PROJECT RADICALNESS AND MATURITY: A CONTINGENCY MODEL FOR THE IMPORTANCE OF ENABLERS OF TECHNOLOGICAL INNOVATION

by

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DECLARATION

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously, in its entirety or in part, submitted it at any university for a degree.

Signature: ……………………………………..

Date: ………………………..

SYNOPSIS

The main proposition of this study is that the notion of a single set of universal success factors (enablers) of innovation is naïve. Rather, the importances of different enablers are contextually based and dependent upon different kinds of projects and their attributes. By investigating the roles of project radicalness and maturity in governing the importance of enablers of innovation in the process industries, two major conclusions were made, viz. (1) the importance of enablers are significantly moderated by project attributes, and (2) the mutual interactions between moderators of enabler importance prevent the formulation of middle-range theories of innovation radicalness or maturity, which propose normative relationships between innovation attributes and enabler importance. Although a number of previous studies have posited such outcomes, this study provides empirical evidence thereof for a set of generic enablers of innovation.

These findings have suggested that the modelling of innovation at the project level should follow a contingent approach. While contingency theory has widely been applied to correlate structural and environmental attributes when the unit of analysis is the organisation, the literature on project management has largely ignored the importance of project contingencies, assuming that all projects share a universal set of managerial characteristics. This void is addressed through the development of a contingency model of the influence of secondary contingencies (project radicalness and maturity) on the importance of enablers. It represents an integrative perspective of the contextual importance of a number of enablers (and constructs thereof) that have previously been investigated and reported independently.

Given that theory development in project management is still in its early years, it may therefore be concluded that the study contributes to the validity of classical contingency theory arguments in the context of the project. Although it does not consider an exhaustive list of all possible contingencies, and findings thereof strictly pertain only to process innovation, it does represent a considerable step in the evolving process of theory development on the modelling of innovation at the project level.

OPSOMMING

Die studie poneer in hoofsaak dat die idee van ‘n enkele stel universele suksesfaktore (drywers) vir innovasie, eng is. Dit word eerder voorgestel dat die belangrikheid van verskillende drywers kontekstueel is en bepaal word deur verskillende tipes projekte en hul eienskappe. Na gelang van ‘n ondersoek na die rolle van projek radikaalheid en stadium van ontwikkeling in die bepaling van die belangrikheid van drywers van innovasie, is twee hoofgevolgtrekkings gemaak, naamlik dat (1) projekeienskappe ‘n beduidende invloed op die relatiewe belangrikheid van drywers het, en (2) die onderlinge interaksies tussen moderators van die belangrikheid van drywers dit verhoed om middel-omvang teorieë van innovasie radikaalheid of stadium van ontwikkeling te formuleer, wat normatiewe verhoudings tussen die eienskappe van innovasies en hul drywers voorstel. Alhoewel sulke resultate deur ‘n aantal vorige studies gepostuleer is, verskaf hierdie studie empiriese bewyse daarvan in terme van ‘n generiese stel drywers van innovasie.

Bevindinge in hierdie verband het getoon dat innovasie op die projek-vlak deur ‘n voorwaardelikheidsmodel gemodelleer moet word. Alhoewel voorwaardelikheidsteorie algemeen gebruik word om strukturele en omgewingseienskappe op organisatoriese vlak te korrelleer, het die projekbestuur-literatuur tot dusver grootliks die belangrikheid van projekvoorwaardelikhede geïgnoreer deur aan te neem dat alle projekte ‘n universele stel bestuurseienskappe deel. Hierdie leemte word geadresseer deur die ontwikkeling van ‘n voorwaardelikheidsmodel vir die invloed van sekondêre voorwaardelikhede (projek radikaalheid en stadium van ontwikkeling) op die belangrikheid van drywers. Dit verteenwoordig ‘n geïntegreerde perspektief van die kontekstuele belangrikheid van ‘n aantal drywers (en konstrukte daarvan) wat voorheen onafhanklik nagevors en gepubliseer is.

Aangesien teorie ontwikkeling in projekbestuur steeds jonk is, word die gevolgtrekking gemaak dat die studie bydra tot die geldigheid van klassieke voorwaardelikheidsteorie-argumente in die konteks van die projek. Alhoewel dit nie ‘n veelomvattende lys van alle moontlike voorwaardelikhede beskou nie, en die bevindinge daarvan streng gesproke slegs betrekking het op proses-innovasie, verteenwoordig die studie ‘n beduidende stap vorentoe vir teorie-ontwikkeling in die modellering van innovasie op die projek-vlak.

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- Finally, but most importantly, the Lord, for giving me the opportunity to do this work; and his almighty presence and guidance in my everyday life – without Him, I would be capable of nothing.

DEDICATION

This dissertation is dedicated to my best friend, André, and his family. *Dankie vir jou en jou familie se liefde, vriendskap en ondersteuning deur die afgelope nege jaar, André. Ek waardeer dit opreg.*

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CHAPTER 1

Introduction

"Twenty-five years of research into why new products succeed, why they fail and what distinguishes winning businesses, and are we further ahead? Some pundits say no! So what's the problem? Surely after myriad studies into NPD [New Product Development]*, almost every product developer should be able to list the 10 or 15 critical success factors that make the difference between winning and losing. …Anyone introduced to new product management since 1980 should be as familiar with the critical success factors as a school child is with the ABCs. But we still make the same mistakes."*

- Cooper (1999)

Cooper provides two explanations for this statement. The first is that the success factors are "invisible" – that they are not found in typical business practices. The other is that researchers are guilty of "missing the boat" – focusing on the wrong problems, communicating poorly, or not making the success factors as visible as possible. While these explanations are plausible, it is the contention of this study that this phenomenon may largely be ascribed to researchers' neglect in taking into account the contextual nature of these factors.

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1.1 THE CONTEXTUAL IMPORTANCE OF SUCCESS FACTORS

Many researchers still cling to the notion that a universalistic theory of innovation can be applied to all types of innovation, neglecting the fundamental differences that exist between projects of different types and attributes. Shenhar et al. (2002), for example, argue that *"…to date, little attention has been given to the project's type and its relation to strategic and managerial variables".* As a result, NPD and innovation managers are being bombarded by a plethora of factors deemed critical for success, while little attention is given to the context(s) in which these factors are valid: as stated by Balachandra & Friar (1997): *"… several of the critical factors identified by these studies are contextual. The contexts determine the appearance and non-appearance of some critical factors. Varying contexts also cause the somewhat contradictory nature of some of the factors."*

Such arguments point to the fact that strategic and contextual variables should receive greater emphasis in the research and management of innovation. This will not only reduce the number of factors critical to a particular strategic *posture* or *orientation*[1], but also improve theory development and accuracy by taking into account different *contingencies* relevant to these orientations.

Organisations adopt and evolve different innovation orientations or strategies to develop relatively stable and enduring patterns of behaviour and distinctive competencies – also termed technological trajectories (Pavitt, 1990) – in the quest to achieve optimal adaptation to their environments. However, not all innovation orientations are appropriate for a given environment. In an analysis of performance tendencies of Miles and Snow's (1978) innovative types, Hambrick (1983) showed that different strategies are associated with different levels of performance, depending on the nature of the environment. Thus, the question arises as to which innovation orientation is most suited to a specific environmental condition. Or, in layman's terms, which types of innovation should be pursued in order to best support an organisation's strategy.

Past research on organisational innovation has typically addressed this issue via *structural characteristics* of organisations by employing the classical distinction between mechanistic and organic organisations (Burns & Stalker, 1961). In this regard, theorists have posited that mechanistic structures do not facilitate (radical) innovation and hence predominate in stable and certain environments, whereas organic structures are presumed to be innovative and therefore are better able to cope with uncertain and complex environments. Upon this premise, a number of structural theories of innovation have emerged, based on bi-polar distinctions between different dimensions (also termed "attributes") of innovation, such as that between radical and incremental[2]. Given such correlates between attributes of innovation and organisational structure, innovation orientations most congruent with the environment are predicted.

However, having established which types of innovation should be dominant in a particular context, another question arises: what are the factors that drive and support

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[1] Strategic orientation refers to how an organisation uses strategy to adapt to aspects of its environment for a more favourable alignment (Manu & Sriram, 1996).
[2] For an excellent review of these models, consult Damanpour & Gopalakrishnan (1998).

these types of innovation and are the importances of these factors contingent upon different dimensions of the innovation being pursued? This question is very actual and is supported by a number of statements made in relation to the conditionality of success factors underlying innovation, most notably the following: *“These hypotheses suggest that even if there were a universal set of factors for predicting the success of a new product or an R&D project, the relative importance for the factors would be different depending on the contextual nature of the project”* (Veryzer, 1998). This study will investigate the validity of this proposition.

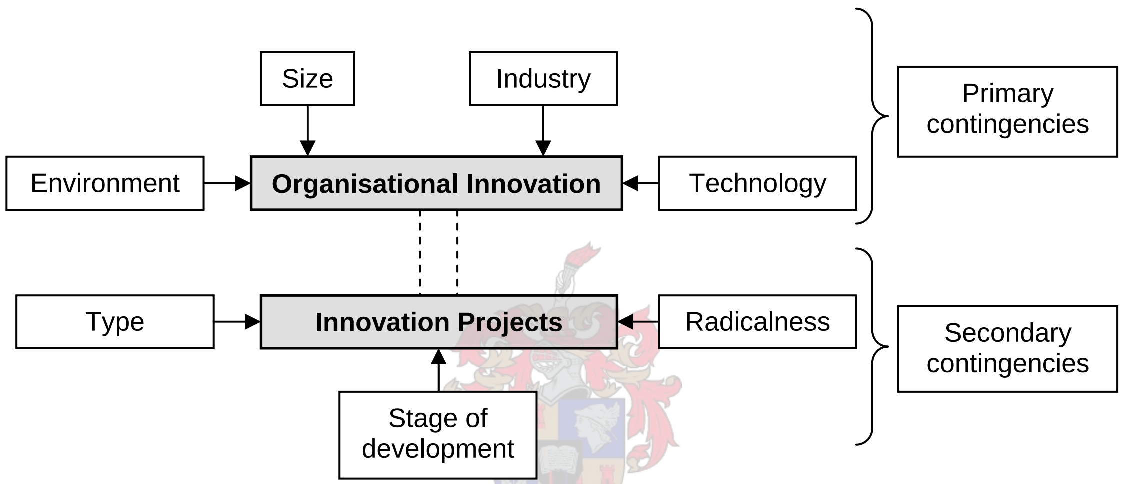

Figure 1.1 Damanpour’s (1991) distinction between primary and secondary contingencies

Based upon the work of Damanpour & Gopalakrishnan (1998), which arguably represents the most accurate model of structure-innovation relationship to date, three attributes of innovation may moderate the importance of these factors. Damanpour (1991) defines such attributes as “secondary contingencies” or intermediate variables between primary contingencies and organisational characteristics, as illustrated in Figure 1.1. They are: (1) *types of innovation* (technical vs. administrative), (2) *radicalness of the innovation* (radical vs. incremental), and (3) *stages of the innovation process* (initiation vs. implementation). The following section discusses the relevance of these moderators in the context of this study and supplies a number of definitions for terms and concepts used therein.

1.2 SCOPE OF THE STUDY AND DEFINITIONS

Given the multiple meanings associated with the concept of "innovation", it is important that it be defined in the context of this study, prior to any further discussion. According to Tidd et al. (1997), innovation may be defined as *"a process[3] of turning opportunity into new ideas and putting these into widely used practice".* Hence, innovation is not only invention, but also the successful exploitation thereof.

In general, two broad types of innovation may be discerned, viz. technical and administrative innovations. Technical (or technological) innovations are associated with the technical core of the organisation and pertain to products, services and production process technologies, i.e. the primary work activities of the organisation. Administrative innovations, on the other hand, are associated with the social system of the organisation and involve organisational structure and administrative processes, i.e. they are indirectly related to the primary work activity of the organisation and more directly related to its management (Daft, 1978).

As intoned in the above definition thereof, it may further be sub-classified into product and process innovations. Product and process innovations are distinguished on the basis of the different areas and activities that each of them affect within the organisation. Product innovations are new outputs or services that are introduced for the benefit of customers or clients. On the other hand, process innovations are new tools, devices and knowledge in throughput technology that mediate between inputs and outputs (Utterback & Abernathy, 1975). Process innovations typically improve the efficiency of creating or establishing the product or service, but they may also add value to the customer, such as through improved quality and reliability.

In the context of this study, the term *innovation* specifically refers to technological process innovations[4], which is largely an artefact of the industry in which the study was performed, namely the Chemicals and Minerals & Mining Industries – process

[3] In the context of this study, it is important that innovation is seen as a process, i.e. a *set of activities* related to taking an idea to its final form.
[4] Note the distinction between "process innovations" – as described here – and the process of innovation, which encompasses the set of activities in bringing an idea to commercialisation.

industries[5]. In these industries, process innovation is typically manifested (or becomes tangible) in the quality or performance of a product. Often, product innovation is impossible without process innovation.

Given this distinction between product and process innovation, it is necessary to note the subtle difference between implications of the terms “innovation” and “NPD”. According to the PDMA[6] glossary, NPD may be defined as *“the overall process of strategy, organisation, concept generation, product and marketing plan creation and evaluation, and commercialisation of a new product."* Hence, in the strictest sense, the term NPD only applies to product innovation. On the other hand, the term “innovation” encompasses all types of innovation. However, given the fact that new product development (i.e. product innovation) and process innovation share a set of core principles, findings presented in terms of NPD are assumed to be valid for innovation in general and hence also process innovation[7].

The remaining *secondary moderators* of innovation relate to the radicalness of the innovation and its stage of development. In empirical research, radicalness is typically collapsed into the terms “radical” and “incremental”. Dewar & Dutton (1986) define radical innovation as fundamental changes that represent revolutionary changes in technology – they represent clear departures from existing practices. In contrast, incremental innovations are minor improvements or adjustments in existing technology. In essence, the difference between radical and incremental innovation lies in the (perceived) degree of novel technological process content embodied in the innovation and hence, the degree of new knowledge embedded in the innovation. The PDMA defines this difference in terms of the degree of behaviour change or change in consumption.

Finally, it is necessary to define the concept of “stage of development”. The PDMA defines the term “product development process” as *“a disciplined and defined set of tasks, steps, and phases that describe the normal means by which a company*

[5] In Chapter 4, the scope of the study is discussed in greater detail. This has significant implications for defining the constraints within which the results of this dissertation are generalisable to (1) other types of innovation, and (2) innovation in other industries.
[6] Product Development & Management Association – www.pdma.org
[7] This is an important assumption, given the fact that studies on innovation generally relate to product development; findings specifically pertaining to process innovation are far less ubiquitous.

repetitively converts embryonic ideas into saleable products or services". Therefore it is evident that "stage of development" refers to the maturity of the project in its development life cycle[8] – hence the term "maturity" in the title of the study. As suggested by the ambidextrous theory of innovation (Duncan, 1976), project maturity may be dichotomised in "initiation" and "implementation". Although this distinction typically relates to the adoption of innovations, it may also be applied to the generation thereof. In this regard, the distinction between invention and innovation may be helpful. According to Twiss (1974), invention represents the end-point of research, whereas innovation (which follows invention) is the end of successful development – based on this distinction, initiation may be defined as relating to ideation, feasibility study and the bringing about of a workable concept or prototype, whereas implementation refers to the bringing of this concept into useful application through execution, start-up and operation thereof[9].

Having defined the core concepts employed in the study, the objectives thereof are highlighted in the following section. In this discussion, the specific aims of each chapter, and how these relate to one another, are discussed with reference to Figure 1.2.

1.3 OBJECTIVES OF THE STUDY

The primary objective of this study relates to the development of a contingency model for the importance of enablers (success factors)[10] of technological innovation at the project level. Shenhar (2001) argues that, while contingency theory has (widely) been applied to correlate structural and environmental attributes at an organisational level of analysis, this is not so at the project level, stating that *"the project management literature has often ignored the importance of project contingencies, assuming that all projects share a universal set of managerial characteristics".* Based on this, he suggests that research be undertaken to establish the validity of contingencies in projects and to further explore the

[8] Note the distinction between "project life cycle" and "product life cycle", which refers to the four stages that a new product is thought to go through from birth to death: introduction, growth, maturity, and decline.
[9] As a convention in this study, the term *maturity* will refer to the distinction between initiation and implementation, whereas the term *stage* will denote any stage of product development as defined, for example, in a stage gate model. This aspect is discussed in detail in Chapter 4.
[10] The relationship between the terms "enablers" and "critical success factors" is elucidated in the following chapter.

