunities, not just to react to exogenous changes; to make educated guesses and take risks, to maintain flexibility, and to learn (Carlsson and Stankiewicz, 1991:101).

Given that the (structural and functional) institutional arrangements that generate technological innovations have to possess a relatively high measure of flexibility in order to survive, it seems reasonable to suggest conceptual similarity between the *why* and *what* attributed to evolutionary 'preservation' and technological innovation. In particular, the on-going resilience of 'selection' mechanisms (ie. paradigmatic frameworks or learning systems), along with the technological innovations themselves, would derive the same 'preservation' benefits if they exhibited such adaptability. The influence of 'selection' mechanism adaptability on the 'preservation' of technological innovation processes was noted in the previous section (see Section 5.4), and highlights not only the need for such mechanisms to posses an adaptable nature, but also the inherent logic of such a nature. As argued, paradigmatic frameworks or learning systems are neither developed nor maintained through the simple progressive acquisition and possession of common knowledge (Metcalfe, 1994; Hodgson, 1998). This can never be the case because "human purpose is not some clearly defined goal, but rather the fuzzy and changing imagined of an actor's future world on which their active interventions in the present are sighted" (Farmer and Mathews, 1991:111). As consistently pointed out, a technological innovation is essentially a collection of information, and as such, does not appear fully formed, but adaptively emerges. This emergence occurs because the information that constitutes the paradigmatic framework (ie. selection mechanism), and the information that is selected upon (ie. variation) are not 'givens'. The full meaning of both 'sets' of information can never be presupposed because it is adaptable in the sense that it undergoes constant (re)conditioning due to differing interpretations and applications (Popper and Eccles, 1977; Lave, 1993).

That ‘preservation’ (ie. ongoing resilience) can derive from ‘adaptability’ at the specific technological innovation level is explicitly suggested in research examining the notion of ‘modularity in product design’ (Dixon and Duffy, 1990; Morris and Ferguson, 1993; Baldwin and Clark, 1994; Kogut and Kulatilaka, 1994; Sanchez, 1996). This research shows that within a growing number of industries (see Sanchez and Mahoney, 1996 for a review) engineering at the design level no longer follows the traditional approach of constrained maximisation or optimisation. Within such a tradition, technological designs are based on a composition of highly integrated and tightly coupled components, the overall aim being the highest level of specific product performance attainable within given cost constraints. This approach is not concerned with adaptability or flexibility *per se*, (whether that be technical configuration or usage situation) for that is thought to entail some measure of excess technical baggage which pushes up costs, lowers profits, and therefore leads to the eventual demise of the technological innovation, and possibly the organisation that offered the design. It is now being argued that a technological design developed in this mindset and manner limits the possibilities of on-going innovation (and of its expanded applicability) due to component composition and interface relationship(s) specificity (Morris and Ferguson, 1993). Support for this argument is also found within research examining ‘dominant design’ (Rosenbeg, 1982; Clark, 1985; Sahal, 1986) which claims that technological innovation within such a context is at best, incremental, for ‘improvements may occur in individual components, but the underlying core design concepts, the component set, and the links between them, remain the same’ (Henderson and Clark, 1991).

As an alternative to this traditional engineering mindset and practice, a growing number of organisations and industry groups are viewing technological innovation through the practical concept of ‘modular product design’;

> a methodology in which standardized interfaces between components and subsystems of components are specified to *allow for a range of variations* in components or subsystems to be introduced into a product architecture… A modular product architecture is *flexible* in the sense that a number of different versions of a product can be leveraged by substituting different modular components into the modular product architecture without necessitating a redesign of other components or subsystems within the product architecture. In essence, the loose coupling of the components within a modular product architecture allows the 'mixing and matching' of modular components in a potentially large number of distinct combinations that give each product variation distinctive functionalities, features, and/or performance levels (Sanchez and Mahoney, 1996:9-10).

That the 'preservation' of technological innovation is largely a function of adaptability at the design level is supported implicitly within the aforementioned literature which examines technological innovation through the notion of 'dominant design'. This research found that when a traditionally-engineered design becomes dominant within a product class, product diversity diminishes because there is little scope for alternative design configurations, and as a result, the on-going exploration of technological possibilities is stifled because organisations cease to invest in experimental learning (Daft and Lewin, 1993). By contrast, modular product design approaches (incorporating a level of flexible adaptability at the architectural level) place an emphasis on learning at this level. This is learning at a critical juncture within the technological innovation process, for it is here that paradigmatic frameworks or learning systems (ie. selection mechanisms) are maintained, enhanced and/or destroyed (Anderson and Tushman, 1990). Specifically, having some measure of 'adaptability' at the design level preserves technological innovation because: it focuses innovative effort beyond short-term benefit (Levinthal and March, 1993); increases the absorptive capacity of firms (Cohen and Levinthal, 1990); and allows for the full realisation of a firm's combinational capabilities (Bartlett, 1993).

If the *why* and *what* of 'preservation', as conceptualised within the explanation of evolution presented in the previous chapter, exhibit an explanatory plausibility within both the theoretical and practical contexts of technological innovation, it would seem

reasonable to assume that the *how* of this principle might also display such plausibility. As previously noted, there is a growing consensus that evolution within the natural world cannot possibly occur solely through the direct inheritance (ie. replication) of a particular fortuitous random adaptation. This view flows from research within the natural sciences which shows that the defining characteristic of all evolving systems is 'self-organisation', that is, an ability to not only make relatively minor modifications (ie. reproduction) to their structural and/or functional design configuration, but to also construct an entirely novel (ie. renewal) design configuration (Prigogine, 1980; Hahlweg, 1991; Plotkin, 1995; Depew and Weber, 1997). In essence, replication, and to some extent reproduction, are 'preservation' aspects that provide a measure of structural and/or functional integrity within 'largely known' current environmental conditions. 'Renewal', and to some extent 'reproduction', are on-going 'preservation' aspects that provide a measure of future structural and/or functional integrity through adaptability, what Lewontin (1987) referred to as the ability to expand one's 'typology of accessibility'.

As previously argued, much of the socio-economic research into innovation, irrespective of type, is based within the 'adaptionist thesis', and it is therefore hardly surprising that 'replication' dominates both theoretical and empirical considerations. Given the propensity for an overwhelming majority of both producers and consumers of artefacts to replicate their behaviour and/or the behaviour of others so as to reduce uncertainty, this view is one possible representation of reality. However, it is highly questionable in a theoretical sense to consider this replicated behaviour as innovation *per se*, for the essence of innovation concerns the invention of novelty, with an increase in qualitative diversity, not quantitative change. As Schumpeter (1934:64) noted; "Add successfully as many coaches as you please, you will never get a railway thereby."

Imitative behaviours may contribute to socio-economic progress, but within the explanatory framework proposed in the current thesis, the principle of ‘preservation’ as it applies to technological innovation is explicitly concerned with on-going resilience, rather than short-term gain.

Research specific to technological innovation, including that stemming from an evolutionary perspective, also exhibits a preoccupation with ‘replication’, conceptualising it as an organisation’s and/or industry group’s production and/or process routines, and considering such as akin to memory and therefore a repository of regular, continuous and predictable patterns of innovative behaviour (Nelson and Winter, 1982; Dosi, 1988; Dosi and Nelson, 1995; Boschma and van der Knaap, 1997). Similar to previous comments, ‘replication’ via these routines is considered to be the dominant operational approach of most economic institutions because it reduces contextual or localised uncertainty, and has the additional benefit of offering possible economies of scale (Witt, 1991; Saviotti, 1996). While it is acknowledged that the ‘replication’ effects of routine behaviour may endow an organisation with a measure of structural and/or functional integrity or stability, ‘replication’ on its own is not a mechanism for the ‘preservation’ of technological innovation. In fact, organisational routines (in concert with positive feedback loops) act as impediments to technological innovation, not only trapping organisations into their existing circumstances, but also dampening further innovation possibilities because there is no promotion of purposeful, forward- looking behaviour (Elliott, 1990; Kirchoff, 1991; Vromen, 2001).