“one-size-does-not-fit-all” paradigm. Although this study does not consider an exhaustive of all possible moderators (or contingencies), it represents a considerable step in the evolving process of theory building on innovation management at the project level.

Based on Damanpour & Gopalakrishnan’s (1998) model of structure-innovation relationships, this study considers the roles of project radicalness and maturity as moderators of the importance of success factors of innovation. The investigation of the role of project radicalness is warranted, given that Damanpour & Gopalakrishnan argue that *“empirical research that distinguishes between predictors of radical and incremental innovation is scarce and a dominant theory has yet to emerge”.* This is reflected in the vague or even contradictory research findings in the literature regarding project radicalness as a moderator, as will be elucidated in Chapter 3.

Consideration of the role of project maturity is further warranted in light of the fact that the only prominent theory that considers the role of *stage of development* in the product development process (the ambidextrous theory of innovation) relates not to the generation of innovations, but the adoption thereof. Given the importance of the creation of new knowledge within the organisation for achieving competitive advantage, development of a maturity-related model for the importance of success factors for the generation of innovation is justified. This, coupled with a model of project radicalness, holds significant implications for the management of projects within the product development portfolio of an organisation.

As illustrated by Figure 1.2, development of the contingency model is based primarily on (the outcomes of) a set of hypotheses in Appendix 3 regarding the effects of these moderators on the importance of enablers of innovation. Such hypotheses are derived from two bases of knowledge:

1. A literature survey of all relevant findings pertaining to the relative importance of enablers in different contexts and for different attributes of a project.
2. Results of a multi-firm *exploratory study* on the relative importance of enablers in specific functional environments of organisations, specifically R&D, Engineering and Production. Based on knowledge regarding these environments’ propensities for radical and incremental innovation, as well as their involvement during stages of NPD, inferences are made regarding the roles of project radicalness and

maturity as moderators of enabler importance. Since results in this regard are not in essence related to the core theme of the study, but are only used in the formulation of hypotheses, the research methodology and results associated with this study are supplied in Appendices A1 – A4.

Chapter 2 presents a brief survey of the relevant literature on organisational innovation for the purpose of selecting a set of critical success factors to represent the scope of the study, after which the research methodology in evaluating these hypotheses is discussed in Chapter 4. Chapter 5 presents the results of empirical testing of these hypotheses and evaluate these against original hypotheses formed.

Based on conclusions in this regard, Chapters 6 and 7 discuss the development of a contingency model of enabler importance. In particular, three key issues are considered, namely (1) the role of the distinction between equivocality and uncertainty in characterising the importance of enablers in terms of project radicalness and maturity, (2) the interactions between these moderators of enabler importance, and (3) the implications of the model for managers of innovation, and the innovation literature.

In summary, it has been shown how knowledge gained from an extensive literature survey of innovation management, as well as an exploratory survey of the relative importance of enablers in functional environments, lead to the development of a set of hypotheses regarding the moderated importance of enablers of innovation. Based on the empirical validation of these, a contingency model for the importance of enablers of innovation is suggested. Chapter 2 takes the first step towards this by defining the scope of variables to be investigated in this study.

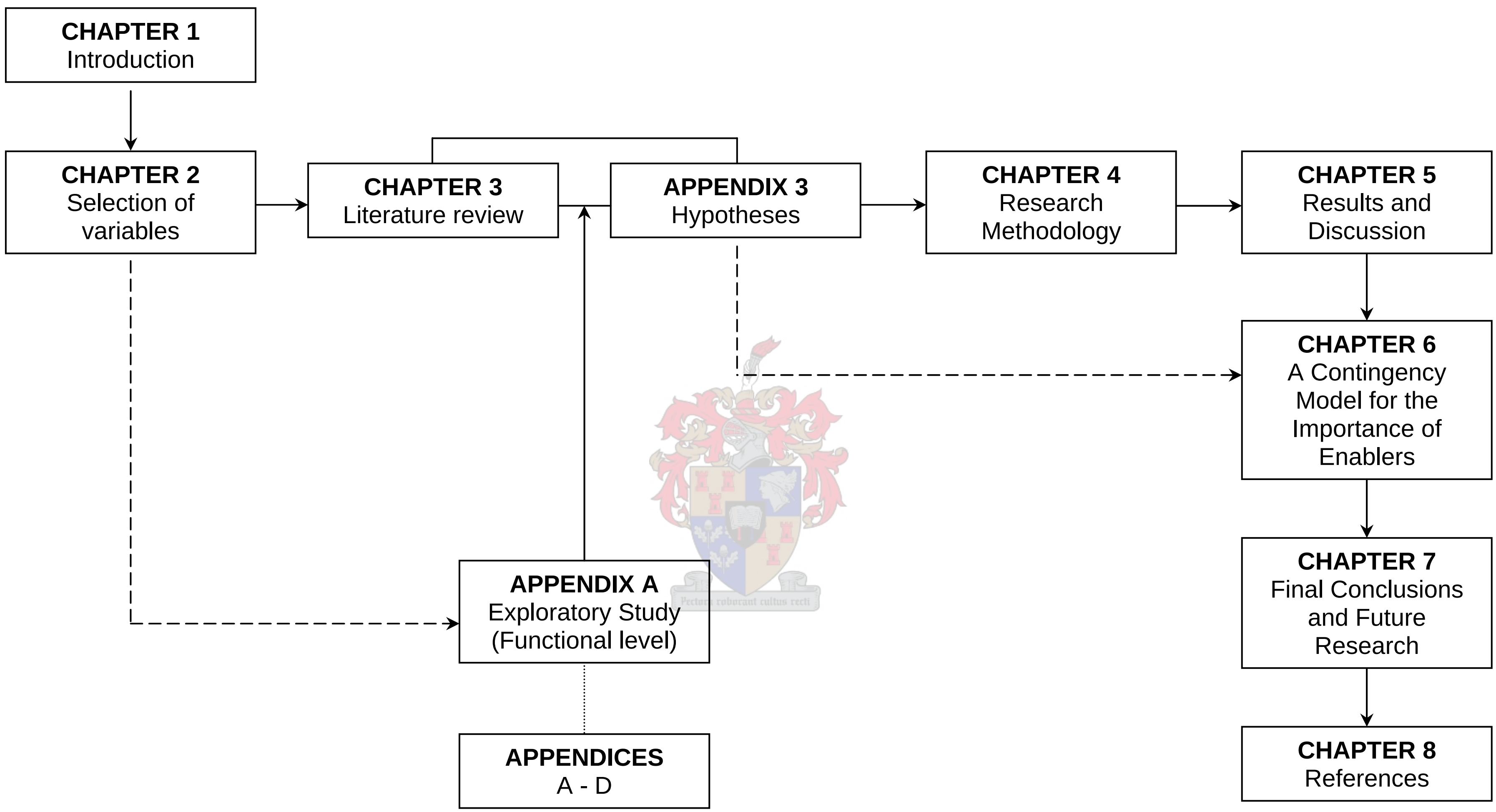

Figure 1.2 Map of the Study

CHAPTER 2

Literature Review: Selection of Variables

2.1 INTRODUCTION

Before an analysis of the relative importance of enablers can be attempted, it is important to identify all such factors relevant to innovation success from the literature, gleaned either from case studies, anecdotal material, management opinion or rigorous empirical studies. This will not only set the scope of variables under investigation, but will also lead to the development of a conceptual framework in which the major constructs of individual variables may be evaluated. In this vein, the purpose of the next section is to (1) introduce the concept of an "enabler", and (2) present the results obtained from an exhaustive study of the literature on factors enabling success in innovation.

2.2 ENABLERS OF INNOVATION

Since the mid-1950s, both academia and practitioners have investigated the factors leading to the success and failure of NPD (Jensen & Harmsen, 2001). It is said that more than two hundred such studies have been conducted in various industries and geographical settings and by different functional disciplines, ranging from marketing, organisational behaviour and engineering to operations management (Montoya-Weiss & Calantone, 1994). Some of these studies have taken a broad approach toward investigating new product success and failure factors, whereas others have focused on specific factors. For the purpose of this section, attention is limited to studies of the former type – these studies have an added advantage over *monadic* studies (focusing on a single perspective) in that they capture the general similarities between individual factors, while highlighting the distinct differences between key themes.

The success factors underlying innovation, as reported in these studies, are generally based upon or derived from one of the following:

1. *Empirical studies*, employing some form of statistical analysis to arrive at a number of success factors. Such studies typically relate a set of measures or proposed success factors to a pre-determined set of performance metrics (such as percent sales, profitability relative to spending, etc.) in order to determine whether the measures actually "predict" success. In this vein, the identified factors are called *success factors*, since they can directly be linked to success (or performance) at the business level.
2. *Theoretical models and conceptualisations* of innovation or their attributes, typically from an auditing perspective (Chapman et al., 2001; Tang, 1998; Chiesa et al., 1998). Such studies rely on logic and analytical reasoning and inference to arrive at a set of factors necessary for innovation, based upon the suggested model and its assumptions[1].
3. *Experience* – real-life accounts of how various factors have driven innovation in organisations. Such studies provide valuable anecdotal evidence of how various factors or measures have improved or radically changed innovative cultures within organisations. In this case, and also in the case of theoretical models, the factors identified are not explicitly linked to success at some level, but should rather be interpreted as possible drivers or enablers that need to be in place in order to foster innovation. In light of this difference, this study adopts the collective term of *enablers* for all such factors identified as relating to innovative success, irrespective of the basis from which they were derived or hypothesised[2].

In practice, all of these studies point to a relatively consistent, though expansive, list of enablers. The following section aims to provide a synthesis of the most prominent enablers identified from these divergent sources. A major difficulty in synthesising such a list is the lack of a comprehensive framework for classification of enablers in the literature, since any framework, to a large extent, dictates or influences the context in which a given enabler is interpreted. Such frameworks range from being based upon *key themes* derived from factor analysis (Cooper & Kleinschmidt, 1995; Craig & Hart, 1992),

[1] In essence, the difference between points 1 and 2 lies in the fact that empirical studies identify the structure of relationships between enablers through statistical analysis of data (typically factor or cluster analysis), whereas these relationships are pre-defined in the case of models or conceptualisations.
[2] The PDMA glossary defines critical success factors as *"those factors that are necessary for, but don't guarantee, commercial success"*. In light of this, the term enabler is very apt.

process models of the innovation process (Chiesa et al., 1996; Johne & Snelson, 1988) and competence perspectives such as the knowledge-based view of the organisation (Leonard-Barton, 1992). To date, the most comprehensive framework provided in the literature is that of Jensen & Harmsen (2001), which coalesces the six key themes of Craig & Hart (1992) with the four knowledge dimensions of Leonard-Barton (1992). Since this framework is compatible with both the *traditional* classifications of enablers (most notably that of Cooper & Kleinschmidt (1995)), and the more modern and popular competence perspective (Prahalad & Hamel, 1990), it is adopted for the purposes of presentation of enablers in this study.

From the perspective of Craig & Hart (1992), enablers of innovation may be classified under six key and two major themes (Figure 2.1):

- *Strategic themes*
    - Management
    - Company characteristics
    - Strategy
- *Project themes*
    - Information
    - Process
    - Individual[3]

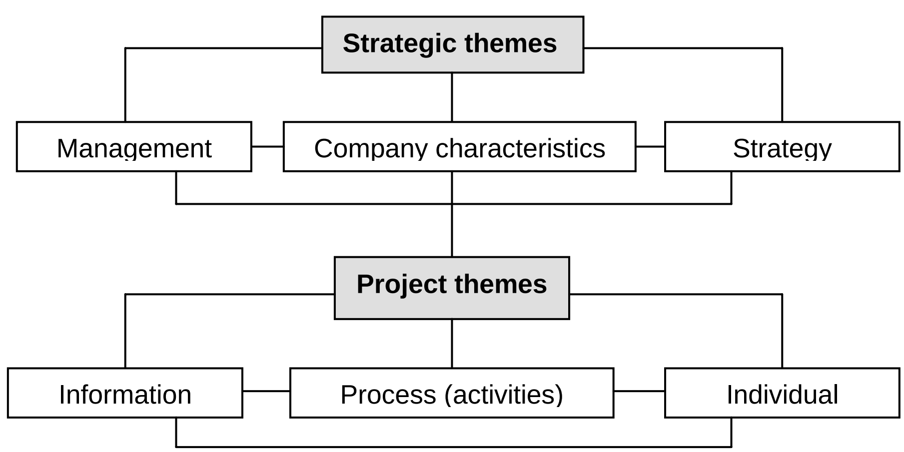

Figure 2.1 Strategic and project themes of enablers – adopted from Craig & Hart (1992)

[3] Craig & Hart (1992) define this theme as “people”-centric. However, given that it relates specifically to the role of the individual, it is designated as “individual”-centric in the context of this study. This designation is of significant importance for Chapters 5 and 6.

2.2.1 Management-related enablers

Tushman & Nadler (1986) define management's role in innovation as one of *envisioning*, *enabling* and *energising* the innovation program. Each of these dimensions relate to a different function/role to be played by management.

1. By envisioning, management provides *leadership* to employees. This does not take the form of direct hands-on control over projects, but rather a subtle control over projects by setting broad goals for innovation, inculcating an acceptance of change within the organisation (Johne & Snelson, 1988) and sending clear messages about the role and importance of new product development (Cooper & Kleinschmidt, 1995). Zien & Buckler (1997) equate the leadership role of top management to sustaining faith and treasuring identity as an innovative company amongst employees; they relate how corporate storytelling provides a valuable means of doing this.
2. By enabling, management shows their *commitment* to innovation by becoming *involved* in innovative activities, when necessary. This role is fulfilled by ensuring availability of funds (*capital*) and resources for product development and ease of access to senior management in the case of difficulties or for major new product decisions (Cooper & Kleinschmidt, 1995).
3. By energising, management promotes an innovative *culture* within the organisation by setting the necessary *climate* conducive to innovation. This is established by means of:
    - Providing support in terms of *recognition*, *rewards* and autonomy (White, 1996);
    - Fostering an openness and interchange between functions to enhance *creativity* through *diversity* of perspectives (Johne & Snelson, 1988);
    - Treating *failures* as opportunities for learning and *sharing of experiences*, not occasions for punishment (Nicholson, 1998);
    - Creating a supportive environment in which *risk-taking* and *experimentation* is encouraged (Booz-Allen & Hamilton, 1982; Roberts & Fusfeld, 1981). For example, 3M allows employees to explore and try new ideas outside of their assigned responsibilities for 15% of their work time – this rule exists entirely in the company's lore, as part of its culture (Nicholson, 1998).

2.2.2 Enablers related to company characteristics

Numerous studies concur that good organisational design is strongly associated with innovation success (Montoya-Weiss & Calantone, 1994; Peters, 1987). Based on the findings of an empirical study relating organisational structure and style to new product development success, Bentley (1990) cites the following three company characteristics as the most important factors associated with high performance[4]:

1. Use of integrative mechanisms,
2. Availability and use of good communications systems, and
3. Suitable systems of control.

These factors, and many other so-called *structural variables*, may be grouped under two major constructs (Damanpour & Gopalakrishnan, 1998): *organisational complexity* and *bureaucratic control*. Organisational complexity is embodied in specialisation, functional differentiation and professionalism (thus, relating to factors 1 and 2 above), whereas bureaucratic control is embodied in formalisation, centralisation and vertical differentiation (thus, relating to factor 3 above).

Team-based structures, where responsibility for coordination and decision-making are decentralised and shared among members of the development team, have become increasingly popular in new product development (Olson et al., 1995). In light of this, modern management literature in the field of innovation has addressed the issues of organisational complexity and bureaucratic control in terms of *cross-functionality* and *team autonomy*, respectively. Cross-functionality refers to the integration and coordination of different specialities and functional groups of the organisation (i.e. those factors associated with organisational complexity) in the context of the product development team. In this regard, research has focused on two key areas, namely (1) *cross-functional responsibility and interfaces between departments and (2) attributes of cross-functional teams*[5].

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[4] A fourth factor associated with high performance is also cited by Bentley (1990), namely the *existence of individuals who can take broad perspectives, solve problems and cope with risks.* Since this factor relates more to the key theme of *People* in the context of this study, it is not included here.

[5] Craig & Hart (1992) classify functional coordination and integration as a people-related enabler. However, in the context of this study, cross-functional integration relates more specifically to how

Innovation, by its very complex nature, requires the cooperation and coordination of various functional groups in the organisation. Souder (1981) has shown that 68% of projects suffering from ineffective Marketing-R&D relationships result in commercial failures, whereas only 19% of projects with effective Marketing-R&D relationships do so. Gupta & Wilemon (1990) relate how 40% of their interviewees suggest that the greater involvement of R&D, Marketing, Engineering and Manufacturing early in the development process would accelerate the NPD process. This problem is not easily solved, since between 44% and 45% of respondents rate the management of the Manufacturing/Marketing and Marketing/R&D interfaces as *very difficult* to accomplish. Through mechanisms such as job rotation or co-location of multi-functional teams, improved communications and trust between functions is established, thereby also improving NPD cycle time and performance.

Cooper (1999) identifies *true* cross-functional project teams as one of the 8 most important actionable critical success factors for innovation. He defines such teams as having the following characteristics:

- Being comprised of members from various functions and with *complementary skills,* from the beginning of the project. In this way, joint ownership of the project is established among all relevant role players.
- Each member having an equal stake in the project – avoiding the situation where the team leader from one function dictates to members from other functions.
- An assigned group of team members, each of whom are sure about their role in the team and *accountable* for the entire duration of the project
- Having a dedicated (not involved in many other projects) team leader, who is held responsible for the project's success[6].
- Enjoying genuine *commitment of resources* to the team by management – functional bosses give defined release time to team members and are not allowed to renege on such resource commitments.

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the organisation is structured for innovation, and hence is treated as an enabler related to company characteristics.

[6] In his earlier work with Kleinschmidt (Cooper & Kleinschmidt, 1996), Cooper makes a distinction between *cross-functional* and *high-quality* teams, stating that high-quality teams have a more significant impact on new product performance than cross-functional teams. Having a dedicated project leader was one of the characteristics of such a high-quality team. It seems that Cooper's modern concept of a *true cross-functional team* coalesces the characteristics of the teams distinguished earlier.

Team autonomy, on the other hand, relates to the degree to which bureaucratic meddling and micro-management by top management is limited in the team, i.e. the degree to which decision-making is decentralised to the level of the team and its leader. Olson et al. (1995) describes the ultimate autonomous team, termed a *design team*, as one that has great authority to choose its own internal leader(s), establish its own operating procedures and resolve conflicts through consensual group processes.

Kessler & Chakrabarti (1999) argues that autonomous teams have the ability to speed up new product development because it increases workers' involvement, awareness and commitment to a project, provides a buffer against excess outside interference and limits the amount of bureaucratic approvals needed. From a psychological perspective, Kiella & Golhar (1997) argue that the unique cultural code of researchers necessitate the concept of autonomous teams. Since this culture is portrayed by a tendency to discipline-related isolation and a general disinterest in, or scepticism of, conventional management, decision-making must be decentralised to the team.

Apart from the use of interfunctional integration mechanisms and cross-functional project teams, organisations may use other mechanisms related to company characteristics or structure to foster innovation. These include:

- Keeping radical new product activities shielded from those of ongoing operations through establishment of informal project laboratories or *skunk works* (Stringer, 2000: Morden, 1989b). Such mechanisms facilitate the establishment of micro-cultures within organisations where innovators are given the necessary flexibility and fat to toy with *crazy* ideas that do not necessarily promise immediate pay-offs.
- Establishing corporate *venture teams* (Lester, 1998) that create and support new businesses by managing them independently from an organisation's existing businesses, as in the case of Sun Microsystems and Intel (Stringer, 2000). However, it has been noted that venture teams have been found to be an infrequently and poorly executed mechanism for NPD (Stringer, 2000; Bart, 1988).

2.2.3 Strategy-related enablers

Tang (1998) asserts that there are three crucial questions to answer concerning the role of strategy in innovation. They are:

1. What innovations should an organisation choose to develop?
2. How should an organisation go about developing them?
3. What market-entry method should it adopt?

The purpose of the following section is to provide answers to each of the above questions.

In deciding what innovations an organisation should choose to develop, it is important to consider the *competitive advantage* that may be derived from them. This is determined by the organisation's technology or innovation strategy, which also governs the market-entry strategy it should adopt, i.e. technological leadership or followership (Porter, 1985)[7]. Cooper (1999) states that *"delivering a differentiated product with unique customer benefits and superior value for the customer"* is one of the top success factors for innovation, adding that such superior products have five times the success rates of products lacking these ingredients.

However, as Porter (1985) warns, not all innovation is strategically beneficial – the choice of innovations to pursue must be constrained by the organisation's areas of strategic focus and core competences (Prahalad & Hamel, 1990). In order to prevent projects outside these arenas filtering into the new product portfolio, the decision to adopt or develop an idea should be founded in an *innovation strategy*, which serves to align NPD with corporate strategy.

In a benchmarking study of 16 industrial products companies' NPD programs, linking front-end development processes to overall business strategy emerged as the most important factor for NPD success (Miller, 1998a). The study concluded that success is more dependent on a strong link between strategy and NPD than on the robustness of the NPD process. Crawford (1980) advocates the use of a *Product Innovation Charter* to

[7] The relationships between technology strategy (encompassing innovation strategy), type of competitive advantage sought and technological leadership and followership are discussed in detail by Porter (1985). However, these issues fall outside the scope of this discussion and hence are only discussed briefly.

provide managers with a guide to the contents of a new product strategy. Cooper & Kleinschmidt (1996) list the following three ingredients of such a new product strategy:

- Providing explicit *goals and objectives* for the organisation's total new product effort, such as a measure of sales derived from new products in a pre-determined amount of time;
- Clearly *communicating* the role of new products in achieving business goals, thus providing a common purpose to everyone involved, and
- Ensuring that the organisation's new product effort has a long-term thrust and focus (i.e. *vision*), since this emerged as the most important factor for performance amongst strategy-related enablers. Techniques such as portfolio management represent valuable tools for this purpose.

2.2.4 Information-related enablers

Cohen & Levinthal (1990) describe the ability of an organisation to recognise, assimilate and apply new information (termed the absorptive capacity of the organisation) as a critical factor in the ability of a firm to innovate. Gilbert & Cordey-Hayes (1996) model this process of absorption as a four-stage process consisting of the following stages: acquisition, communication, application and assimilation. Acquisition relates to the sourcing of new knowledge (from either the internal or external environment of the organisation), which must then be communicated within the organisation via dissemination and transfer mechanisms, either informally or formally. Having acquired and communicated this knowledge, the organisation must apply it in order for it to be retained. Assimilation of the results and effects of application of this knowledge finally enables the organisation to *learn*, rather than the knowledge itself.

In the context of organisational learning[8], the models of *Internal vs. External Learning* (Kessler et al., 2000) and *The Learning Organisation* (Garvin, 1993) provide a suitable framework for identification of different sources of information and mechanisms for knowledge dissemination. Kessler et al. (2000) define internal learning as the creation of knowledge by individuals and the dissemination and integration thereof within the organisation and other knowledge areas. External learning is defined as the identification

[8] This study makes a distinction between organisational learning and individual learning, which supports the former. In the context of information-related enablers, the study focuses on organisational levers for acquisition and communication of knowledge. Assimilation thereof is treated at a more individual level in terms of the development, learning and growth of individuals.

of a new idea by an outside source, such as customers, competitors and other external entities (universities, research centres, etc.).

According to Garvin (1993), a learning organisation can be defined *"as an organisation skilled at creating, acquiring and transferring knowledge and modifying its behaviour to reflect new knowledge and insights".* For these purposes, it should exhibit the following characteristics:

1. Systematic problem solving;
2. Experimentation with new approaches and ideas;
3. Learning from a company's own experience and past history;
4. Learning from experiences and best practices of others, and
5. Transferring knowledge quickly and efficiently throughout the organisation.

From the brief description of the above models, it is clear that a distinction between *learning from internal sources* and *learning from external sources* is consistent with classifications used in the literature. Transfer of information is discussed under the former heading since information, irrespective of its source, is disseminated *within* the company.

2.2.4.1 Internal Learning

Garvin (1993) sees one of the biggest sources of knowledge internal to the organisation as its ability to *learn from past experience*. Companies should review, assess and record the lessons learnt from successful and failed projects in order to avoid the well-known phrase[9]: *"Those who cannot remember the past are condemned to repeat it."* Indeed, in a study of more than 150 new products, Maidique and Zirger (1985) conclude that the knowledge gained from analysis of failures enables subsequent successes, termed *productive failure*.

Due to managers' indifference to events of the past and failure to reflect on them, this type of learning has, to date, occurred mostly by chance in organisations. As a remedy for this problem, Garvin (1993) advocates the use of established processes that foster learning from the past, such as the filing of *post-completion audits* of projects (Lynn et al., 1998; Bowen et al., 1994), or establishment of a post-project appraisal unit to review major projects, write up case studies and derive lessons for managers (as is the case

[9] Quotation attributed to George Santayana, famous American philosopher.

with British Petroleum). However, Bowen et al. (1994) warn against the trap of using post-completion audits to ensure compliance with bureaucratic procedures.

However, to achieve learning outside the “community-of-practice” (Kessler et al., 2000) in which the knowledge was generated, information captured by the team should be stored and organised in an easily accessible manner for retrieval by all other organisational members. Lynn & Reilly (2000) suggest the use of computerised information retrieval systems (such as e-mail, Lotus Notes or a *knowledge database* on the company intranet) in order to facilitate the information storage and transfer process. Such *systems and tools* not only facilitate access and retrieval of information, but also facilitate the capturing and formulation of ideas or concepts (Wagner & Hayashi, 1994) or manipulation thereof, as in the case of Xerox’s WYSIWIS system (Zien & Buckler, 1997) or Shell’s GameChanger scheme (Watts, 2000).

Internal learning, however, is not limited to formal tools, systems and procedures - a substantial amount of information and knowledge is shared and transferred simply via individual interactions. Such learning, termed *informal learning* or face-to-face learning, may happen either haphazardly or in a structured fashion: learning by chance generally occurs through personal interactions between colleagues during conversations, coffee-sessions or other such gatherings[10], while structured learning is typically associated with learning during meetings, where the purpose of collocation is face-to-face information exchange and deliberation. Both haphazard and structured informal learning are equally critical in enabling innovation through information and knowledge exchange at the personal level.

2.2.4.2 External learning

While an introspective approach towards learning has many advantages, it does not constitute the whole sphere of learning available to the organisation. Whereas internal learning allows the organisation to develop its core competences and to achieve a

[10] Informal learning of this kind is not necessarily intentional learning, and so may well not be recognised even by individuals themselves as contributing to their knowledge and skills. The role of informal learning in the development of employee knowledge and skills is discussed under people-related enablers.

greater understanding of the tacit knowledge embedded in its development process, external learning is required to expand the organisation's knowledge base and ensure its flexibility by keeping abreast of cutting-edge technologies and other external influences. Powerful new insights and perspectives may be obtained from the following external sources of information, which are briefly discussed underneath:

- Benchmarking
- Competitors
- Customers
- Suppliers
- Other external sources

Camp (1989) defines *benchmarking* as *"an ongoing investigation and learning experience that ensures that best industry practices are uncovered, analysed, adopted and implemented."* As noted by Garvin (1993), these investigations need not be limited to the industry in which the organisation is operating, but can also focus on completely different businesses. Having established what actually constitutes best practices, organisations can formulate and implement action plans to reduce and eventually eliminate the performance gap between itself and other organisations.

Traditionally, organisations benchmark themselves against their *competitors*. Competitors play a major role in enabling innovation in that most organisations employ sophisticated competitor analysis systems (via patents, publications and public statements) to keep abreast of competitors' emerging technologies and marketing strategies (Goshal & Westney, 1991). Information gained in this regard provides visible input for organisational strategic decision-making and positioning. Additionally, competitor products may serve as points of departure for reverse-engineering.

Customers, and their input into new product development, can arguably be described as the most popular source of information and knowledge external to the organisation. Miller (1998b) states that more than 60% of companies name prospective and present customers as the most important sources they systematically use for idea generation. Cooper (1999) identifies customer involvement as one of the eight common denominators of successful new product projects, stating that successful businesses *"have a slave-like dedication to the voice of the customer."* Garvin (1993) lists the inputs that customers may provide as:

- Up-to-date product requirements[11]
- Competitive comparisons
- Insights into changing preferences
- *Feedback* regarding service and patterns of use

However, organisations need not always be reactive in their attitudes towards customers (Berthon et al., 1999): organisations can act pro-actively by (1) helping customers articulate their needs and (2) exceeding customer expectations. This is accomplished by extending the traditional relationship between sales & marketing and customers to a continuous multi-functional exchange between customers and the organisation's technologists (Miller, 1998b). Morden (1989a) elaborates on the added advantage of paying particular attention to *lead customers* for this purpose. Peters & Austin (1985) recognise the value of such customers in their willingness to try out new prototype models and suggest design modifications for input into the product development process.

Suppliers also have an important role to play in enabling innovation. Not only does vertical integration of suppliers (and distributors) accelerate new product development and commercialisation (Kiella & Golhar, 1997; Gupta & Wilemon, 1990; Gold, 1987); but also, by developing strong networks with external suppliers of technology, organisations can reduce their need for internal specialised research. Bonaccorsi & Lipparini (1994) relate how, based on a case study of a leading Italian firm, gradual integration of suppliers into the NPD process has lead to a cut in development costs to one-third of original levels and several weeks from the product development cycle. Harryson (1997) notes that Canon and Sony maintain extensive supplier *keiretsu*[12] for the sourcing of production technologies and component manufacturing.

[11] Gupta & Wilemon (1990) cite poor definition of product requirements as the most significant reason for product development delays. This is a significant problem since short lead times are critical for satisfying customers (Kiella & Golhar, 1997).

[12] A network of businesses that own stakes in one another as a means of mutual security, especially in Japan, and usually including large manufacturers and their suppliers of raw materials and components.

Many other sources of external information exist. Successful innovation of technologies often requires the support of *networks* of universities and government agencies and research labs (Rycroft & Kash, 1999; MacPherson, 1997); and/or *partnerships* with other organisations. *Strategic scanning* of the technological and other environments affords the organisation the opportunity to identify or predict emerging discontinuities in technology. Xerox uses so-called *edge designers* that operate at the edges of disciplines and markets (*white spaces*) to pro-actively find solutions to these discontinuities (Brown, 1998).

2.2.5 Process-related enablers

Booz-Allen & Hamilton (1982) were among the first to indicate that a formal new product process was the key to successful new product performance. Since then, numerous studies, notably those by Cooper & Kleinschmidt (1987, 1991) and Cooper (1990), have provided empirical evidence for this proposition. Stringer (2000) provides anecdotal evidence of this by citing a recent study of the growth records of the Fortune 50 (sponsored by HP and the Corporate Strategy Board), which concluded that the single biggest inhibitor of growth for large companies was the *"mismanagement of the innovation process"*.

The *process* of new product development can be defined as the activities and decisions involved in taking a new product project from idea to launch. These activities and decisions are aimed at systematic removal of uncertainty through evaluation of information of both technical and commercial natures (Moenaert & Souder, 1990). Craig & Hart (1992) identify three areas of research pertaining to the activities associated with the NPD process:

1. Specific process activities, with particular reference to marketing activities, such as market launch activities, prototype activities and test marketing
2. The proficiency and completeness of these activities, i.e. the *quality* of the new product process
3. The compacting and simultaneity of NPD activities, in order to achieve shorter lead or development times (Dwyer & Mellor, 1991; Takeuchi & Nonaka, 1986).