Furthermore, while it could be argued that on-going adherence to the organisational routines affecting technological innovation is a ‘preservation’ measure, there is ample evidence to suggest that such adherence is due to ‘internal traditionalising processes’,

rather than to any perceived or actual superiority of these routines (Astley, 1985; Perez, 1985; Foss, 1997; Hodgson, 2001). For many organisations, and indeed for many researchers, ‘preservation’ is less concerned with the on-going resilience of the technological innovation process, and more with conserving the status quo. On this view, innovative behaviour is perceived and practiced by both groups as a form of efficiency gain through the repetitive routinisation of skills and knowledge. However, innovation, whether technological or epistemological, cannot be considered merely as the accumulation of unambiguous and codifiable information, for this implies uniformity of meaning and passivity of learning, and fails to acknowledge “the fundamental imprint of interested parties, multiple activities, and different goals and circumstances, what constitutes ‘knowing’ on a given occasion or across a multitude of interrelated events” (Lave 1993:12-13).

As stated previously, within the context of technological innovation, ‘replication’ provides a measure of structural and functional integrity, providing stability by insulating current paradigmatic frameworks and specific learning systems from the disruptions imposed by any unexpected changes to internal and/or external environmental conditions. However, as Anderson and Tushman (1990:629) have pointed out, “technological evolution puts a premium on the firm’s ability to develop multiple, often inconsistent competencies simultaneously.” Within such a context, ‘replication’ is not a driver of technological innovation *per se*. The latter process is considered to be essentially one of continuous learning, a case of not only processing uncodified information, but of creating it as well (Utterback, 1994; Nelson, 1995; Mandeville, 1998). Thus, the emphasis within any evolutionary-based explanation of technological innovation, and in particular, the ‘preservation’ or on-going resilience

aspect of the process, necessarily requires a shift in emphasis from ‘replication’ to ‘reproduction’ and ‘renewal’.

It was argued by Marshall (1949:295) that “the tendency to variation is the chief cause of progress,” a call that echoes Schumpeter’s (1939) assertion that economic growth is dependent on ‘creative destruction’, which shakes up and redefines (pre)existing conditions. In marrying the thoughts of these two eminent economic philosophers, it seems reasonable to conclude that a diversity of technological innovations not only underpins the ‘preservation’ of the innovation process itself, but also that of broader socio-economic systems, and that such ‘preservation’ is dependent upon the ‘reproduction’ (ie. shaking up) and ‘renewal’ (ie. redefining) of in-place understandings. Within the current explanatory framework context, ‘replication’, ‘reproduction’ and ‘renewal’ could be conceptualised as the learning types or approaches that provide the range of fixity and freedom needed to maintain and drive the technological innovation process. While the links between learning types and technological innovation are readily apparent, it has been argued that the research area is “marked by considerable heterogeneity, often compound by definitional differences.., and has concentrated rather narrowly on the learning that occurs as a ‘natural’ result of cumulated experience” (Dodgson, 1992:145). To a large extent this argument is merely a reflection of the ubiquitous plethora of literature on the subject, highlighting the multitude of different loci, foci and processes that impact on learning, and the difficulties associated with its conceptualisation (Arrow, 1962; Cyert and March, 1963; Ansoff, 1982). Such difficulties are not new, for there has been philosophical and psychological despair associated with the conceptualisation of learning since Plato’s *Theaetetue* (Sosa, 1991; Maddox, 1993).

Notwithstanding this broad and confusing array of research, within the organisational management literature there is some consistency of thought with respect to learning in a technological context. While a number of authors have contributed to this research area (eg. Burns and Stalker, 1961; Arrow, 1962; Cyert and March, 1963; Ansoff, 1982; Rosenberg, 1982; Sweeney, 1987; Drucker, 1993), it is the research of Argyris and Schon (1978) that provides both a collection and departure point for most of these contributions. The authors identified three types of learning that underpin the strategic intent of an organization. The first is termed 'single loop' learning, and denotes the imitative feedback into current decision-making practices that occurs through learning by doing and/or using. 'Double loop' learning (the second learning type) refers to embodied learning in which questionable decision-making practices are (re)modified so as to provide a better basis for medium term, and somewhat unclear, strategic imperatives. The final learning type is termed 'deutero' learning, a case of learning about learning in which the complete process of knowledge development within the organisation is renewed so as to provide perceived strategic capabilities in addressing future environmental conditions. These three identified types of learning lend strong support to the conceptual similarity between the *how* of evolutionary 'preservation' and the *how* of technological innovation. In effect, the on-going resilience of technological innovation occurs through a (re)combination of information 'replication', 'reproduction' and 'renewal'. That the latter two are the ultimate drivers and sustainers of technological innovation (as they are for the process of evolution) is evident in Lynn, Marone and Paulson's (1996:10) contention that;

> a careful reading of recent industrial history leads to the conclusion that in competitive, technology intense global markets, advantage is built and renewed through the more discontinuous forms of innovation-through the creation of entirely new families of products and businesses.

In addition to their direct impact in supporting the on-going resilience of the technological innovation process, 'reproduction' and 'renewal' play a broader

‘preservation’ role, for learning, whether (re)combining existing information or discovering new information, expands the ‘multidimensional possibility space’. In effect, these two learning approaches could be considered as the internal and external mechanisms of ‘variant information’ generation, helping to enlarge the ‘multidimensional possibility space’ for technological innovation, and thereby providing a measure of ‘preservation’ for the on-going resilience of the overall technological innovation system (Allen, 1994; Hodgson, 1998).

To conclude, it is argued that the conceptualisation of the ‘preservation’ principle as it applies to evolution has a measure of analogical applicability to an explanation of the process of technological innovation. As for evolution, the process of technological innovation cannot be considered as consequential. It is not about a specific type of product, process and/or organisation ‘winning’ because it displays some perceived or actual superiority. Irrespective of whether it is termed on-going resilience, survival or competitive advantage, the ‘preservation’ of technological innovation, like any evolving system, is considered to be irrevocably tied to an increase in diversity, rather than the opposite. As argued, technological innovation is not some fully-formed result, neither is it an outcome of inexorable technical logic, for it is essentially a ‘heuristic information core’ that emerges from the raft of ideas, both good and bad, that constitute the ‘multidimensional possibilities space’ of ‘variant information’ (Babba and Imai, 1993).

This emergent process of technological innovation occurs not only as “an outcome of the social or political dynamics of compromise and accommodation between actors of unequal influence” (Anderson and Tushman, 1990:617), but also because of the compromise and accommodation that is required when assigning meaning to information that may itself exhibit changeable influence(s) (Mandeville, 1998). Within

such an environment of diverse, discontinuous, and sometime contradictory bodies of information, compromise and accommodation can only occur through some manner and measure of adaptability. Furthermore, such adaptability is necessary to facilitate not only the organisation of current technological innovation endeavours, but also to broaden the scope with respect to the possibilities and potential of future endeavours, for "uncertainty is not only about future events themselves but also about the opportunities available" (Hodgson, 1998:35). In order to sustain this innovative adaptability it is argued that socio-economic systems exhibit similar 'preservation' approaches as those adopted by evolving systems (as detailed in the previous chapter).