Since it is not the purpose of this study to investigate the NPD process in detail, but rather to investigate its role and interaction with other enablers in innovation, attention is mainly focused on the *quality of the NPD process* and its associated characteristics[13]. Cooper & Kleinschmidt (1995) list the following characteristics of a high-quality new product process:

- A focus on *quality* of execution, i.e. that every activity must be carried out in a quality fashion. In light of this, quality programs and initiatives (such as Total Quality Management (TQM) and Quality Function Deployment (QFD)) need to be supported in the organisation. This, in turn, supports continuous improvement.
- Thoroughness of the process. In this vein, product development *procedures* and objectives should be clearly documented, accessible and formalised for controlling and coordinating product development projects. Formalisation of such procedures discourages shortcutting of the NPD process and hence ensures quality of execution of projects.
- *Flexibility* of the process. The NPD process, and associated procedures, must not be too rigid: allowance should be made for stages and decision points to be skipped or combined, depending on the risk and nature of the project.
- An emphasis on up-front homework.
- A focus on sharp, early product definition.
- Tough Go/Kill decision points in the process.

Another issue related to the new product development process, which has received significant attention in the literature, is *making the transition from R&D to manufacturing*. Gupta & Wilemon (1990) report that 46% of respondents in their study on NPD cycle time reduction identified this factor (the 4th most significant factor) as being very difficult to accomplish. Canon and Sony directly transfer development teams from R&D to production (Harryson, 1997) as a solution to this problem. Implied in this is the fundamental role of *people* in the integration and transfer of development activities. The importance of people in enabling innovation is discussed in the next section.

[13] Refer to Craig & Hart (1992) for a detailed discussion on specific marketing activities and the parallel processing thereof.

2.2.6 Individual-related enablers

Successful innovation ultimately depends upon people (Morden, 1989b). Craig & Hart (1992) and Johne & Snelson (1988) argue that, although the different dimensions of the people-theme have only been treated obliquely in the literature[14], two central issues have emerged[15]:

- The nature of the roles people (individuals) adopt, and
- The knowledge and skills embedded in individuals.

2.2.6.1 The nature of the roles people adopt

Although innovation is initiated by individuals, it inevitably grows to involve a team of people (and ultimately the whole organisation). To cross from the individual domain to the team domain requires the right mix of people to fulfill specific roles[16]. Roberts & Fusfeld (1981) identify five major work roles critical to innovation, namely:

- Idea generator
- Entrepreneur or champion
- Project leader
- Gatekeeper
- Sponsor or coach

In the context of this study, the role of idea generator has implicitly been implied in enablers such as *creativity* and *experimenting*[17], whereas that of sponsor has been addressed under the role of top management support of innovation. The role of the project leader will be addressed in greater detail in a literature survey pertaining to

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[14] According to Craig & Hart (1992), there are few studies focusing on aspects of "people" in NPD and the understanding of "people" in new product development literature is indeed limited. While research into the people-theme has certainly enjoyed increased attention during the past decade, the majority thereof still pertains to the roles that individuals adopt in the NPD process.

[15] Craig & Hart (1992) include aspects of functional co-ordination of people, project management and organisation structure under people-related enablers. These aspects have already been addressed under enablers related to company characteristics and are therefore not discussed in this section.

[16] Belbin (1981) argues that people with certain behaviour traits make them more suitable to fulfil particular roles than others, and that successful teams have the right *combinations* for these roles. This field of research, however, falls outside the scope of this study.

[17] It is important to note that ideation is not always the product of experimentation and creativity: invention is often attributed to natural human inquisitiveness and serendipity (curiosity mixed with some good fortune). Examples of such cases include the discovery of Velcro, Polypropylene and 3M's Post-it notes.

project-level enablers of innovation. Thus, for the purpose of this section, attention is limited to the roles of *champion* and *gatekeeper*.

Howell & Higgins (1990) define champions as *informal transformational leaders*, who generally work outside official roles, using visionary statements, concern for others and stimulating ideas to influence people's actions. Numerous studies have provided anecdotal evidence of the profound positive impact of champions on new product performance (Frohman, 1999; Norling & Statz, 1998). A recent study by Markham & Griffin (1998) has, however, provided empirical evidence of this. Examining the association between championing and different performance-related variables, findings revealed that champions have indirect effects on firm performance (via increased NPD program performance) and that strategy innovativeness and the use of NPD processes mediate the impact of champions. In other words, championing is more prevalent in positive environments with strategies that emphasise innovativeness and have implemented NPD processes.

Hauschildt & Schewe (2000) define gatekeepers as sociometric stars that take up, process and pass on information from internal and external sources[18]. As such, they serve the following purposes in enabling innovation:

- To establish an information and communication network within the organisation;
- To reduce information-related deficits on the parts of individual employees in the organisation.

Although little empirical evidence of the importance of gatekeepers for successful innovation exists in the literature, significant anecdotal evidence is available (Forrest & Martin, 1992; Katz & Tushman, 1981).

[18] A large degree of ambivalence exists in NPD literature regarding the meaning of the concept of *gatekeeper*. The first meaning relates to the definition given above. The second relates to the *"group of managers who serve as advisors, decision-makers and investors in a Stage-Gate™ process"* (PDMA glossary). In the context of this study, the term *gatekeepers* refers to the first definition given.

2.2.6.2 Knowledge and skills embedded in employees

Two aspects of the knowledge and skills embedded in employees are relevant when considering the role of people in enabling innovation. These are:

- *Development* of individual knowledge and skills, and
- Matching individuals and their associated skills to their jobs.

Development of individual knowledge and skills is achieved through learning. Such learning may either occur through individuals' own natural interactions with other employees (informal learning), or in a *structured* fashion via organisational learning initiatives (formal learning). There is a growing body of literature on the importance of organisational learning for new product success. Indeed, it has been argued that *"the rate at which individuals and organisations learn may become the only sustainable competitive advantage, especially in knowledge-intensive industries"* (Stata, 1989).

Informal learning may occur through a variety of mechanisms, such as sharing of insights between one team member and others, interest in others' work, or learning by doing. Formal learning may occur through initiatives such as formal training and education, *job rotation* and inter-organisational conferences and symposia. For example, at Sony, all researchers and engineers begin with an initial month of work on a production line, plus at least three months of Marketing and Sales training. At Canon, engineers and scientists are relocated every six months for knowledge sharing with new colleagues. Sony's Open-House Meetings, Technology Symposia and Technology Exchange Forums provide ample opportunity for further learning (Harryson, 1997).

Through the initiative of job rotation, employees are also given the opportunity to identify those jobs with which they identify the most. When people work at what they like doing best, their *intrinsic motivation* is maximised – they have a *passion* for their jobs (Wiley, 1997; Savery, 1996). Indeed, Buckler & Zien (1996) note that respondents cited the shear pleasure of achieving creative goals as one of the wellsprings of innovation in the organisation. One way in which organisations aim to *match people to their jobs* is by providing them with a dual ladder system for advancing in the organisation. Such a system allows scientists and engineers, who do not want to become involved in management, to be promoted within their fields of specialisation without *"being left behind"* on the corporate ladder.

2.3 SUMMARY

The findings of numerous empirical studies, supported by anecdotal evidence from case studies and personal experiences, have been presented to (1) introduce the concept of an “enabler”, (2) identify the scope of enablers to be investigated in this study, and (3) classify these according to a suitable theoretical framework for facilitation of an improved understanding of the linkages that exist between different enablers or groups of enablers. Based on this foundation, a literature survey of the relative importance of such enablers of innovation at the project level, which pertains to the core objectives of this study, is presented in the following chapter.

CHAPTER 3

Theoretical model and hypotheses

3.1 INTRODUCTION

Having fixed the scope of variables to be investigated in the study, this chapter describes the formulation of a number of hypotheses regarding the roles of project radicalness and maturity in moderating the importance of these enablers of innovation. Two sources of knowledge are used for this purpose: (1) a literature survey of findings on the relative importance of enablers, which indicates that evidence in this regard is generally either controversial, or consistent, but lacking in empirical proof or based on anecdotal evidence; (2) the results of a multi-organisation exploratory survey on the importance of enablers in different functional environments of organisations, based on the premise that its findings allow inferences to be made regarding the importance of enablers for different types and attributes of innovation. The outcomes of these hypotheses form the basis for development of a contingency model for the importance of enablers.

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3.2 THE RELATIVE IMPORTANCE OF ENABLERS IN FUNCTIONAL ENVIRONMENTS

Prior to presenting the development of hypotheses, it is important to briefly consider the role of the exploratory study therein and the premise upon which this is done. As introduced in Chapter 1, hypotheses regarding the relative importance of enablers are derived not only from evidence in this regard in the literature, but also from the results of a multi-organisation exploratory study[1] on the relative importance of enablers in specific functional environments of organisations (specifically R&D and Production), since knowledge in this regard allow inferences to be made regarding the roles of project

[1] Simply referred to as "the exploratory study" from here on.

radicalness and maturity in moderating the importance of enablers. The validity and implications of this assertion are discussed in the following paragraphs.

Figure 3.1 is a simplified diagram of the stages in the project life cycle of a typical innovation and reflects the stages associated with the initiation and implementation of innovations. Given that concept development and process development (and to a large extent pilot testing) are largely R&D-based activities, whereas facility design & construction and operation relate more closely to the Engineering and Production functions of organisations, it is evident that different functions display *relative intensities of involvement* during different stages of the project life cycle.

In light of this, it may be argued that enablers that exhibit high levels of importance in an R&D environment should be relatively more important for the initiation than implementation of innovations; conversely, it may be argued that enablers of particular significance in Engineering or Production environments are of relatively greater importance during the implementation than the initiation of innovations. Hence, inferences regarding the relative importance of enablers for the maturity of projects may be based on findings on the relative importance of enablers in associated functional environments.

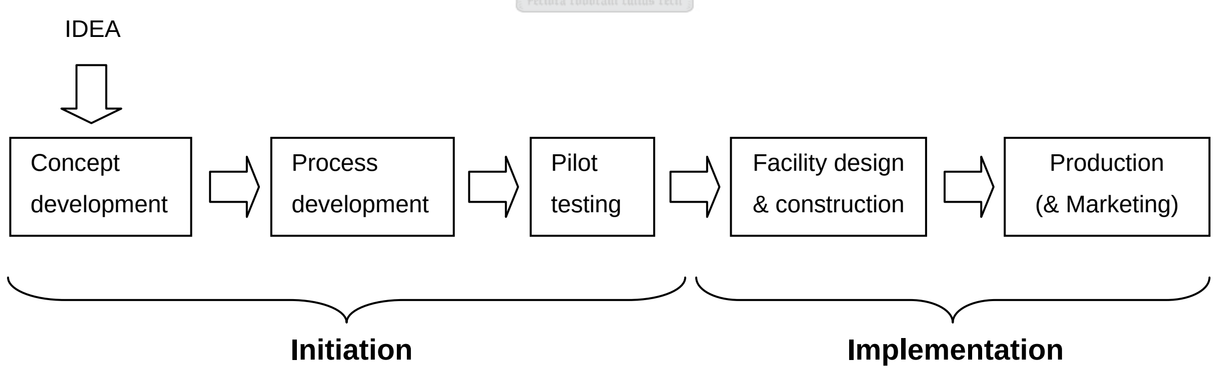

Figure 3.1 Activities associated with successive stages in the life cycle of a project

In an analogous fashion, it may be argued that different functional environments exhibit propensities for different types of innovation. Based on the contention of Steele (1975) that technology-push innovations (i.e. originating from R&D) most likely lead to major achievements and large discontinuities in technology, it is argued that enablers of significant importance in R&D are also important for radical innovations. On the other hand, it is suggested that enablers that exhibit higher levels of relative importance in Production environments are of greater significance to incremental innovations, based on the greater inherent interest of these environments in refining and optimising the throughput *process*. These arguments are consistent with the findings of Snow & Hrebiniak (1980) and Hambrick (1983) regarding the attributes of different functional strategies.

Table 3.1 Summary of enablers that exhibited significant differences in relative importance between R&D and Production.

Theme	**Enabler**	**Direction**
Management	Diversity*	–
	Experimenting***	–
	Learning & Growth**	–
	Reward & Recognition*	–
	Capital**	–
Information	Benchmarking***	+
	Customers**	+
	Suppliers**	–
	Strategic Scanning*	+
	New Markets**	+
Process	Quality*	+
Individual	Skills & Competences*	–

Legend: Significance of difference: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$[2].

[2] *The null* hypothesis states that there is no appreciable difference between the two sets of variables being studied. The *alternative hypothesis* contradicts this. By performing a statistical hypothesis test, a p-value gives the probability of obtaining a result as extreme as the observed result if the null hypothesis was in fact true. Therefore, when the p-value is less than or equal to 0.1, the null hypothesis is rejected; i.e. that a significant difference between the two sets of data does exist.

In summary, inferences regarding the roles of project radicalness and maturity as moderators of enablers may be derived from knowledge of the propensities of different environments for radical and incremental innovation, as well as their involvement during stages of NPD. Specific results of this study, which indicate whether significant differences exist between the importances of enablers in the functional environments, are presented in Appendix A3[3]. Table 3.1 provides a summary of enablers that exhibited significantly different levels of importance between R&D and Production, and the *directions* of these differences: a significant increase in importance from R&D to Production is denoted by a positive ("+") sign, whereas a significant decrease is denoted by a negative ("–") sign.

The following section discusses the development of hypotheses regarding the moderated importance of enablers, based on the results of the exploratory study and findings from the literature. Prior to this, two methodological issues require brief discussion, viz. (1) the use of hypotheses, and (2) how the reliability of contradictory findings are weighed up against one another for the formulation of hypotheses.

Given the general inconsistency in findings on the relative importance of enablers in the literature and the general lack of empirical evidence in this regard, formulation of hypotheses affords the researcher the opportunity to suggest a proposition that is *most compatible* with (or representative of) the majority of beliefs or findings in the literature. It may therefore be considered to be an abstraction of the general notion in the literature (when a reasonable amount of consistency in evidence is prevalent). Testing of hypotheses thus not only facilitates a comparison between experimental findings and those from the literature; also, the outcomes thereof constitute the foundation of a contingency model for the importance of enablers.

With regard to judging the reliability of findings from the literature and the exploratory study, a number of guidelines were followed for the "construction" of hypotheses. Firstly, findings from empirical studies in the literature were taken to be more trustworthy than those derived from anecdotal evidence or proposed trends, given the scientific validity of empirical results. Secondly, if a choice between the reliability of "older" findings and

[3] Given that the sole purpose of the exploratory study relates to the development of hypotheses, its research methodology is presented in Appendices A1 – A2.

more recent findings needed to be made, the latter results were taken to be more valid. Thirdly, findings from the exploratory study were mainly used in a confirmatory manner to support findings from the literature, since these were inferred from data on the relative importance of enablers in functional environments.

Therefore, if the majority of findings in the literature were supported by those from the exploratory study, a hypothesis to that effect was formulated. If results of the exploratory study contradicted the general notion prevalent in the literature, possible reasons for this discrepancy were sought and typically a hypothesis consistent with the general belief in the literature was formulated. When evidence from the literature was found to be sufficiently contradictory that no general trend could be discerned, findings from the exploratory study were used to suggest a possible "direction" in the importance of an enabler.

In cases where the findings from the exploratory study did not provide any additional insights or suggested no significant difference between the relative importance of enablers for project radicalness or maturity, hypotheses were formulated as not committed to either direction, e.g. that project radicalness or maturity does not moderate the importance of an enabler. In such cases it was assumed that conditions prevalent in studies differed to such an extent that no discernable direction in the importance of enablers could be identified. Adherence to these guidelines ensured that hypotheses were derived in a consistent fashion.

3.3 DEVELOPMENT OF HYPOTHESES

3.3.1 Project management-related enablers

Analogous to the three roles of management at an organisational level (*envisioning, enabling and energising*), project management has certain responsibilities, i.e.:

3.3.1.1 Leadership

Project radicalness

In this regard, significant research has been done on both the *attributes* and *roles* associated with the project leader. McDonough (1993), investigating the characteristics of the project leader and team on new product development speed, argues that routine (incremental) projects are completed faster under project leaders who have been in their jobs for fewer years (i.e. less tenure). This finding is partially supported by the work of Kessler & Chakrabarti (1998, 1999) who found that the quality and speed of routine new product developments are associated with a leader low in the organisational hierarchy. Conversely, they found that, for radical projects, speed and quality of development is positively related to a leader high in the organisational hierarchy (higher authority), but with less tenure in the organisation. McDonough (1993), however, found no significant association between project leader tenure and speed of development for radical projects.