In an effort to preserve structural and/or functional integrity, a technological innovation system will adopt 'replication' behaviour(s) so as to provide a measure of stability. These 'replication' behaviours are themselves overlaid by 'reproduction' and 'renewal' behaviour(s) in an attempt to preserve the capacity for future technological innovation. Perhaps more importantly, these two latter 'preservation' behaviours close the loop, both in a theoretical and practical sense, by consciously/unconsciously feeding 'variation' (ie. the broader 'multidimensional possibility space') with novel information. Technological innovation, like evolution, should be considered essentially as a process that attempts to ensure the continuity of existence through either the expansion of the possibility space within which it occurs, or the creative discovery of a new possibility space which offers greater potential for future technological innovation.

5.7 Conclusion

The underlying premise of this chapter is that evolutionary theory is not only a rich source of ideas for socio-economic research in general, but that many of these ideas can be employed as structural analogies in an explanation of technological innovation. The

proposed explanatory framework of the current thesis is essentially a formal model based on ideological reasoning, that is, ‘as-if’ thinking in which the processes of evolution and technological innovation are considered to resemble one another in terms of their underlying organising principles. Furthermore, it is argued that the theoretical attributions ascribed to these principles within the evolution literature provide a sound basis for the development of plausible conceptual understandings and associated basic assumptions of the technological innovation process. This is not to suggest that a direct analogy exists between the social and natural worlds, but rather that evolution and technological innovation have a high degree of isomorphism. It should be appreciated that the explanatory framework proposed is not suggested as the ‘mirrored truth’ of technological innovation, for that process is so complex it will always deny a complete explanation. Rather, the explanatory framework is a ‘simplification’ of the perceived realities of technological innovation based on an evolutionary perspective, one which highlights key aspects and relationships, and hopefully, acts as a heuristic device in that it stimulates and guides future inquiry.

Developing an explanation of technological innovation through recourse to evolutionary theory is not novel. The research area however, has been criticised as being quite narrow in design and analysis, still awaiting a discussion on general principles, dominated by empirical approaches, based almost exclusively within a (neo)Darwinian perspective, and providing little to draw upon when constructing an evolutionary theory germane to economic change (March, 1994; Meldrum, 1995; Nelson, 1995; Hodgson, 2001; Vromen, 2001). In an effort to overcome these criticisms the current thesis focuses on the overall process, arguing that the underlying principles of evolution (ie. variation, selection, preservation) can be used not only to broadly pattern the process of technological innovation, but their conceptual conditions can also be used gain deeper

insights into this process. While the adoption of a textual explanation approach might be considered as merely a counter to the dominance of ‘scientific empiricism’, such an approach has been used because it is only through the mobilisation of both reason and metaphor that the complexity of evolutionary processes can be acknowledged and explained (Lewontin, 1991; Brownlie, 1997). To overcome what is perhaps the most problematic aspect of the research area, that is, the proliferation of direct analogies to (neo)Darwinian biological metaphors, the explanatory framework has been based on the abduction of theoretical considerations and conceptualisations of system evolution from a range of (sub)discipline research areas. This approach not only negates the parsimony of (neo)Darwinian dominance, along with the conscious manipulation of such to support ill-conceived assumptions, but also expands the theoretical perspective of evolution, thereby broadening the context and case applicability of the explanatory framework in technological innovation research.

In adopting the broader theoretical considerations of system evolution, as distinct from biological evolution, the explanatory framework proposed in the current thesis explicitly recognises that technological innovation, both of itself and as part of the broader socio-economic fabric, is a process essentially fuelled by open and dissipative structural and functional interdependencies, and that such interdependencies are subject to on-going discontinuous adaptive emergence due to the impact of internally and externally generated novel information. This ontological stance is in direct contrast to the majority of current mainstream thought and practice which treats technological innovation in an atomistic, reductionist, deterministic, gradualistic and/or mechanistic manner (Metcalfe and Diliso, 1996). Such treatment is manifestly illogical given the widely-held consensus that technological innovation is essentially a collective, social,

learning process, one that translates individual subjective/objective information into collective outcomes.

The principles (ie. variation, selection, preservation) that form the theoretical backbone of the proposed explanatory framework are ‘not premises of inference or argument or laws,’ but simply ‘conditions that have to be satisfied’ when utilising an evolutionary perspective, and as such, they are ‘open to conceptualisation through tentative agreement rather than established facts’ (Kaplan, 1964). ‘Variation’ is the starting point of the explanatory framework because it is the defining and paramount reality of any technological innovation process. Within the current context ‘variation’ is conceptualised as the pool of ‘variant information’ that results from the perpetual accretion of bits of information, the (re)combination of this information, and the creation of novel information through mechanisms of ‘selection’ and ‘preservation’. In effect, ‘variation’ is a ‘multi-dimensional possibility space’ of ‘variant information’ that arises from, and is subjected to, not only intended behaviours, but also the unintended consequences of interdependent behaviours that occur during the technological innovation process.

While the possibilities inherent within the notion of ‘variation’ may be limitless, and therefore largely indeterminate, these possibilities are constrained through ‘selection’ mechanisms. In the current context ‘selection’ is deemed to be the paradigmatic frameworks or learning systems that not only (re)define the technological possibilities or problems, but also shape and guide the development of technological design(s) that may offer a possible solution. ‘Selection’ is considered to be emergence in a dual sense. It refers not only to the on-going evolution of the paradigmatic framework itself due to the open-ended and provisional nature of learning, but also to the idiosyncrasies that

arise as a result of the subjective application of this framework. As argued, ‘selection’ is not simply an individual, rational, economic response to perceived market conditions, but rather a mechanism of adaptive emergence where the need to maintain structural and/or functional integrity is conditioned by the multiplicity of technological endeavours, the intended/unintended consequences of organisational and technical interdependencies, the social and political imposition of competitive/cooperative behaviours, and the constraints inherent within historical contingencies.

While (near)optimal technical artefacts may arise from technological innovation, these are incidental consequences, for the process itself is more concerned with the ‘preservation’ of on-going resilience through the constant creation of artefactual diversity, which incorporates both success and failure. Such diversity necessarily requires a measure of adaptability, that is, an ability to operate within an evolving range of turbulent environmental conditions. This applies to both the processes underlying technological innovation, and to the technological designs that may possibly emerge from such processes. Notwithstanding the freedom required for adaptability, the technological innovation process must also provide a measure of fixity so as to preserve some measure of in-place structural and/or functional integrity. These two contradictory aspects of technological innovation manifest in the paradigmatic frameworks that constitute the ‘selection’ mechanism, and are preserved in ‘replication’, ‘reproduction’ and ‘renewal’ learning approaches, with the latter two approaches closing the evolutionary cycle of technological innovation through contributions to the pool of possibilities that constitute informational ‘variation’.

The explanatory framework proposed in this thesis, and the principles and associated conceptualisations on which it is formulated, are not presented as being the ‘truth’ of

technological innovation, but rather an ‘as if’ representation based on evolutionary theory. While the proposed explanatory framework could be considered as the major outcome of the thesis, it is incidental in the sense that the primary aim of the research was to provide an answer to the question; *does evolutionary theory provide a good explanatory framework for examining the phenomenon of technological innovation?* It is argued the answer is ‘yes’ because the proposed explanatory framework satisfactorily addresses the criteria of ‘interesting’, ‘plausibility’ and ‘acceptability’. The explanatory framework developed in this thesis not only challenges marketing’s current representations of technological innovation, but offers a plausible alternative based on ‘realities’ of system evolution that exhibit a relatively high level of (sub)disciplinary acceptability. This is not to suggest that evolutionary theory (or the particular theoretical stance of the theory adopted by this thesis) is the best approach with respect to technological innovation research. What it offers however, is the possibility of igniting and/or fuelling the on-going process of research, and in particular, of injecting a measure of pluralism into the marketing discipline. Without such diversity the marketing discipline itself will not evolve, thereby becoming at best, irrelevant or redundant, merely a lesson of history.

Truth is a process not a state (Ward 1998:113)

6.0 CONCLUSION

6.1 Introduction

It has been argued that in serious theorising there should be a dispensing of 'schools of thought' or 'differences of principle', and that the only fundamental cleverage in knowledge development is 'between good work and bad' (Schumpter, 1928). Echoing this sentiment, the material presented in this chapter will not offer the argument that evolution theory, the particular perspective of evolution adopted by this thesis, or the proposed explanatory framework based on this perspective offers the 'best' approach when undertaking technological innovation research. It will be argued however, that this approach to explaining technological innovation is 'good'. That it is 'good' is not merely due to its perceived satisfaction of criteria identified as congruous with *interesting*, *plausible* and *acceptable* research, but also because it injects a much needed dose of pluralism into both the marketing discipline in general, and the technological innovation research area specifically. Furthermore, both explanation of evolution offered in this thesis, and the explanatory framework taken from such, are characterised by levels of generality and openness. The former characteristic allows for broad contextual applicability, while the latter provides room for additional theoretical musing. Material presented in this chapter will provide a consideration of the outcomes of the research, identify general contributions made to the research area and implications for theory, suggest some policy and management implications, and offer possible opportunities for further research. It should be noted that the material pertaining to the latter three aspects

exhibits a level of abstraction, a function of the generalised nature deemed necessary for a ‘good’ explanation.

6.2 Outcomes of the research

The departure point for this thesis was the recognition that technological innovation, however defined, irrespective of context, and without regard to consequence(s), is a major driver of socio-economic ‘change’. Such an idea is neither novel nor insightful, for the impact of technological innovation is as readily apparent in the stone flint as it is with the Internet. However, despite the centrality of technological innovation to the on-going resilience of humanity itself, most of the conventional approaches to researching this phenomenon (particularly those within the marketing discipline) fail to appreciate the inherent complexities of the underlying process. This is not to infer that such complexity could be ‘realistically’ incorporated into a formal model, but to merely state that the majority of current research offers simplistic representations of the complex realities of technological innovation. As discussed in Chapter Three, current research, including that purporting to be ‘evolutionary’, is based largely within the (neo)classical framework of ‘scientific empiricism’. As a consequence, technological innovation is considered and/or treated in ways that are atomistic, reductionistic, deterministic, gradualistic and mechanistic in tenor.

The issue of timely relevance with respect to the phenomenon to be examined, in concert with the problems identified with current research practices, and the need for plausible

alternative approaches, resulted in the research question that directed the thoughts and pragmatic development of the current thesis. That is, *does evolutionary theory provide a good explanatory framework for examining the phenomenon of technological innovation?* While the response to this question is 'yes', it is incidental in the sense that the research journey is considered to be more important than the destination. During this journey a number of outcomes were achieved. These relate to the adopted methodology, the explanation of evolution, and the proposed explanatory framework of the technological innovation process.

6.2.1 Research methodology

It has been argued that the marketing discipline is caught in a 'paradigmatic gridlock of positivist and technical orientation', and as a consequence, the discipline is 'incapable of illuminating real world phenomena' (Lowe, Carr and Thomas, 2004). Such a research orientation has been fashioned by marketing's history, the discipline 'abducting' the (neo)classical theoretical and methodological frameworks of its sociological/economic parents when it sought to legitimise itself as a valid and viable research area. Given the influence of 'path dependency' within paradigm expansion, it is hardly surprising that current marketing thought and research practice are orientated primarily towards the 'logical positivism' and 'predictive determinism' of 'scientific empiricism'. This is not to criticise 'scientific empiricism' *per se* (though one may question the 'truth claims' placed upon it) but to state that its methodological approaches have become little more than 'ritual invocation' within the marketing discipline. This ritualism is readily apparent in marketing's (re)cycling of theories and research methodologies, and the bringing together

of such through the application of ‘off-the-shelf’ statistical analysis techniques. However, this ritualistic orientation towards the ideals and practices of ‘scientific empiricism’ will not confer on the marketing discipline the superior intellectual status it so desperately desires. Much of socio-economic behaviour is a complex riddle that cannot be fully explained and/or understood through the formalism of ‘scientific empiricism’ (Boulding, 1982; Lawson, 1997). Furthermore, the (predominately socialised) pre-occupation with ‘scientific empiricist’ methodology within the marketing discipline, irrespective of research context, ignores a central tenet of research, that “the general character of knowledge as an abstract term is determined by the nature of the methods used, not *visa versa*” (Dewey, 1938:11). Given the aforementioned pre-occupation it is hardly surprising that the marketing discipline is caught in a ‘paradigmatic gridlock’.

The methodology that underpins the current thesis reflects Dewey’s (1938) observation in that there is a conscious attempt to design a methodology congruent with the explanatory goal of the research. However, in contrast to the ‘predictive’ approach common to the marketing discipline (and to the socio-economic area in general), research which adopts an ‘explanatory’ focus is confronted by a dearth of in-place methodology structures, and little in the way of practical guidance in formulating a valid methodology. To overcome these issues the current thesis ‘abducted’ research approach elements from a number of (sub)disciplines, the overall aim being the design and construction of a methodology that helped to ‘explain’ the realities of technological innovation, as distinct from the predictive ‘truths’ of these realities. Such an aim is consistent with the argument that research methodology is merely a device for (re)formulating knowledge about

phenomena, rather than a true representation of such (Kaplan, 1964; Appleyard, 1992). The developed methodology, described and justified in Chapter Two, is founded within the critical sensibility of a *postmodern* philosophy (Gergen and Tojo, 1996); reflects societal convention(s) through an epistemology of *transcendental realism* (Lawson, 1997); adopts the reasoning logic of *abduction* (Bhaskar and Lawson, 1998) and *textual explanation* (Outwaite, 1998); and imposes order through the strictures of *interesting* (Davies, 1971), *plausibility* (Weick, 1989) and *acceptability* criteria (Whetten, 1989).

It is argued that the methodology developed in the current thesis offers a rigorous process for research attempting to 'explain' socio-economic phenomena. The underlying structure and associated elements of the methodology are not only internally valid, but more importantly (and a point often neglected in research), provide a strong measure of external validation with respect to the knowledge generated through the research process. Furthermore, the methodology is robust and flexible. It appreciates and accommodates the diversity of socially constructed frames of reference (both of the observer and observed) that are unavoidable in research endeavours. Specifically, the underlying philosophical and epistemological frameworks, in concert with the reasoning logic of 'abduction', draw heavily on the researcher's perspective, beliefs and experiences. This is an important consideration because it is essential for all methodologies to make (or allow) the clear distinction between the philosophical claims of a 'world out there' and the 'true out there'. As previously argued, the notion of 'truth', however defined and determined, is a questionable criterion for the validity of research. Knowledge is made not found, a social creation rather than a true representation of how things really are, and

as such, any ‘truth’ claims placed upon such knowledge are, by default, socially constructed (Rorty, 1991). It is argued that the methodology underpinning the current thesis is a ‘good’ outcome as it offers both an appreciation of the social construction of ‘knowledge’, and a viable means for such construction. In essence, the methodology is dually pluralistic, offering not only an alternative approach to the predictive orientation of ‘scientific empiricism’, but also presenting a research instrument that can accommodate a variety of socially constructed explanations of technological innovation.