The need for high authority people to lead radical projects lies in their ability to attract the best people for the team and to promote projects within the organisation by facilitating their movement through bureaucratic snags. Indeed, Maidique & Zirger (1984) relate how functional line managers stressed the significance of top management backing for innovative projects in their study. Lee & Na (1994), however, find no indication that the significance of top management support is heavily increased when innovativeness is radical. This notion is supported by results from the exploratory study (Appendix A3), which show that Leadership is of equal importance between R&D and Production. Despite this evidence, it may be argued that general findings in the literature provide sufficient evidence of the fact that more "heavyweight" leadership is required for radical changes than for incremental modifications. Hence, it is argued that Leadership plays a significantly more important[4] role in enabling radical than incremental innovation (H1a)[5].

Project maturity

Irrespective of the attributes and roles associated with project leaders, Johne & Snelson (1988) argue that one of the most critical roles of Leadership is to ensure the interplay and balance between marketing and technical inputs in idea generation, which may explain why the role of Leadership was perceived to be of comparative importance

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[4] The term "significantly more important" may be interpreted as implying that, *relative to radical innovations,* Leadership is not important for incremental innovations.

[5] Codes such as *H1a* and *H1b* refer to research hypotheses forwarded regarding the moderating roles of project radicalness and maturity in determining the importance of enablers studied. All of these hypotheses are summarised in the Appendix to Chapter 3.

between R&D and Production[6] in the exploratory survey. This is achieved by fusing the ideas that originate in the technical skill base of the firm with the necessary marketing input to ensure a need-pull for the innovation. Through this fusion process, project management establishes a vision and strategy for the project – such project goals are of prime importance during the early stages of development that are characterised (and troubled) by high levels of unfamiliarity and uncertainty. Only once the product proposition is crystallised and major elements of uncertainty have been removed from the project, can the function of the project leader migrate from a leadership-orientation to a management-orientation. This orientation requires highly directive supervision and careful measurement of performance (Ansoff & Stewart, 1967). Based on evidence in this regard, it is suggested that Leadership plays a significantly more important role in enabling the initiation than implementation of innovations (H1b).

3.3.1.2 Tenure of team members

In the context of this study, attention is limited to human resource commitments to the project[7], and generally relates to the tenure of team members on a particular project.

Project radicalness

Brown & Eisenhardt (1995) argue that teams with a short history tend to lack effective patterns of information sharing and cooperation; due to this unfamiliarity, the amount and variety of information that can be communicated among team members is limited (Katz, 1982; Allen et al., 1980). Thus, based on the premise that radical innovations involve greater information requirements in terms of amount and diversity, it may be argued that tenure of team members on the project is more important for radical innovations.

This finding is tentatively supported by Shenhar et al. (2002), who find that *"sharing project resources seems to affect more the success of high-uncertainty projects".* Kessler & Chakrabarti (1999), on the other hand, find that the speed of incremental projects is accelerated by assignment of members with full-time commitment to the

[6] Based on the close relationship between the Production and Marketing functions of operational units.

[7] In the organisation used for data collection in the main study, not one of the respondents complained about a lack of financial resources for projects. Indeed, availability of venture capital for pursuit of innovative projects was regarded as one of the organisation's strongest points. Therefore, in the context of this study, availability of resources in terms of capital is not considered.

project[8], while radical projects are completed faster when there are fewer projects in the organisation's pipeline competing for resources. Therefore, in light of the fact that full-time member commitment to a project appears to be equally important between radical and incremental innovations and very little additional insight into the importance of this enabler may be gained from the exploratory study, it is hypothesised that project radicalness does not moderate the importance of the tenure of team members (H2a).

Project maturity

Lanigan (1994) argues that, while limited effort should be assigned to projects in basic research, concentration of forces is critical for rewarding product development and design: in this case, as much engineering effort as possible should be assigned in order to achieve the earliest market entry possible, subject to the law of diminishing returns. Jenkins et al. (1997), on the other hand, warn against indiscriminate addition of manpower to projects, since simply adding more manpower to a project could actually increase its development time. These reservations may, however, be reconciled by keeping the core (cross-functional) development team as compact as possible with incorporation of extra team members only when necessary. Indeed, both Cooper (1999) and Johne & Snelson (1988) recognise the need for multi-functional participation in and commitment to such a core team from as early as the idea generation process. Since new knowledge is constantly generated during development of the project, it may be argued that continuity of the collective knowledge and learning associated with it becomes increasingly important as the project progresses. Full-time commitment of the core team provides a means of ensuring this. Hence, it is suggested that tenure of team members plays a significantly more important role in enabling the implementation than initiation of innovations (H2b).

[8] It is interesting to note that Kessler & Chakrabarti (1998) find that the opposite is true for the *quality* of incremental innovations, i.e. that part-time assignment of members improve the quality of incremental innovations. This phenomenon may arguably be attributed to the learning associated with the rotation of team members between projects, which is discussed under *section 3.3.3.1.2.2.*

3.3.1.3 Sub-culture

Project management must establish and maintain an appropriate team-based *sub-culture* in which the team can work and function. In this regard, it should support individuals through Reward & Recognition and encourage appropriate levels of Creativity, Risk-taking and Experimenting.

3.3.1.3.1 Reward & Recognition

Project radicalness

Although the literature abounds with references relating to the importance of Reward & Recognition, very little has been published regarding the relative importance (or types of) of Reward & Recognition for radical and incremental innovations. Kessler & Chakrabarti (1999), once again, make an oblique reference to this in reporting that incremental projects are developed faster when a *reward system* geared towards speed was prevalent. On the other hand, Kiella & Golhar (1997) argue that Reward & Recognition of the efforts of R&D researchers in really innovative projects should be emphasised, due to the low odds of success and long time spans associated with such projects[9]. This argument is supported by the results of the exploratory study, which indicate a significant decrease in importance from R&D to Production. Based on this evidence, it is hypothesised that Reward & Recognition plays a significantly more important role in radical innovations (H3a).

Project maturity

In addition to the above comments, Kiella & Golhar (1997) make the point that management more readily recognises and rewards scientists and associates who are working on highly visible and successful research agendas, where *research* is being fashioned by *development* into what promises to be an innovative final product. Thus, it may be argued that Reward & Recognition becomes more *visible* during later stages of the project. However, from an importance-perspective, Reward & Recognition is also critical during research activities in order to support the self-actualisation of researchers. Since such self-actualisation is directly linked to researchers' intrinsic motivation (as will

[9] It is the assertion of this study that a simple dichotomy between high and low importance is not relevant in the case of this enabler. Rather, research should be focused on *tailoring* reward & recognition systems to the intrinsic motivational factors associated with different kinds of people that fulfil different roles in the product development process. In this regard, researchers have suggested reward systems geared for speed of development (Kessler & Chakrabarti, 1999) or learning and project leadership (Bowen et al., 1994).

be discussed later), Reward & Recognition is hypothesised to be equally important during all stages of innovation (H3b).

3.3.1.3.2 Creativity, Risk-taking and Experimenting

Project radicalness

Radical innovations, by nature, are more complex than other innovations; therefore they involve higher levels of uncertainty, risk and information needs. This can be attributed to the fact that:

- Conventional approaches to new product development may be inappropriate or even detrimental to radical innovations.
- Standard solutions and technologies are inadequate for, or not applicable to, the complex problem at hand.

In light of these complications, radical innovation typically requires significantly higher levels of Creativity and Risk-taking to facilitate problem solving between paradigms. By allowing and fostering such *ambiguity* in the team, project management provides a sub-culture more conducive to radical innovation. Such ambiguity and uncertainty must, of course, be managed and reduced for the product development effort to continue. In this regard, Experimentation is key. Lynn (1998) provides theoretical evidence for this from the perspective of new product team learning. According to Lynn (1998), so-called *within-team* learning is critical to the development of discontinuous innovations. Bearing in mind that *within-team* learning can be characterised as *learning by doing*, and that *learning by doing* captures the essence of Experimentation, this model of learning argues that higher levels of Experimentation should be associated with the development of discontinuous innovations. This notion is echoed by the results of the exploratory study, as presented in Table 3.1. In light of the consistency of evidence with regard to these enablers, it is hypothesised that enablers related to the sub-culture of the project team (such as Creativity, Risk-taking and Experimentation) play significantly more important roles in enabling radical than incremental innovation (H4a).

Project maturity

Invention involves a series of activities that seek to generate a number of development options from which the optimum is chosen. In this context, the objective of *research-intensive* activities is to discover and evaluate alternative solutions, rather than implement a single solution. Since design specifications in such environments are less definite and technical insight and contribution are individual rather than group attributes, Ansoff & Stewart (1967) argue that managers should permit freedom of individual initiative and progress. In this, Creativity and Experimentation are encouraged. Such a culture is supportive of basic research that is staffed mostly by scientists who tend to be *"fascinated by the journey rather than the destination"* (Lanigan, 1994). Hence, it is suggested that enablers related to the sub-culture of the project team, such as Creativity, Risk-taking and Experimentation play significantly more important roles in enabling the initiation than implementation of innovations (H4b).

3.3.2 Enablers related to the characteristics of the project team

In Chapter 2, the importance and characteristics of a true cross-functional project team for successful NPD was motivated and discussed. In the discussion, aspects of *Team Complexity* and *Team autonomy* were addressed.

3.3.2.1 Team complexity

Project radicalness

Team complexity[10] relates to the degree of diversity needed in terms of functional specialisation and cross-functional input needed for successful development of a project of a particular radicalness (Hage & Dewar, 1973). Literature and empirical evidence on this factor is both old and variable. For example, whereas Ettlie et al. (1984) find that complexity is a more suitable structural arrangement for incremental innovation, Dewar & Dutton (1986) find that it has a weak and insignificant effect in distinguishing between radical and incremental innovation.

More recent studies do, however, seem to concur that high complexity facilitates radical innovation more so than incremental innovation. Olson et al. (1995) empirically prove that as the development process increases in difficulty, the greater the perceived interdependency among the various functional areas becomes. They qualify this finding by stating that such participative coordination mechanisms are associated with better product development performance *only when* innovative new-to-the-world or new-to-the-

[10] Complexity = Specialisation + Functional differentiation + Professionalism (Damanpour & Gopalakrishnan, 1998)

company projects (with which the organisation has little relevant previous experience on which to draw) are developed. Finally, Kessler & Chakrabarti (1998) present empirical evidence indicating that the representativeness of interest groups is negatively related to the Quality of moderate innovations, but positively related to the Quality of radical innovations.

From the results of the exploratory study, it is evident that whereas Diversity and Learning & Growth (which principally relate to interaction between *specialties*) show significant decreases in relative importance between R&D and Production, Cross-functionality is of comparable importance between the functional environments (a logical conclusion, given the implications of the term). In this regard, it may be argued that a distinction between the importance of Specialisation and functional differentiation (Cross-functionality) needs to be made, which could explain some of the variability in findings from the literature for the construct of complexity. Based upon this premise, two hypotheses are forwarded, viz. (1) Specialisation plays a significantly more important role in enabling radical than incremental innovation (H5a1), and (2) project radicalness does not moderate the importance of Cross-functionality in the team (H5a2).

Project maturity

Tang (1998) argues that a crucial ingredient in creative problem solving and opportunity discovery is insight, which needs creative thinking and domain-relevant knowledge. Since such knowledge is associated with experience, and experience with professionalism and Specialisation, it may be argued that Specialisation is a necessary condition for the initiation of innovations. Given that this argument is tentatively supported by results from the exploratory study and the ambidextrous theory of innovation, it is suggested that Specialisation plays a significant more important role during the initiation of innovations (H5b1).

Ansoff & Stewart (1967), however, suggest that development-intensive activities call for a more structured management approach than research-intensive activities, due to the highly interrelated work involved in design, testing and scale-up. In this statement, development activities are associated with a high degree of complexity and formalisation. Hence, complexity may also represent a necessary condition for the implementation of innovations. Based on the distinction between Specialisation and functional integration suggested above, it may therefore be argued that Cross-functionality is of comparable importance for both the initiation and implementation of innovations. This notion is supported by modern researchers such as Cooper (1999) and Johne & Snelson (1988) who recognise the need for multi-functional participation in a core team from as early as the idea generation process. Thus, it is hypothesised that project maturity does not moderate the importance of the Cross-functionality of the team (H5b2).

3.3.2.2 Team autonomy

Project radicalness

As is the case with team complexity, research on Team autonomy does not, to date, provide a consistent view. Ettlie et al. (1984) and Hage (1980) advocate the use of decentralised organic structures for incremental innovations and more mechanistic structures for radical innovation, whereas Dewar & Dutton (1986) and Nord & Tucker (1987) find no empirical evidence to suggest that centralisation plays a significant role in promoting either radical or incremental innovations. This notion is tentatively supported by the trend in Organisational Structure (which represents the degree of bureaucracy prevalent in the functional environment) in the exploratory study.

The research of Shenhar et al. (2002), Kessler & Chakrabarti (1998) and Olson et al. (1995) does, however, concur that decentralised structures and empowered teams are more suitable for radical innovations, whereas bureaucracy and centralisation support incremental innovations more – quite the opposite of the models predicted by Ettlie et al. (1984) and Hage (1980)[11]. For the purpose of this study, the most recent view is adopted. Hence, it is suggested that Team autonomy plays a significantly more important role in enabling radical than incremental innovation (H6a).

Project maturity

The ambidextrous theory of innovation suggests that high complexity, low formalisation and low centralisation (decentralisation) facilitate the initiation of innovations, while low

[11] It is interesting to note how the literature on the relationship between organisational structure and innovation radicalness has evolved – it is contention of the study that the advent of the "project team" has significantly redefined the concepts of Centralisation and Complexity in terms of organisational structure – thus the "apparent" discrepancy between the views of authors in 1984-86 and 1995-2001. This validity of this assertion is discussed in Chapter 7.

complexity, high formalisation and high centralisation facilitate the implementation of innovations. This is theory is supported by Ansoff & Stewart (1967), who argue that development-intensive activities require *"sophisticated controls to ensure that technical objectives are achieved within planned time and cost limits".* Nord & Tucker (1987), however, find that decentralisation is not a necessary condition for the design phase of the innovation but acknowledge that this seeming contradiction may be attributable to low levels of formalisation (which will be discussed later) during the stage. In light of the relatively consistent evidence in this regard, it may be asserted that lack of bureaucratic control or decentralisation more strongly influences the initiation than implementation of innovations (H6b).

3.3.3 Information-related enablers

Tang (1999) argues that it is ultimately information and more importantly exchange of information (not management, people, process or knowledge and skills) that first spark and later sustain innovation efforts. In the previous chapter, the process of absorption of information and knowledge was analysed to establish a link between information and learning. Using the model of Gilbert & Cordey-Hayes (1996), it was shown how learning at the level of the individual is transferred to that of the organisation. Barker & Neailey (1999), however, argue that a vital, and often ignored, component of organisational learning is the learning that occurs within teams, especially given their presence in almost all organisations. It is the purpose of this section to explore the sources of information and mechanisms associated with learning at the level of the team.

Lynn and various associates (Lynn & Reilly, 2000; Lynn et al., 1999; Lynn et al., 1998; Lynn, 1998) have arguably presented the most valuable findings regarding the importance of team learning in successful new product development. This is especially relevant in the context of how specific team learning strategies are contingent upon different innovation strategies and the dominant types of innovation associated with them. Lynn (1998) defines three different forms of team learning. The first is defined as *Within-Team Learning*, since it is associated with the learning that occurs within the context of the team itself and can be characterised as learning by doing. The second form of learning is called *Cross-Team Learning* and relates to the transfer and transplant of knowledge gained in one team to another – Barker & Neailey (1999) sees this type of learning as providing a potential stepping-stone for other teams in the organisation. Finally, *Market Learning* is defined as knowledge gained from sources external to the firm – from Competitors, Suppliers, Customers and other Partners or Collaborators.

It is evident that these strategies are consistent with the framework of *internal vs. external learning*[12], as defined in Chapter 2 for learning at the organisational level. Hence, the framework used in Chapter 2 is also adopted in this section, with references as to how it relates to the different team learning strategies of Lynn (1998).