6.2.2 An explanation of evolution

An ‘explanation’ is a way of achieving at least a partial understanding of causality through the identification of observable/non-observable underlying mechanisms, structural and/or functional interdependencies, and associated contingent conditions. The explanation of evolution offered in the current thesis is not novel *per se*, but rather a rough and somewhat simplistic appreciation of current theoretical and empirical research into evolutionary processes within the biology, physics and chemistry (sub)disciplines. Some may even argue that this particular explanation of evolution is not novel to the socio-economic area, citing the use of principles (and associated aspects) of the explanation within published research, particularly within evolutionary economics. Indeed this is the case, however, much of this research uses some elements and/or aspects and not others, usually in an attempt to support in-place assumptions regarding specific socio-economic behaviour(s). Such a piecemeal approach is inappropriate. The explanation offered in this thesis takes a more process perspective approach by highlighting the overall ‘integrated nature’ of this new ‘reality’ of evolution. It

emphasises the interrelational interdependencies (both known and unknown) of the principles (and inherent elements and aspects) that are considered as denoting the process of evolution.

While the ‘completeness’ of the offered explanation of evolution, both in itself and as a basis for research, is deemed to be a ‘good’ outcome of the current thesis, its significance resides in its challenge to the dominant (neo)Darwinist tradition within the social sciences. Appeals to this view of evolution are common within the socio-economic literature, however, such appeals are paradoxical in the extreme. As discussed (Chapter Five), much of the literature invokes the (neo)Darwinist appreciation of evolution in an attempt to overcome the perceived (neo)classical influences on current socio-economic thought and practice. However, (neo)Darwinist evolution and (neo)classical socio-economics are cut from the same cloth of ‘Newtonian’ science, with both viewing systems as ‘closable’, causality the sole result of ‘non-purposive’ exogenous forces, and with such causality identifiable through objective analysis (Sober, 1984). In effect, the socio-economic literature which borrows metaphorical representations from the (neo)Darwian perspective on evolution has transcended into what Merton (1968) referred to as an ‘opportunistic shortcoming’. This is a result of the sloppy examination of the existential base of (neo)Darwinism, and the theoretical frameworks that flow from this doctrine of existence.

While the process of evolution is at present not completely understood, if indeed it ever will be, the explanation of evolution offered in the current thesis is considered to be both

plausible and acceptable. As stated, the explanation is not novel in itself, but merely an attempt to synthesise current knowledge on the evolution of biological, physical and chemical systems into a coherent patterning of the conceptual generalities underpinning its principles. In a general sense the explanation offered in this thesis has satisfied the identified need to make a distinction between the story of evolution and the underlying principles that drive the process of evolution (Plotkin, 1995). Furthermore, it also satisfies the need to present conceptualisations of the principles of evolution that are not only common to all systems, but also to all levels within these systems (Vromen, 2001). Of particular relevance to the current context, the explanation also incorporates a number of assumptions that are considered as having analogous relevance to 'evolutionary' explanations of technological innovation.

6.2.3 Evolution as an explanatory framework for technological innovation research

The central argument of the current thesis is that evolutionary theory provides a good explanatory framework for examining the phenomenon of technological innovation. Notwithstanding the subjective influence of researcher bias, it is considered a 'good' framework because it is based on a synthesis of plausible current understandings of evolution from a cross-section of sound, relevant and acceptable scholarship. It is a relatively 'complete', though broad representation of the evolution of any system. Such a representation has explicit analogical appeal to current understandings of technological innovation as an essentially emergent dynamic phenomenon, the result of on-going variability within and between the technological and socio-economic interdependencies that constitute a complex system (Van de Ven and Garud, 1994; Drazin and

Schoonhoven, 1996; Vromen, 2001; Fleming and Sorenson, 2004; Becker and Knudsen, 2005). The inherent aspect of 'completeness' in representation is an important consideration in determining the notion of 'good', for the offered explanation provides a relatively thorough template of the overall process of evolution on which technological innovation research can be placed. Such an initial template of evolution allows for a distinctly different research approach when compared with current mainstream endeavours, which in the main start from a representation of the technological innovation process based on in-place assumptions, and then attempt to overlay this representation with a hotch-potch of aspects deemed to be evolutionary.

To conclude, it is argued that the identified outcomes of the current thesis are not only 'good' in a research sense, but also make a 'good' contribution to both the marketing discipline and the research area. The adopted methodology is specifically designed as a device for 'explanatory-based' research, and as such, is a counter to the intellectual culture of generalisation within the marketing discipline that has tended to dismiss the need for particularisation and difference of methodology (O'Shaughnessy; 1997). Furthermore, the methodology explicitly promotes the idea that knowledge of phenomena such as technological innovation is not a static infallible, but is conditioned by social convention and will therefore exhibit a diversity of meanings over time. The explanation of evolution is considered a 'good' outcome because it adopts a 'process' orientation, and as such, makes a clear distinction between the story of evolution and the underlying principles that drive evolutionary change. The conceptualisation of these principles not only highlights their theoretical commonality with the evolution of all systems, but is also

suggestive of a rich mine of intellectual thought appropriate for analogical transfer. The offered explanatory framework is ‘good’ because it shifts understanding beyond the mere recognition that evolutionary processes drive technological innovation by identifying the mechanisms, structural and/or functional arrangement and contingent conditions that enable technological evolution to occur.

6.3 Contributions to research area and implications for theory

As previously discussed, the assumptions inherent within the offered explanation of evolution are not novel *per se*. However, their subsequent analogical abduction into the proposed explanatory framework for technological innovation is considered a contribution to the research area. While some of this contribution could be considered as supportive in that many of the assumptions are implicit in areas of technological innovation research (though rarely in the marketing literature), a novel contribution is made to the research area through their (re)interpretation, emphasis and placement in the explanatory framework. Furthermore, and perhaps a more important contribution, is the explicit acknowledgement that these ‘abducted’ assumptions are not in themselves free-standing. Much of the research into technological innovation utilises many of the evolutionary assumptions identified within the current thesis as a sort of ‘scaffolding’ surrounding a central theoretical proposition, for example, ‘competitive market-place forces as an optimal selection mechanism for technological innovation’. However, many, if not all of these ‘scaffolding’ assumptions have little connection to ‘reality’, being developed merely as a prop for the central proposition, such as ‘the competitive market-place is rational’.

The lack of a reasonable representation of the ‘realities’ of technological innovation is rarely acknowledged or questioned. In many instances this is due to a ‘taken for granted’ acceptance that such ‘scaffolding’ assumptions are merely research conveniences, easily removed, with little or no impact on the central theoretical proposition. Such a mentality is misplaced for all assumptions contained within an explanatory framework or theoretical model must contribute to its structural and functional integrity. Kaplan (1964) refers to this notion of integrity as ‘concatenation’, arguing that all elements in a theoretical pronunciation are necessarily relational. Therefore, the removal of even one assumption, however minor, will compromise model integrity. The structural and functional integrity of the explanatory framework offered in this thesis is maintained via the theoretical congruency linking all assumptions, not only to each other, but also to the perceived ‘realities’ of technological innovation. The following material supports this assertion of framework integrity through an identification of the current thesis’ contributions to the research area and possible implications for theory. This is accomplished through a brief discussion on the ontological, enumerative and associative assumptions that ‘bond’ the explanatory framework together.

6.3.1 Ontological assumption

An ontological assumption is essentially the ‘study of being’ and defines how things are perceived to work (Depew and Weber, 1997). The ontological assumption of evolution ‘as and of’ an *open and dissipative system* sets the nature of all subsequent assumptions, whether in reference to the phenomenon itself, or when used analogously to explain technological innovation. The very nature of open and dissipative systems is

disequilibrium, a function of their primary tendency to generate on-going discontinuity (ie. variation) through internal and/or external informational energy sources. This is not to suggest that such systems are unstable, for they maintain their structural and/or functional integrity or stability through mechanisms such as the self-organisation and autocatalytic (re)cycling of informational energy. In adopting this overarching ontological assumption, the present research makes an important contribution to the research area, one which is a direct and explicit contradiction of the common ontological assumption that the nature of systems is essential one of *equilibrium*. Within such an ontology, gradual continuity and closure (both in a spatial and temporal sense) are considered to be the underlying causes of system stability. While it is acknowledged that adoption of such an ontological assumption may be due to research convenience rather than belief, material present in Chapter Three shows that the dogmatic application of such an ontological stance has a far-reaching (and far too often) ill-conceived influence on theory development within the technological innovation research area.

While the ontological assumption offered in the present thesis is considered to be a contribution to the research area, it will not be welcomed in many quarters. An ontological assumption defines the basic workings of a phenomenon, and as such influences all subsequent assumptions regarding that phenomenon. The ontological assumption in this thesis views systems as open and dissipative in nature, and therefore largely discontinuous in character, and requires many of the current theoretical understandings of technological innovation to be ‘turned on their heads’. At its most basic this ‘turning’ refers to a necessary emphasis on such things as; disorder rather than

order; on-going process rather than final consequence; and asymmetry rather than symmetry. While the theoretical implications of such basic assumptions on the technological innovation research area are difficult to qualify and/or quantify, material presented in Chapter Five identified issues such as; the imprecise and largely unpredictable nature of technological innovation; the constant (re)structuring of organisational aspects associated with technological innovation; and the irregularity in meaning assigned to essentially the same technical information. While it is accepted that the proposed ontological assumption may in itself be an 'unwelcome' contribution to the research area, it is expected that the conceptualisation and operationalisation of this assumption (which offers two contributions to the research area) will be more acceptable.

Analysis at the system level is an attempt at explaining the constitutive characteristics of phenomena, however, the operationalisation of system analysis is beset by two problems. The first of these could be termed the *hierarchy problem*, and refers to the difficulties in theoretically linking the macro-micro relationships that are deemed to represent the 'whole' system, even those arbitrarily closed. The common approach, whether in theory or practice, is to formulate a hierarchy of (sub)systems, and then identify and analyse the order of interdependent relationships between these (sub)systems. However, this very act of hierarchically stratifying a system has a tendency to distort or hide a system's internal/external interdependent relationships. This occurs due to two 'operational' aspects. The first aspect is the highly subjective nature of hierarchy definition: is the organisational group at a higher (or more important) level than the individual in a technological innovation system? The second aspect revolves around the belief that

specifying the ‘laws’ governing a complete system are beyond rational formulation. A result of this belief is ‘reductionism’, manifesting in the tendency to employ empirical indicators that allow only an examination of the interaction(s) between two hierarchical layers within a system (eg. individual and organisation) or an individual hierarchical layer and the defined system itself (eg. organisation and industry). The current thesis offers a contribution to the research area by offering a solution to the hierarchy problem. The solution is an explicit recognition that the principles (and associated conceptualisations) of evolution on which the explanatory framework is based, apply to all emergent systems, even those considered to be merely a part of a larger system. In this view, the general implication for theory is a ‘workable’ conceptual bridge, identifying the same underlying pattern of systemic processes operating in both the micro (eg. organisation) and macro (eg. industry) levels of technological innovation.

The second problem is *system specification* and refers to the operational difficulties associated with defining the boundaries of an open system. Similar to hierarchical stratification, system boundary definition is a subjective judgement, and is usually based on a particular spatial context (eg. organisation, network, industry). Given the recent conceptual emphasis on technological innovation as ‘informational content’, the notion of a contextually-defined system boundary seems somewhat illogical. The current thesis makes a contribution to the research area through an explicit acknowledgement of the ‘technology as information’ thesis, and in particular, offers the notion of *doing information* as a possible means by which the boundaries of a technological innovation system may be defined. In addition, an operational contribution is made to the research

area through the provision of a typology and taxonomy of *doing information*, the contents of which could be used in system boundary definition. In developing the 'information as technology' thesis, a number of assumptions were raised that have profound implications for current mainstream approaches to the theoretical consideration and treatment of information. In particular, it questions the tendency within the research area to consider information as merely a 'given' set of basic characteristics (ie. formal/informal), and to treat such as a commodity that is merely diffused through the technological innovation system in a symmetrical manner.

6.3.2 Enumerative assumptions

An enumerative assumption denotes a universal characteristic of an observed or imagined phenomenon, irrespective of the condition or system state of that phenomenon (Dubin, 1978). Within the explanatory framework offered within this thesis these assumptions are that technological innovation occurs within a *multidimensional possibility space*, is denoted by a process of *adaptive emergence*, and is essentially concerned with *on-going resilience*. While providing individual support to the ontological assumption, these enumerative assumptions (in combination) contribute to the research area by (re)emphasising the *indeterminate* nature of technological innovation. Such a nature (and the assumptions that denote it) is rarely seen in mainstream market thought, due largely to a pre-occupation with 'scientific empiricism's' faith in causality as a predictable inevitability, a consequence if you will, of observable 'law-like' regularities. As argued, such a deterministic mindset is ill-advised when undertaking technological innovation, for causality, irrespective of the point of departure, is never a mere collective of simple

cause and effect relationships. Though somewhat of a paradox, by (re)emphasising the notion of ‘indeterminacy’ the current thesis is in effect arguing for a greater research emphasis on what is actually occurring within the process of technological innovation.

In themselves, the enumerative assumptions offered in this thesis are considered as making a number of positive contributions to the research area. The notion that technological innovation occurs within a *multidimensional possibility space* not only challenges the arbitrary and/or convenient approaches commonly adopted for research scope closure, but also questions the research area’s fixation on ‘given similarities’ and the associated tendency to dismiss/downplay ‘variational diversity’. In promoting the idea that technological innovation is a process of *adaptive emergence*, a general contribution is made to the current research area which shows little appreciation of the existence of emergent properties within technological innovation research (Hodgson and Knudsen, 2004). Furthermore, any consideration of emergence means that technological innovation cannot be explained (never mind predicted) by reducing the process to its constituent parts. Specifically, the idea of *adaptive emergence* contributes to the research area through a focus on the cumulative effects of intrinsic nonlinear relationships within the system of technological innovation, as distinct from the current focus on discrete relationships between perceived internal and/or external aspects. The depiction of technological innovation as essentially *on-going resilience* is an important contribution to technological innovation research as it questions the ‘(near)optimality’ thesis that dominates current thinking. Irrespective of whether the analysis is directed at process or outcome, technological innovation is uncertain, imperfect, messy, disruptive, and in

many instances, unsuccessful. Specifically, the current thesis raises concerns about the tendency within the research area to develop assumptions on technological innovation based solely on an analysis of identifiable, and in the main, ‘successful’ artefacts. Such analysis offers little insight into the process itself, and will fail to identify the broader qualitative changes that may be occurring within the overall system of technological innovation.