3.3.3.1 Internal learning

In Chapter 2, three major mechanisms of internal learning were identified, namely i*nformal learning*, *formal learning* and *learning from the past*. In analysing the relative importance of different modes of communication (and learning), specifically relating to informal vs. formal learning, the classical model of media richness proposed by Daft & Lengel (1986) may be employed. Media richness is based on the theory of organisational information processing according to which uncertainty and equivocality reduction is the main goal of communication. Daft & Lengel (1986) propose four factors governing media richness, namely: speed of feedback, channel mode (visual, audio or mixed), personal focus and language use. Based on these factors, they suggest a ranking of media in order of richness: face-to-face (FTF), telephone, personal written documents, impersonal unaddressed documents and numeric documents.

3.3.3.1.1 Informal Communication vs. Information and Communication Systems

Project radicalness

If the link between uncertainty reduction and mode of communication is interpreted in the context of innovation, it may be argued that more rich media, particularly FTF communication, is relatively more important for radical than incremental innovation, since the former is associated with higher levels of uncertainty. Kessler & Chakrabarti (1999) present empirical evidence for this based upon the importance of team proximity for radical innovation. Relating co-location to rapid feedback, decoding and synthesis of complex information (Katz & Tushman, 1979), it is argued that a project team would require more FTF communication when an innovation is less familiar, i.e. more radical.

[12] Note that Lynn (1998) uses the term *"external"* to denote sources external to the organisation and not the team, even though the team is the object of analysis.

Alternatively, it is argued that communication would be less for incremental innovation, since communication is less important for more familiar tasks that represent smaller changes and may even introduce unnecessary complexity and more frequent interruptions into tasks. This is contradicted to some extent by Lynn (1998), who argues that Cross-Team Learning is critical for incremental innovations. However, the mode of communication or information transfer is not specified in this case; hence this seeming contradiction may be invalid.

Shenhar (2001), however, notes that, in most projects the choice is not between rich and non-rich media (i.e. one *or* the other): rather, all projects preferably employ the lower end of the richness spectrum for communication. Indeed, McKee (1992) argues that less rich media such as information systems and tools are associated with enhancing the *depth of contact* of individuals in a specific environment by (1) increasing the number of contacts the organisation has in a given environment, (2) increasing the velocity of information between these contact points and the organisation, and (3) increasing the reliability of information obtained by the organisation. Given the fact that knowledge *depth* is important for adoption of both radical and incremental innovations (Kessler & Chakrabarti, 1999; Dewar & Dutton, 1986), it may be argued that less rich media play an important role in enabling both radical and incremental innovation. Based on this evidence and the fact that Information and Communication Systems were of equal importance between R&D and Production in the exploratory study, it is suggested that project radicalness does not moderate the importance of less-rich media of communication (H7a1).

Despite this, Shenhar (2001) does find evidence of the fact that more rich media types (in the form of more frequent team meetings and an informal working climate) are typically added with increased technological uncertainty of projects – hence, rich media of communication play a relatively more important role in enabling radical innovation (H7a2).

Project maturity

Having established the importance of face-to-face communication for uncertainty reduction via the model of media richness (Daft & Lengel, 1986), it may be argued that, in the context of the maturity of an innovation, personal interaction and learning is of greater importance during the initiation of an innovation, when the uncertainty associated with the project is at a maximum. Upon this premise, it is hypothesised that rich media of communication play a significantly more important role in enabling the initiation than implementation of innovations (H7b2).

At the opposite end of the innovation cycle, it is argued that media of low richness are effective for processing well-understood messages and standard data. Since implementation generally involves a higher degree of standardisation and formalisation, it may therefore be argued that information systems and tools are more appropriate during the implementation stage of an innovation. Such systems and tools may, however, be instrumental in idea generation too: companies like Xerox (Zien & Buckler, 1997) and Shell (Watts, 2000) use highly sophisticated information technologies to promote ideation between teams and members of teams, especially when they are geographically removed from one another. Once again, this argument is tentatively supported by data regarding Information and Communication Systems in the exploratory study. Hence, systems and tools may play an important part in enabling innovation during both initiation and implementation (H7b1).

3.3.3.1.2 Learning from the past

Learning from the past is essentially achieved via the personal experiences of team members. This type of learning is not related to the current project (and as such is directly linked to the tenure of team members on the project, discussed under *section 3.3.1.2*), but primarily relates to past projects in which the team members have been involved or have knowledge of (in which case experience is directly linked to tenure in the organisation).

Project radicalness

Findings on the relationship between tenure in the organisation and radicalness of the innovation have mainly been presented by McDonough (1993) and Kessler & Chakrabarti (1999). However, the results of these empirical studies are contradictory: whereas McDonough (1993) advocates the use of team members that have been with the organisation for fewer years (in order to avoid falling into traditional ways of doing things and traditional approaches to solving problems), Kessler & Chakrabarti (1999) find a high degree of correlation between tenure in the organisation and speed of development of radical projects (a similar relationship is suggested for incremental innovations).

Learning from the past is synonymous with *Cross-Team Learning* (Lynn, 1998) and occurs when the experience gained by one team in the organisation is *transplanted* to another. Takeuchi & Nonaka (1986) were among the first to warn against carrying institutionalisation of knowledge too far: passing down lessons from the past or building routines based on previous success stories are only applicable in stable environments. Changes in the environment have the ability to quickly nullify such lessons and hence limit their value for radical innovation. This argument is supported by Lynn (1998), who argues that *Cross-Team Learning* should be restricted for innovations that are targeted at new markets and involve new technologies outside the core competencies of the organisation. Bowen et al. (1994) warn against core capabilities becoming *core rigidities* if a company fails to update or replace its capabilities as the industry evolves.

On the other hand, Barker & Neailey (1999) view learning within one team as a stepping stone approach on which other teams in the organisation can build and therefore consider it to be a platform for developing a major source of competitive advantage. Therefore, given that (1) sufficient contradictory evidence exists in the literature on the relative importance of this enabler, and (2) results from the exploratory study indicate that Auditing (capturing and learning lessons from the past) is of equal importance between R&D and Production, it is asserted that past learning and experience of team members is of equal importance for radical and incremental innovations (H8a).

Project maturity

It has been shown that the *ambidextrous theory of innovation* states that formalisation is associated with the implementation of innovation. Such formalisation is only possible when tasks or procedures involved in implementation are reasonably standardised or employ common principles. In this regard, it may be argued that past project experience of team members become more relevant during the implementation of projects, when a greater degree of commonality exists between tasks of the current and previous projects. Garvin (1993) relates how companies such as Boeing and Xerox have institutionalised best project management practices to improve their product development programs. Due to a greater degree of overlap that exists between activities of project teams in the implementation-stage of innovation, more common ground exists for sharing of knowledge and experience. Hence, it may be argued that past experience in projects or knowledge of others becomes more relevant during the implementation of innovations.

On the other hand, it may be argued that extensive experience of team members on the current project could also facilitate initiation of innovation: past experience may allow such individuals to recognise the new potential of a past project or concept that had previously been thought of as unfeasible or "impossible", or even link such concepts with new ones to arrive at completely new applications. In this regard, Tang (1998) recognises domain-relevant knowledge (through experience or training) as a crucial ingredient in creative problem solving and opportunity discovery. Therefore, based on evidence that points in both directions and the findings of the exploratory survey, it is suggested that project maturity does not moderated the importance of Learning from the past (H8b).

3.3.3.2 External learning

McKee (1992) argues that *"diverse points of reference help in interpreting an ambiguous environment"*; hence, organisations engaged in discontinuous innovation should increase both the diversity of information obtained from the environment and its receptivity to remote signals. Ettlie et al. (1984), on the other hand, find no empirical evidence that exposure to external information significantly enables either radical or incremental innovations.

In the context of Lynn's (1998) team learning strategies, external learning is closely associated with *Market-Learning.* This form of learning is defined as knowledge gained from Competitors, Customers, Suppliers and Partners external to the organisation. In suggesting that teams need only *adequate Market-Learning* for radical innovation[13], Lynn (1998) implies that certain forms of external learning are more important for radical innovation than others. It is the purpose of this section to explore the validity of this

[13] Note that the simple distinction between internal and external learning - and the strategies defined by Lynn (1998) – is inadequate to model the relative importance of learning-related enablers for radical versus incremental innovation.

proposition[14], since it is the most plausible explanation for the inconsistent findings in the literature to date (as illustrated above).

To date, only Kessler et al. (2000) have forwarded findings related to the relationship between external learning and stage of development. In their study, it was concluded that external sourcing (1) is more detrimental to competitive advantage during the idea generation stage, and (2) significantly increases project completion time during the technology development stage. Since *sourcing* may relate either to the identification of an idea or use of external knowledge or expertise, these findings are directly applicable to the concept of external learning. The following sections also explore the importance of each of the different sources of external learning in the stages of the project life cycle.

3.3.3.2.1 Benchmarking

Project radicalness

Cross-Team Learning is closely associated with intra-organisational Benchmarking between teams – in this context, Benchmarking represents one form of external learning available to the team[15]. In this case, learning may be based upon the difference in performance and quality standards between alternative (or competing) technologies within the organisation or management practices and procedures in non-related processes. Since the essence of Benchmarking lies in the reduction (or elimination) of a *difference* between *existing* processes, it represents more of an incremental approach to innovation than radical change. Given this evidence, along with the fact that Benchmarking was of greater importance in Production than in R&D in the exploratory study, it is hypothesised that Benchmarking plays a significantly more important role in enabling incremental innovations (H9a).

Project maturity

In a recent study of the *"invisible"* success factors in product innovation, Cooper (1999) argues that superior up-front homework (more time, money and better quality work) and sharp, stable and *early* product definition (product requirements, features and

[14] For a more comprehensive summary of the role of environmental factors in enabling pioneering versus radical innovation, consult Ali (1994).

[15] Although Benchmarking is operationalised as internal to the organisation (Chapter 4), it still relates to information gained from sources outside the object of analysis, the project team, and hence relates to external, rather than internal, learning.

specifications) are critical to new product success. Since Benchmarking allows the team to compare technologies and products and identify the necessary standards for these, this enabler should play a significant role in the initiation of innovations. Benchmarking is, however, a continuous process: it ensures the Quality of the development process and allows the team to continually measure itself against changing standards. Ansoff & Stewart (1967) relate how results achieved on another project may obsolete a piece of research or change its priority. Given the validity of this argument and the fact that findings from the exploratory survey contradict those of Cooper, it is suggested that project maturity does not moderate the importance of Benchmarking (H9b).

3.3.3.2.2 Competitors

Project radicalness

In investigating the relationship between organisational evolution and innovation strategy, Tushman & O'Reilly (1996) note that discontinuous change is almost always driven either by organisational performance problems or by major shifts in the organisation's technological or competitive environments. Therefore, organisations should not only react to environmental jolts, but also proactively initiate innovations that reshape their market. In light of this, completing a thorough external audit of alternative technologies of competitors is an important enabler of radical innovation (Lynn, 1998).

Dasgupta & Stiglitz (1980) distinguish between competition in R&D and competition in product markets. It is argued that competition in R&D is more likely to be relevant for pioneering products which managers design to find specific uses or markets for a promising technology (so-called *technology-push* products), whereas competition in the current product market is more likely to be relevant for modified versions of existing products aimed at satisfying market needs (so-called *market-pull* products). Given the need for higher levels of R&D in competitive markets (Jankowski, 1998; Balachandra & Friar, 1997), Ali (1994) argues that, as the number of organisations in an industry increases (leading to fiercer competition), the rate of introduction of pioneering products increases.

Despite a lack of rigorous empirical evidence, findings in the literature consistently underline the role of Competitors in enabling radical innovation. In this regard it must be noted that the results of the exploratory study not only show that the influence of

Competitors is equally important in R&D and Production, but that activities such as strategic scanning and analysis of new markets play significantly more important roles in Production than R&D, and therefore should be of greater importance to incremental innovation. It is, however, the contention of the author that the consistent findings from the literature are more trustworthy than those of the exploratory study[16]: Hence, it is hypothesised that Competitors play a significantly more important role in enabling radical than incremental innovation (H10a).

Project maturity

As pointed out in Chapter 2, information gleaned from Competitors most significantly provides input for strategic decision-making and positioning: by learning about competitive technologies in the market, the project team is able to *define* a particular direction in which product development should be channelled (Kessler et al., 2000). In this regard, Competitors play a very important role in the initiation of innovations. Rice et al. (1998) provide anecdotal evidence of the importance of scanning of the market for idea generation. Once the idea has been generated and a route for development has been crystallised, Competitors start playing a lesser role in the development process of the innovation. Based on this argument, hypothesis H10b is forwarded, viz. Competitors play a significantly more important role in enabling the initiation than implementation of innovations.

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3.3.3.2.3 Customers

Project radicalness

Since most Customers will couch their needs in terms of products they already know, involving Customers in idea generation and development of new products (listening to the *voice of the customer*) will typically result in imitative, me-too incremental innovations. Balachandra & Friar (1997) point out that traditional market analysis tools tend to direct projects toward existing markets with small, incremental advances rather than to undeveloped markets with major innovations. Frohman (1982) and Hitt et al. (1982) suggest that ideas from the Marketing department of an organisation generally

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[16] It may be argued that, although strategic scanning and analysis (exploration) of new markets enjoy relatively higher priorities in Production environments, the impact thereof is typically of greater consequence to R&D. Hence, the implications of strategic scanning and new markets should be of greater importance to radical innovations and the initiation thereof, consistent with hypotheses H10a and H10b.

result in incremental innovations, since these ideas typically generate little enthusiasm from the technical staff, to whom are attributed the *really innovative ideas* in organisations. Given the close association between Marketing and Production in operational environments, this argument is supported by results of the exploratory study, which indicate that Customers play a significantly more important role in enabling incremental innovations.

Ettlie et al. (1984) extend this notion to strategy by arguing that a market-dominated growth strategy is likely to lead to incremental, rather than radical, innovation. Lynn (1998) follows the same argument for a so-called cost-reduction strategy. Due to their unfamiliarity with radical innovations, Customers will have a difficult time in verbalising and visualising their needs associated with such innovations (Lynn, 1998). In fact, from the point of view of the organisation, the ultimate customer for a radical innovation is typically unknown and unknowable at the beginning of the project (Lynn et al., 1998). Based on the consistency of findings in this regard, it is asserted that Customers play a significantly more important role in enabling incremental than radical innovation (H11a).

Project maturity

Many authors have stressed the importance of the customer for idea generation (Cooper, 1999; Miller, 1998; Morden, 1989). In fact, Shenhar et al. (2002) provides empirical support for this. However, as Garvin (1993) points out, Customers should continuously be involved in the product development process due to the valuable input they provide on (1) up-to-date product requirements, (2) changing preferences, and (3) feedback regarding service and patterns of use. Jenkins et al. (1997) stresses the importance of test marketing with a number of key Customers to ensure that the product matches customer specifications and that it can be produced reliably. Hence, customer involvement during the entire life cycle of the project is imperative. Given the validity of this argument and the fact that findings from the exploratory survey contradict those of Shenhar et al. (2002), it is suggested that project maturity does not moderate the importance of Customers (H11b).

3.3.3.2.4 Suppliers of Technology

Project radicalness

Brown & Eisenhardt (1995) argue that extensive supplier involvement in design of the project can *"cut the complexity of the project"* – thus, in relating radicalness to complexity, it may be argued that Suppliers enable the acceleration of radical projects. Often Suppliers become so involved in the project that they become *partners* in the development process. Rice et al. (1998) note that throughout the discontinuous innovation process, participation of (internal and) external partners varied but had a significant impact. This notion is supported by Stringer (2000), who advocates experimentation with joint ventures and alliances for the development of radical innovations. These findings are supported by the results from the exploratory study, which show that Suppliers of Technology play a significantly more important role in R&D and therefore, radical innovations.

Kessler & Chakrabarti (1999) contradict these arguments by presenting empirical evidence that, for both radical and incremental innovations, utilisation of external sources of technologies decelerated innovation. These findings are consistent with the works of Kessler et al. (2000) and Bierly & Chakrabarti (1996) who attribute this phenomenon to the *efficiency of learning*. According to this concept, involvement of external technologies or partners is associated with slower development due to a lesser sense of ownership of the project and less understanding and interpretation within the team (compared to internal sources of knowledge). In light of the contradictory evidence in this regard, it is therefore suggested that the importance of Suppliers of Technology is not moderated by project radicalness (H12a).