While these enumerative assumptions will have implications for a variety of theoretical propositions, the most far-reaching and profound implication relates to situational determinism. In particular, the assumptions of *multidimensional possibility space* and *adaptive emergence* challenges theoretical concepts stemming from deterministic and/or mechanistic considerations. For example, it cannot be presumed that technological innovation systems (and indeed the actors of these systems) operate according to the same set of laws, heuristics, behaviours, learning approaches, and so forth. The assumption of *on-going resilience* also has implication for theoretical conjecture, in particular, that there exists some definable measure of progress within the technological innovation process. For example, the theoretical consideration of technological innovation as a progression (in both time and space) to economic, social and/or technical (near)optimality is untenable within an environment beset by any manner and measure of discontinuity.

6.3.3 Associative assumptions

An associative assumption denotes a property characteristic of a phenomenon, though such a characteristic may or may not be present due to the variable conditions of said phenomenon (Dubin, 1978). Within the current context the associative assumptions are deemed to be those captured within the *how* aspects attributed to the principles of 'variation', 'selection' and 'preservation' (Figure 4.1). Taken in concert, these associative assumptions are considered to make four general (and intertwined) contributions to the research area. The first is that technological innovation should always be considered as complex and uncertain, a function of the multiplicity of known/unknown relational interdependencies and the influence of simultaneously operating dialectic forces (eg. competition/cooperation, success/failure, intended/unintended responses). The second contribution is a promotion of the view that the persistent heterogeneity imbued by such complexity and uncertainty, rather than being an undermining influence, provides the greatest impetus and input to technological innovation. The third contribution flows from the previous two in that it raises questions regarding the research area's 'faith' in observable facts as the sole providers of unproblematic access to the 'workings' of technological innovation. The final general contribution is merely logical reasoning stemming from the previous contributions, that is, predictive assessment and/or pronouncement of specific technological innovation events are severely constrained. Furthermore, such constraint is rarely overcome through the analytical reduction of uncertainty, complexity and/or multifarious heterogeneity to some type of probability function.

Specifically, the associative assumptions generated in the current thesis contribute to the research area in the following manner. The assumptions of *unintended responses to/from environmental stimuli, positive/negative feedback from interdependent system activities, simultaneous co-selection* and *competitive/cooperative behaviours*, while (re)enforcing the ideas of relational interdependencies and embeddness, also emphasise the theoretical notion that local or minor disruptions within a technological innovation system have wider ramifications than current research implies. Furthermore, these assumptions question the tendency within the research area to focus on individual organisations as the unit of analysis, with little attempt at explaining how these organisations contribute to the structural and/or functional arrangements of the broader technological innovation system. The assumption of *path dependency* contributes to the research area through an expansion of the factors influencing learning and/or decision-making behaviours. In particular, it promotes the theoretical idea that choice (while based to some extent on the current context) is perhaps more dependent on why and how the decision-maker came to this context initially. The assumptions of *replication*, *reproduction* and *renewal* also contribute to the same research area, for they explicitly frame such behaviours as largely interpretive, developmental and reconstitutive processes. This is at odds with current theory in the research area, which tends to view such behaviours as primarily a result of the cumulative discovery of pre-existing codified information. The depiction of behavioural processes within the current thesis has profound implications for information theory, and in particular, that information should not be treated as a tangible good for it is rarely, if ever, interpersonally comparable.

In conclusion, it has been shown that the ontological, enumerative and associative assumptions that (in combination) define the offered explanatory framework are, methodologically at least, internally valid. As these assumptions are somewhat tentative and open, the major contribution they make to the research area is as a bulwark against the premature closure of idea development in explaining technological innovation. While a number of general and specific contributions were identified, they all, in some manner and measure, provide support to an identified need within the research area. For although there is understanding within the research area that technological innovation can produce quite far-reaching and deep changes to socio-economic environments, there is still little understanding of how technological innovation is initiated and sustained (Knott, 2003; Rodan and Galunic, 2004; Hodgson and Knudsen, 2004). It is envisaged that the assumptions offered in this thesis will provide a more diverse and informative basis from which to establish greater understanding of technological innovation. Similarly, while a number of theoretical implications were identified, in the main, these implications concerned the need to question in-place theoretical ideas on technological innovation that have been derived from neoclassical socio-economic theory. While taking recourse in assumptions abducted from evolutionary theory offers no ‘guaranteed’ answers to this questioning, they do offer a plausible representation of technological innovation that satisfies rules of logic, which hopefully, will be expanded and detailed more thoroughly in subsequent research.

6.4 Implications for policy and management

The proposed explanatory framework (and its defining assumptions) has a number of implications for policy development and the practical management of technological innovation. This is not to suggest that such implications are unknown by those actually involved in technological innovation, for the contended 'plausibility' of the proposed framework is directly linked to its ability to explain the current 'realties' or experiences of the phenomenon (see Chapter Five). Given that policy-makers and managers operate within these 'realties', the intention is not to 'teach them how to suck eggs', but hopefully to expand their appreciation of these implications, and to suggest possible practical responses to such. As with previous sections the following material is general in nature, and focuses on implications pertaining to the establishment of environmental conditions conducive to technological innovation and the capturing of possibilities within such an environment.

In adopting an evolutionary perspective on technological innovation an appreciation of the centrality of *variation* is of utmost importance in both policy development and management practice. As material presented in the previous section suggests, within the explanatory framework offered in this thesis the notion of *variation* operates under many guises. The principle of *variation* is essentially an identifying description of the diversity of informational energy, however defined, that initiates, drives and sustains the overall process of technological innovation. As such, *variation* is a dominant condition, readily apparent in the diversity inherent within (and of) process aspects such as: the influence(s) of environmental stimuli; behavioural motivators; structural and/or functional

arrangements; learning approaches; and the interpretive meanings assigned to information. That *variation* is the defining characteristic of technological innovation is explicit in research showing that for the majority of organisations involved in the production and dissemination of technological innovations, their environments are characterised by on-going discontinuity, uncertainty, complexity, asymmetry and heterogeneity (Drazin and Schoonhoven, 1996; Nelson, 2003; Becker and Knudsen, 2005). Furthermore, there is a growing body of research arguing that far from being an impediment to technological innovation, such environmental conditions are necessary requirements for initiating and sustaining the process (de la Mothe and Paquet, 1996; Paulson, Slotnick and Sobel, 2002; Knott, 2003).

Perhaps the greatest implication of *variation* for policy development is a dispensing of the presumption that if an environment is made less uncertain, disorderly and disruptive through natural competitive pressures and/or sponsored artificial manipulation, the most efficient and effective solutions will come to the fore. Such a presumption underlies many policy recommendations and management practices and is apparent in their tendency to promote and employ ordered homogeneity in an attempt to reduce contextual uncertainty. A most obvious government policy example is the establishment of industry networks around a specific product base, and the tendency is also implicit in a tertiary education system designed around homogenised ‘specialist’ degrees. Within management practice, the tendency to utilise ordered homogeneity as an uncertainty reduction method is apparent in the emphasis on routine(s), explicitly exhibited in the continual application of the same planning approaches, and implicit in the on-going focus on the optimisation

of some objective organisational function. This is not to suggest that injecting some measure of order into environmental conditions is wrong *per se,* but rather to argue that its emphasis is based on false logic, for such broad scale homogenisation de-energises the technological innovation process. In fact, it is the central contention of the current thesis that the on-going resilience of technological innovation is ensured when environmental disruptions are present. As such, the implication for policy development and management practice is to ensure, in some manner and measure, diversity within (and of) environmental conditions so as to stimulate the necessity for technological innovation. Examples include: R&D subsidies/tax breaks for technological innovation activities outside the boundaries of that which would be normally undertaken; network development programs that stimulate the involvement of a diversity of product category organisations; decentralised organisational arrangements; and task swapping within organisations.