Project maturity

Brown & Eisenhardt (1995) argue that extensive supplier involvement in product design can cut the complexity of the project through early identification of potential downstream problems. Thus, in the context of design, supplier involvement is important from an initiation perspective, as echoed by results of the exploratory study. On the other hand, it may be argued that reliance on Suppliers is also important for implementation of these designs, since customised solutions are typically needed during this stage to streamline the sourced technology with the current process. Despite evidence to the contrary (Kessler et al., 2000), such actions generally translate into savings of cost and time.

Hence, analogous to the role of Customers in innovation, Suppliers play an important role in enabling innovation from initiation to implementation (H12b).

3.3.4 Process-related enablers

Jenkins et al. (1997) define the aim of any program for the management of the innovation process as a tool to improve the quality and efficiency of innovation, in order to maximise the organisation's success rate for new products. In this regard, Quality and Formalisation of the process are key issues. These are considered in the following paragraphs.

3.3.4.1 Quality

Project radicalness

Jenkins et al. (1997) further argue that this is particularly true in the case where an innovation is not entirely new, since the project team is able to exploit the knowledge and experience gained throughout previous projects. In light of this, it may be argued that the program for the management of the innovation process would have greater value in enabling incremental than radical innovations. This notion is echoed by Deschamps & Nayak (1995), who argue that the Quality of the innovation process provides a sustainable source of *improvements* in the *Quality* of individual new innovations. Since Quality initiatives and programs (such as TQM and QFD) that underpin the innovation process are based upon measurement and feedback of existing processes and systems, it may be argued that Quality enables continuous improvement and incremental innovation, rather than radical changes. This argument is supported by the results of the exploratory study, which indicate that Quality is of significantly higher importance in Production than R&D environments and therefore should be of greater importance in the case of incremental innovations. Hence, it is hypothesised that Quality plays a significantly more important role in enabling incremental than radical innovation (H13a).

Project maturity

Ansoff & Stewart (1967) argue that in development-intensive activities the technical task is not to create new alternatives, but to reduce available alternatives to a single solution for implementation. As soon as this has been done, optimisation of the solution becomes imperative: quality-oriented strategies play an important role in achieving this. Supportive of this theory, but from a different perspective, Kiella & Golhar (1997) argue that Quality control is difficult to apply in research-intensive activities, due to the frequent changes and high degrees of variation inherent to these activities. Hence it is suggested that early measurement techniques (such as TQM) could be erroneous and might allow incorrect conclusions to be drawn during research-intensive activities.

Most modern quality-oriented strategies (such as QFD and Value Analysis), however, advocate applying quality-principles to *all* activities in the product development process, from research to implementation. Shenhar et al. (2002) argue for the need to account for design considerations such as Quality during the design and development stages of projects (specifically for high-uncertainty projects). QFD, for example, takes the voice of the customer from the beginning of product development and deploys it via a sequence of phases to deliver a product that maximises customer satisfaction and minimises waste (King, 1987). As such, QFD is not only a quality tool, but also a planning tool for developing new products and improving existing products (Vonderembse & Raghunathan, 1997).

When the role of the voice of the customer in idea generation is classified as a *customer-related enabler* rather than a *Quality-related enabler* (as it is in the context of this study[17]), it may be argued that Quality plays a more important role during implementation of innovations than initiation thereof (H13b). This hypothesis is supported by results from the exploratory study.

3.3.4.2 Planning & Procedures

Project radicalness

Jenkins et al. (1997) further argue for proper planning of the innovation process. *Planning & Procedures* not only facilitate co-ordination between role-players, but also allow for planning of activities that can be carried out in parallel. In this context, Ruekert & Walker (1987) have argued that *"the use of rules and standard operating procedures appears to reduce confusion over individual roles, and thus foster more productive interdepartmental interaction"*. Given the higher relative importance of interdepartmental

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[17] This, once again, highlights the role of classification of enablers (or factors) in determining the context in which these factors are interpreted.

interaction for radical innovation, it may be argued that Planning & Procedures enable radical innovation more so than incremental innovation. From a different, but related, perspective, Shenhar et al. (2002) find that clearly identified milestones, a detailed work breakdown structure and schedule-monitoring techniques are extremely important to the success of high-uncertainty projects. Since these issues relate closely to project planning and control, it may be argued that Planning & Procedures play an important role in enabling radical innovation.

From an opposite perspective, Planning & Procedures are also closely related to control, since the decisions made and steps taken regarding one aspect of the project have important consequences for all other aspects thereof. Hence, Planning & Procedures aim to establish *routines* to ensure smoothness of development (Nord & Tucker, 1987). Such routines present less resistance to the development of incremental innovations that are more certain and familiar to the organisation. Radical innovations are often associated with uprooting long-standing routines – as McKee (1992) notes: *"Discontinuous innovation requires creation of an internal environment that allows unstructured, playful, contentious and rambling decision processes".* Indeed, Brown & Eisenhardt (1995) argue that, under conditions of uncertainty, maintaining flexibility and learning quickly through improvisation and experience yield effective process performance.

Chapman et al. (2001) provide empirical evidence of the fact that organisations with highly customised and low technical complexity products use project planning and control as the most common lever to manage product development activities. Relating such product attributes to a low-risk strategy of incremental (product) innovation, the role of Planning & Procedures in enabling incremental innovation is illustrated. Therefore, given that (1) findings on the relative importance of Planning & Procedures are not consistent, and (2) this enabler was of equal importance for R&D and Production in the exploratory study, hypothesis H14a is forwarded.

Project maturity

The relationship between formalisation and project maturity is well understood: despite a lack of empirical evidence, research findings provide a relatively consistent view of the need for increased formalisation as the development of the project continues. In this regard, Johne & Snelson (1988) argue that largely informal and non-standardised procedures should be applied in the initiation phase of the innovation process. Lanigan (1994) calls this a “broad-brush” approach to project planning and control, while Ansoff & Stewart (1967) views it as a sacrifice of efficiency in planning and control, due to the highly speculative nature of activities in this phase. At the other end of the project life cycle spectrum, Lanigan (1994) and Johne & Snelson (1988) assert that, once the product proposition is crystallised, more formal and rigid controls are necessary in order to establish credible project time and cost estimates, as well as to time the launch into the market place successfully.

Jenkins et al. (1997) provide the only evidence to the contrary. In this study it is argued that the project team should concentrate on initial planning stages of the project, so that downstream engineering changes are kept to a minimum. It is, however, contended that this argument is forwarded not to suggest a more formalised approach to the initiation of innovations, but rather to remind researchers of the need for detailed and early product definition, since this has been proven to be a key determinant of new product success (Cooper 1999). This issue has previously been addressed under Benchmarking (cf. information-related enablers). Therefore, given the overwhelming evidence in the literature regarding the relationship between planning and project maturity, it is hypothesised that Planning & Procedures play a significantly more important role in enabling innovation during implementation (H14b).

3.3.5 Individual-related enablers

In Chapter 2, two central issues surrounding the roles of identified were identified and discussed, i.e. the nature of the roles people adopt and the knowledge and skills embedded in employees. Considering the five major work roles critical to innovation (Roberts & Fusfeld, 1981), those of Championing and project leadership are relevant in the context of the new product development *project*[18]. However, project leadership has already been treated under management-related enablers. Thus, in terms of roles individuals adopt, this section will focus only on the importance of Championing. Knowledge and skills embedded in employees, and the development these traits, also

[18] In the context of the product development *project*, the role of the gatekeeper is less relevant since it relates to capturing and dissemination of information at an organisational (inter-team) level.

relate more to initiatives at an organisational level and hence have little relevance in the context of the *project.* However, individual motivation was identified to be an important driver for successful innovation – thus, it is also the purpose of this section to investigate how project radicalness and maturity influence the role and importance of intrinsic motivation (especially in terms of tenacity and challenge) of individuals.

3.3.5.1 Championing

Project radicalness

Given the importance of the roles of individuals in innovation, it may be argued that the type of person needed in a project is moderated by its radicalness. McDonough (1993) makes the following claim: *"The actions that technology managers can take to speed up development are different for radical versus routine projects. Selecting individuals to lead or be a member of radical projects involves different criteria than selecting individuals for routine projects. Thus, there is no 'one best' leader or team for project development. It depends on the type of work that is being undertaken."*

Ettlie et al. (1984) were the first to provide empirical evidence of the fact that radical process innovation is significantly promoted by the *presence* of a champion. In a more recent study, Lee & Na (1994) hypothesised that, apart from his/her presence, the *rank* and *timing of appearance* of a champion are also positively related to the technical performance of the innovation and that these relationships are stronger if the technical innovativeness is radical. Empirical results, however, showed no significant relationships between rank, timing and performance, but did show that the existence of a champion is more important for radical innovations.

These findings are partially contradicted by Kessler & Chakrabarti (1999) who find that different levels of influence (closely associated with *rank*) of a champion are indeed associated with different levels of project radicalness. It is argued that radical change projects involve much uncertainty and hence exhibit a greater propensity for political activity – therefore, champions with more *political savvy* are needed for radical innovations[19]. Alternatively, incremental innovations represent less fertile ground for dysfunctional political activity and hence need less such Championing.

However, for the purpose of this study, attention is limited simply to the *degree* of Championing necessary for a project of a particular radicalness, irrespective of the attributes of the person who acts as champion. Therefore, based on the consistency of findings on the importance of champions, it is suggested that Championing plays a significantly more important role in enabling radical innovation (H15a).

Project maturity

The PDMA glossary (online) defines the role of a champion as varying from *"situations calling for little more than stimulating awareness of the opportunity to extreme cases where the champion tries to force a project past the strongly entrenched internal resistance of company policy or that of objecting parties".* Howell & Higgins (1990) add that champions use visionary statements and stimulating ideas to influence the actions of others.

These statements reflect the important role of a champion in the initiation of an innovation. Once the idea is accepted and supported by top management, resources are allocated for its implementation and the majority of internal resistance to the project is eliminated. Johne & Snelson (1988) suggest that the role of the project leader or manager then replaces that of the champion. In light of this, it is hypothesised that champions play a more important role in enabling the initiation of innovations (H15b).

3.3.5.2 Intrinsic motivation

Project radicalness

Herzberg (1987), arguably one of the most prominent behaviourist researchers, has suggested that intrinsic factors represent some of the most important influences on job

[19] In using the term *political*, the concepts of champion and *sponsor* are slightly confused. Since the role of sponsoring is typically associated with a *"higher-ranking person in the firm"* (PDMA glossary) and a high rank is associated with political power, use of the term *sponsor* would be more appropriate in this case. However, in the context of this study, a distinction is not made between the concepts (as is probably the case in the study cited): hence, the above argument remains valid.

satisfaction and hence, employee performance[20]. Savery (1996) provides empirical evidence of this in a recent study on motivation and job satisfaction, stating that *"intrinsic motivators are the most important items influencing a person's job satisfaction"*. In this regard, it is suggested that employees' feeling of achievement be enriched through provision of interesting and challenging work[21].

Olson et al. (1995) argue that because employees have less relevant experience to draw on when developing new and innovative product concepts, they typically see their task as more challenging. Stringer (2000), on the other hand, argues that radical innovation grows from individuals' need for achievement. Having established the link between intrinsic motivation, challenge and need for achievement, it may be argued that intrinsic motivation is more important for radical than incremental innovation (H16a). This argument is supported by results of the exploratory study in terms of the enabler Skills & Competences, since it was illustrated in Chapter 2 how job satisfaction (or matching people to their jobs, as operationalised in the exploratory study) maximises intrinsic motivation.

Project maturity

Kiella & Golhar (1997) argue that, for people involved in research-intensive activities, it may often become clear that research just might not make it through development, despite good research. Given the one percent odds for success in this environment[22], it may be argued that the intrinsic motivation necessary in research should be higher than during later stages of the project when certainty and organisational commitment to the project is greater. On the other hand, Drucker (1985) argues that innovation often "begins with the analysis of the sources of new opportunities" but "when all is said and done, what innovation requires is hard, focused, purposeful work. If diligence, persistence and commitment are lacking, talent, ingenuity and knowledge are of no avail". Hence, intrinsic motivation also plays an important role during the implementation

[20] Although a number of subsequent studies have disputed the rankings of importance of such intrinsic factors (compared to other factors, including extrinsic factors), the role of intrinsic factors in driving motivation has never been disputed.

[21] A considerable body of research pertaining to the motivation of individuals is available in the literature. This, however, falls outside the scope of this study, the object of which is simply to establish a link between intrinsic motivation, challenge and need for achievement.

[22] Shapiro & White (1994) relate that typically, for every one successful innovation, there are roughly 100 failures.

of innovations. Given this result, and the fact that the enabler related to intrinsic motivation in the exploratory study was of equal importance between R&D and Production, hypothesis H16b is forwarded, viz. project maturity does not moderate the importance of intrinsic motivation of individuals.

3.4 SUMMARY

The purpose of this chapter has been to summarise and analyse the contrasting evidence cited in the literature pertaining to the relative importance of project-based enablers of innovation. Based upon a comparison of these findings, and inferences made from an exploratory study on the relative importance of enablers in functional environments, a number of hypotheses regarding the roles of project radicalness and maturity in moderating the importance of enablers of innovation have been forwarded for empirical testing. The outcomes of these hypotheses form the basis for the development of a contingency model for the importance of enablers in Chapter 6. The following chapter presents the research methodology followed in collecting data for testing of these hypotheses.

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APPENDIX TO CHAPTER 3

Summary of Hypotheses

H1a: Leadership plays a significantly more important role in enabling radical than incremental innovation.

H1b: Leadership plays a significantly more important role in enabling the initiation than implementation of innovations.

H2a: Project radicalness does not moderate the importance of the tenure of team members.

H2b: Tenure of team members plays a significantly more important role in enabling the implementation than initiation of innovations.

H3a: Reward & Recognition plays a significantly more important role in enabling radical than incremental innovation.

H3b: Project maturity does not moderate the importance of Reward & Recognition attributed to the team.

H4a: Enablers related to the sub-culture of the project team, such as Creativity, Risk-taking and Experimentation play significantly more important roles in enabling radical than incremental innovation.

H4b: Enablers related to the sub-culture of the project team, such as Creativity, Risk-taking and Experimentation play significantly more important roles in enabling the initiation than implementation of innovations.

H5a1: Specialisation plays a significantly more important role in enabling radical than incremental innovation.

H5b1: Specialisation plays a significantly more important role in enabling the initiation than implementation of innovations.

H5a2: Project radicalness does not moderate the importance of Cross-functionality in the team.
H5b2: Project maturity does not moderate the importance of the Cross-functionality of the team.

H6a: Team autonomy plays a significantly more important role in enabling radical than incremental innovation.
H6b: Team autonomy plays a significantly more important role in enabling the initiation than implementation of innovations.

H7a1: Project radicalness does not moderate the importance of less-rich media of communication.
H7a2: Rich media of communication play a significantly more important role in enabling radical than incremental innovation.
H7b1: Project maturity does not moderate the importance of less-rich media of communication.
H7b2: Rich media of communication play a significantly more important role in enabling the initiation than implementation of innovations.

H8a: Project radicalness does not moderate the importance of Learning from the past.
H8b: Project maturity does not moderate the importance of Learning from the past.

H9a: Benchmarking plays a significantly more important role in enabling incremental than radical innovation.
H9b: Project maturity does not moderate the importance of Benchmarking.

H10a: Competition plays a significantly more important role in enabling radical than incremental innovation.
H10b: Competition plays a significantly more important role in enabling the initiation than implementation of innovations.

H11a: Customers play a significantly more important role in enabling incremental than radical innovation.
H11b: Project maturity does not moderate the importance of Customers.

H12a: Project radicalness does not moderate the importance of Suppliers of Technology.
H12b: Project maturity does not moderate the importance of Suppliers of Technology.

H13a: Quality plays a significantly more important role in enabling incremental than radical innovation.
H13b: Quality plays a significantly more important role in enabling the implementation than initiation of innovations.

H14a: Project radicalness does not moderate the importance of Planning & Procedures.
H14b: Planning & Procedures play a significantly more important role in enabling the implementation than initiation of innovations.

H15a: Championing plays a significantly more important role in enabling radical than incremental innovation.
H15b: Championing plays a significantly more important role in enabling the initiation than implementation of innovations.

H16a: Intrinsic motivation of individuals plays a significantly more important role in enabling radical than incremental innovation.
H16b: Project maturity does not moderate the importance of intrinsic motivation of individuals.