It is acknowledged that the application of routine policy recommendations and/or management practices is an appropriate efficiency mechanism for relatively 'ordered', and therefore relatively predictable environmental contexts. However, the blanket application of such a policy and/or management prescription is inappropriate in the majority of current technological contexts that are beset with high levels of complexity and uncertainty. Within such contexts the 'normative planning' approach to policy development and management decision-making is found wanting. It is difficult, if not impossible, to align action in the present to realise a 'planned' scenario envisaged in a future containing any number of indeterminate contextual conditions. At best, the future

is a ‘predictable unpredictability’, where general patterns may be seen, but specifics over the long run will not. Given such an indeterminate, and therefore somewhat unpredictable future, policy and management practice should place greater emphasis on developing *adaptability*. As discussed (Chapters Four and Five), the central theme of *adaptability* is encapsulated within the depiction of ‘evolutionary selection’ as a number of mechanisms that alter the relative importance of socio-economic aspects, as distinct from the (neo)classical depiction of such mechanisms as ‘selecting’ a particular aspect. The former depiction promotes the need for a broad range of ‘adaptable flexibility’ to sustain on-going resilience, the latter merely an ability to make a single adaptation to ensure immediate survival. The importance that policy and management practice must attach to *adaptability* is readily apparent in research showing that within environments beset with uncertainty, competitive advantage is built and renewed through an ability to develop multiple (and often inconsistent) industrial arrangements, organisational types, strategic directions, learning approaches and competencies simultaneously (Anderson and Tushman, 1990; Lakshmann and Okumura, 1995; Hodgson, 2001). The importance of *adaptability* with respect to the technological innovation itself is also canvassed within the literature (Gerwin and Barrowman, 2002; Ethiraj and Levinthal, 2004), and is based on the premise that the market ‘selects’ a technology system, not a specific technological innovation, and therefore resilient innovations are those that are adaptable to reconfigurations of that system.

At a broad policy and management level, such *adaptability* is stimulated and enhanced by an expansionist, as distinct from an isolationist mindset. At one level, such a mindset is

required to appreciate the wide range of dependent and interdependent relationships that not only provide the structural and/or functional organisational arrangements of the technological innovation process, but also to 'see' those relationships that the innovation itself may have with the broader technological system. Furthermore, such a mindset is at least attuned to the unknown or 'untraded interdependencies', as well as the positive and/or negative feedbacks that influence path dependency within a technological innovation system. On another level, such a mindset is a necessary perception mechanism to 'understand' that constant exposure to this multitude of heterogeneous characteristics and conditions enhances *adaptability*, not just with respect to solving future technological problems, but more importantly, posing them. Specifically, policy recommendations and management practice should be directed at those qualities that underpin long run performance, as distinct from the maximising of current competencies. Such qualities include: increasing learning rates; pooling resources; promoting risk-taking; accepting failure; establishing good internal and external information flows; and displaying a willingness to take on novel ideas. Within the context of technological innovations themselves, policy and management focus should emphasise the exploration of architectural (ie. design) level information and the development of core design concept(s) understanding.

In conclusion, the process of technological innovation, whether in theory or practice, is neither atomistic, reductionist, deterministic, gradualistic or mechanistic. It requires a mix of structural and functional arrangements, is interlinked through multiple layers of complexity, is never at rest, displays jerky, jumpy spontaneity, and therefore tends

towards irregularity. Given these process aspects of technological innovation, the central implication for policy and management practice is one of mutual duality, the enhancement of environment contextual diversity so as to stimulate the opportunities for technological innovation discoveries, and the development of flexible capabilities such that these opportunities can be identified and captured.

6.5 Possibilities for future research

Explanations are, by design, open and abstract with the aim of reflecting upon, and hopefully making some comprehensible sense of the pattern(s) believed to underlie the phenomenon under investigation. As such, explanations are not ‘mirrors of reality’, but rather act as ‘catechumens’, offering elementary principles and associated assumptions as ‘as if’ descriptions of the general mechanisms, structural and/or functional arrangements, and contingent conditions of said phenomenon. As explanations are generalised in nature, and incorporate inherent partiality due to the non-inclusion of all influencing aspects, they also function as a support service by stimulating and guiding research inquiry.

Within the socio-economic literature there is a growing call for more input from other disciplinary areas, and in particular, the utilisation of evolutionary theory as a platform for developing a better understanding of socio-economic phenomena (Odagiri, 1997; Nelson, 2003; Flemming and Sorenson, 2004; Becker and Knudsen, 2005). Such a call however, seems in many cases to be based on the presumption that a single, coherent theoretical understanding of ‘evolution’ is available. This is not the case, for evolutionary

theory is essentially a collection of conceptual models, and while there is some similarity within these models, there is enough difference to suggest that the conception of evolutionary progression is a somewhat open field of inquiry. As discussed, while there is an acceptance that the principles of ‘variation’, ‘selection’ and ‘preservation’ are sacrosanct characteristic conditions of evolution, how these conditions fit together to provide the impetus and fuel for evolutionary processes is subject to continuing debate. Given this debate, it seems logical to suggest that studies examining these broad conditional aspects of evolution are relevant and timely research endeavours.

As the current thesis is essentially concerned with theoretical conjecture (though framed within an explanatory framework of technological innovation), it gives rise to a number of research questions, particularly with respect to many of the assumptions that provide a structure to this framework. Some of the specific assumptions open to further research include;

- Is the ontological status of technological systems open and dissipative?
- Is there a hierarchical nature to technological innovation systems?
- If hierarchies do exist in technological innovation systems are they conceptually similar in that all are conditioned by the principles of evolution?
- Is an uncertain and disruptive environmental context an inducement or impediment to technological innovation?
- Is cooperation or competition dominant within technological innovation systems?
- If cooperation is dominant, how deep or strong is organisational relational embeddness within technological innovation systems?
- Is path dependency a major influence on the direction of technological innovation systems?
- Is learning within technological innovation systems a case of ‘replication’, ‘reproduction’ and ‘renewal’ processes?

As suggested, the explanatory framework offered in the current thesis should be considered essentially as a tool, hopefully helping to expand understanding of the technological innovation process. It has been argued that the framework, and the theory of evolution on which it is based, provides a more 'realistic' appreciation of this process than those currently dominating mainstream marketing. However, the determination of whether or not this particular explanatory framework for technological innovation research is 'better' than alternative approaches requires further theoretical and empirical development.

6.6 Conclusion

This thesis has detailed the development of a proposed framework for explaining technological innovation based on a particular conceptualisation of the process of evolution. It is the central argument of this thesis that evolutionary theory provides a 'good' explanatory framework for examining this phenomenon. Furthermore, the framework offered in the current thesis is considered to be a more plausible explanation of technological innovation than those current used within mainstream marketing. Such a consideration is based on the belief that technological innovation is collective human behaviour, and as such, cannot be encapsulated within the dogmatic generalities of atomism, reductionism, determinism, gradualism and mechanism. People are not machines. They are part of nature, and therefore, are both subjugated by and influential to its purpose, and this purpose is the promotion and prolongation of diversity. This diversity in Nature, irrespective of definition or context, is not the operational consequence of some giant machine, and therefore cannot be explained through

immutable laws. Such a view is central in Darwin's initial foray into biological processes, and in particular, evolution, for his concluding comment in *The Origin of Species By Means of Natural Selection* is that;

> There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed laws of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved (Darwin, 1859:459-460).

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