CHAPTER 4

Research Methodology

4.1 INTRODUCTION

In order to determine the validity of hypotheses forwarded in Chapter 3, the main study followed qualitative and quantitative approaches at the project-level of analysis in order to capture the unique situational attributes that influence the processes and outcomes of actual projects. In this way, concrete conclusions regarding the roles of project radicalness and maturity in moderating the importance of enablers of innovation were made possible. This section presents the general research design of the study and discusses the selection of projects and their associated respondents, upon which data collection was based. Alongside this, the methodologies used for classification and analysis of data are presented.

4.2 RESEARCH DESIGN

Development of the research protocol for the study was driven by a desire to fundamentally understand how the radical innovation process differs from that of incremental innovation, and the role of project maturity in this. For this purpose, a multiple case comparison methodology was used. Veryzer (1998) argues that case study research involves examination of the phenomenon in its natural setting and hence is especially appropriate for research in new topic areas and in obtaining critical insights.

As stated in the introduction to this section, the unit of analysis for the main study was the *innovation project*, since the project-level of analysis is most directly relevant to those attributes of innovation that represent the subject of this research – project radicalness and maturity. Kessler & Chakrabarti (1999) argue that the unit of analysis is an important consideration, since enablers that are appropriate in explaining differences in innovation at the organisational or functional level *may not be* either operational or meaningful in explaining phenomena between different types of projects[1].

While the majority of studies relating to the critical success factors of innovation (and their relative importance) have employed cross-sectional methods involving a large number of projects in a variety of organisations, this study comprised an in-depth investigation of a significant number of projects within *a single organisation* surveyed in the exploratory study. Selection of this organisation was motivated by the following factors:

- *Size*. It is South Africa's largest single industrial investor, with fixed capital expenditure amounting to more than US$1.3 billion over the past 5 years. It employs over 31 000 employees and has recently posted annual sales in excess of US$ 6 billion[2].
- *Performance in innovation*. The organisation has an impressive track record in producing innovative products and processes since the early 1960's. It operates a number of centres of R&D excellence and related activities for innovation, both locally and in North America and Europe. It boasts one of the strongest concentrations of science and engineering doctorates in science and engineering in the southern hemisphere (in its field of expertise). Numerous international awards have recognised the organisation's pioneering of unique products and technologies.
- *Project management capability*. It employs an established and formalised program for the management of innovation projects, which is a necessary criterion for investigating the role of project maturity on enabler importance. Currently the organisation has major projects (both locally and internationally, in partnership with global players) to the value of approximately US$6 billion in progress, with completion dates ranging from 2003 – 2005.
- *Familiarity*. The organisation was chosen for its close and long-standing relationship with the researcher and the research institution which he represents, and its willingness to co-operate to the furthest extent in terms of data collection.

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[1] Cooper & Kleinschmidt (1995) propose the converse argument, i.e. that an organisational-level of analysis should be adopted in that it facilitates the identification of company characteristics that influence project-level success, which, at the project-level, would be invisible. Ultimately, both arguments are valid if the levels at which different enablers are *operational and meaningful* (Veryzer, 1998) are kept in mind.

[2] Based on its annual report for 2002.

The fact that the sample consisted of projects within a single organisation may make the findings less representative than if data had been collected from a broader sample of organisations. However, focusing on only one organisation enabled the researcher to obtain an in-depth and integrative understanding of the roles of, and interactions between, different enablers in driving innovation. Given that the study is aimed at the validation of a theoretical model of enabler importance, based in part on findings from a multi-organisation perspective, the research design sacrificed some level of external validity for the necessity of demonstrating internal validity of the model, as argued by Ruekert & Walker (1987). This methodology is consistent with other (R&D-based) studies in the field, particularly those by Allen et al. (1980) and Wolff et al. (1981).

4.3 DESIGN OF THE QUESTIONNAIRE

Design of the questionnaire was dictated by the fact that it needed to (1) serve as a basis for personal interviews for the collection of qualitative data, and (2) provide a standard scale according to which interviewees' perceptions[3] of the importance of enablers in the context of the specific project could be scored (for quantitative purposes). In light of this, a simple questionnaire was developed in which enablers were listed according to the framework of Craig & Hart (1992). The definitions and meanings of these enablers were discussed with interviewees - in this way, maximum congruence between interviewees' interpretations of enablers and their operationalisation during formulation of hypotheses was ensured.

Analogous to the collection of quantitative data in the exploratory study, interviewees were also asked to rate the importance of enablers according to their perceptions in the project. For this purpose, a 10-point Likert-type scale was adopted, since it was believed that a 5-point scale would not yield sufficient "resolution" in distinguishing between the importances of enablers for different projects and attributes thereof. This scale ranged from "Low Importance" (1) to "High Importance" (10). Appendix B1 shows the layout of a typical questionnaire.

[3] Refer to section A1.2.1 in Appendix A1 for comments regarding the validity of using Likert-scales in self-assessment tests.

In addition to measuring the perceptions of respondents on the importance of these enablers, data was also collected regarding the following aspects of the respondent and project, for data classification purposes:

- Name of the project,
- Function of the respondent in the project (leader or team member),
- Project maturity, according to the innovation project management program (model) of the organisation, and
- Project radicalness, according to a pre-defined classification scheme.

Aspects pertaining to key informants and respondents, as well as the characteristics of projects, are considered in greater detail in the following section.

4.4 RESEARCH SAMPLE

4.4.1 Projects

Project selection was governed by the fact that a representative number of projects spanning the continua of radicalness and maturity needed to be sampled. In addition to this consideration, projects needed to satisfy the following criteria:

- *Real-time sampling*. Veryzer (1999) and Shenhar (2001) argue that studying new product development as close to the process as possible, in real time, offers the best opportunity for addressing research questions at hand. In light of this, only projects that were currently in development during sampling, i.e. in some stage of the organisation's product development process, were selected. This methodology effectively addressed concerns related to the inaccuracy of retrospective views and perceptions of past projects, as highlighted by Fowler (1988).
- Since projects were sampled according to stages of development *prior to commercialisation*, and hence commercial success of the project was not guaranteed, it was left to the discretion of the executive in charge of product development to identify projects that were considered to be *commercially viable* at the time of study.
- Projects identified needed to be typical of product development in the organisation, in order not to result in a sample of exception and outlier projects

(Kessler & Chakrabarti, 1999). Essentially this translated into projects in which the organisation had some degree of existing competency, albeit low in the case of radical innovations.

- Projects identified needed to contain significant technological components. This was a necessary condition for keeping the scope of the study within the bounds of technological innovation.

The Head of Process Development at the organisation was interviewed to develop a list of projects that fitted the objectives of the study. During these meetings, project leaders and team members were identified for interviews. Given the fact that the projects were not chosen randomly, caution should be exercised in generalising the results, since they may not be representative of projects in general. However, as mentioned earlier, it is believed that the methodology followed for project selection and data collection allows for the generalisation of results to other organisations in the industry[4].

4.4.1.1 Project radicalness

Although hypotheses forwarded in Chapter 3 relate to the simple distinction between radical and incremental, a suitable classification scheme for process innovations[5] needed to be found according to which projects could objectively be divided between radical and incremental. The only suitable taxonomy that currently exists in the literature for this purpose is that of Van Deventer (1991), who suggested a classification scheme for process innovations based on a number of actions and objectives associated with the innovation. Although this action-objective matrix was considered for use during the design of the questionnaire, it was deemed overly complex for the simple classification of projects between radical and incremental.

Booz-Allen & Hamilton's (1982) six-category classification scheme arguably represents the most popular means of measuring the innovativeness of *product innovations*. Based on the arguments of Griffin & Page (1996) that this classification system (1) implicitly captures the process technological aspects of projects, and (2) seems to best follow

[4] Practically the entire portfolio of projects of the organisation in the R&D Stage Gate and BD&I Models (i.e. major projects with durations in excess of 6 months) were sampled. Hence, it may be argued that conclusions are (1) certainly valid for the sampled organisation, and (2) may be extrapolated to other organisations pursuing similar types of innovations (in analogous industries).

[5] As stated in Chapter 1, innovations surveyed were primarily process-related.

industry semantics in describing types of projects, it was decided to use a modified version thereof for the classification of process innovations. By adapting the terminology of the original scheme to also encompass process innovation, the following scheme was used for project classification[6]:

1. New-to-the-world technology,
2. New-to-the-company technology,
3. Additions to existing product lines or processes,
4. Improvements/Revisions to existing products or processes,
5. Repositionings, and
6. Cost reductions.

For data analysis, projects associated with numbers 1 – 3 were classified as radical, whereas those associated with numbers 4 – 6 were classified as incremental. A total of 27 projects were identified, 12 (44%) of which were radical and 15 (56%) incremental – hence a balanced spread of radical and incremental projects were surveyed, eliminating a possible bias in the validity of results for the effect of project radicalness.

4.4.1.2 Project maturity

It was pointed out earlier that a necessary criterion for investigation of the moderating role of project maturity on enabler importance was that the organisation relied on a formalised and established model for the management of the innovation process. This was an important consideration in that it allowed the research team to classify the projects undertaken by the organisation according to the stage of development with which they were associated, as defined by the new product development model. This methodology provided a structured and objective way of classifying projects according to their maturity.

The organisation selected for sampling in the main study employs two linked NPD models. The first relates to the management of mainly Front End Loading activities, and is generally associated with R&D – hence its name: R&D Stage Gate Model. The second model relates more specifically to the development and implementation of business opportunities generated from the first model, and is generally used by people outside of

[6] The Head of Process Development verified the appropriateness of this classification scheme beforehand.

the R&D-sphere – hence its name: Business Development and Implementation (BD&I) Model. Although these models are characterised by distinct stages and gates, they overlap in the typical activities that are associated with different phases of the innovation process.

The R&D Stage Gate Model is characterised by the following stages:

A. Ideation,
B. Assessment,
C. Research, and
D. Scale-up (Piloting)

The BD&I Model is characterised by the following stages:

I. Pre-feasibility,
II. Feasibility,
III. Basic Development,
IV. Execution,
V. Start-up, and
VI. Evaluation & Operation.

Due to some degree of overlap between these models, and in an attempt to reduce these stages to a smaller number, the Head of Process Development was asked to coalesce these models into a condensed version according to which the maturity of projects could be classified. Grouping stages according to related activities and accounting for analogous stages between the two separate models, a final model consisting of 5 stages was suggested, as depicted in Figure 4.1.

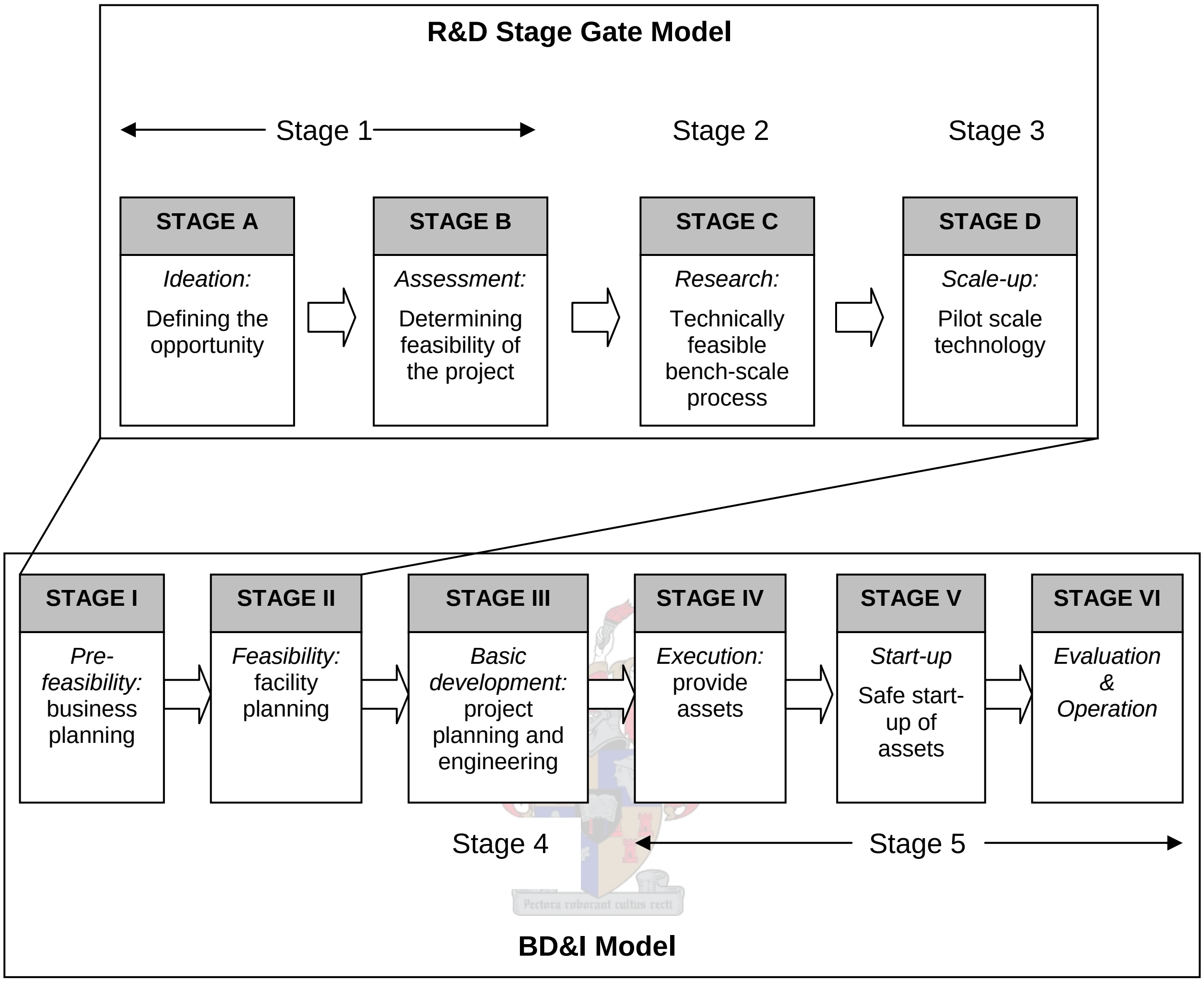

Figure 4.1 Integration of the stages of the R&D Stage Gate and BD&I models to yield a final model consisting of 5 stages according to which projects were classified

Projects selected in terms of radicalness were then classified according to this model. If it was found that certain elements of the (2x5) radicalness-maturity matrix lacked representative projects, additional projects were identified to fill such gaps. In a number of cases this proved difficult, since the choice of projects was constrained by the portfolio of projects under development at the organisation. Hence, a few elements of the matrix were ill represented. This impacted negatively on the reliability of some data points in graphs depicting general trends in the importance of enablers from stages 1 to 5[7]. However, in terms of the dichotomies between project radicalness and maturity (for the purposes of testing the hypotheses), all of the four elements of the resulting 2x2 matrix were represented adequately.

4.4.2 Key Informants and Respondents

As noted earlier, perspectives were sought from both project leaders and team members. Chakrabarti (1989) and Katz & Tushman (1979) argue that, since leaders and members have different tasks and are exposed to different aspects of projects, they bring different perspectives to a project. Additionally, where possible, both technically (scientists and engineers) and business-oriented team members were interviewed – because of their differing backgrounds and responsibilities, individuals from different disciplines emphasise different aspects of projects.

By polling multiple respondents for each project, the validity and reliability of scores given for a project were increased. However, in two cases only one person per project (typically the project leader) was interviewed, due to time constraints or low staffing of the project. In spite of the appropriateness of these respondents, concerns about single respondents remain an issue. However, as noted by Cooper & Kleinschmidt (1995), the use of single respondents is valid when the respondents have unique process insights. In total, 63 respondents were interviewed, yielding an average of 2.3 respondents per project. Given that this average translated into 16 respondents for each of the radicalness-maturity configurations, it was believed that a sufficient number of respondents had been polled. This was confirmed by an analysis of the residuals of scores, which showed that experimental data was robust and that its spread was within acceptable limits[8].

[7] In Chapter 5, knowledge of the *timing* of involvement of role players or deployment of resources during the innovation process was cited as an important reason for investigating the effect of project maturity on the importance of enablers. This aspect of the study is discussed further in the following chapter.

[8] A residual is the difference between the observed value of a response measurement and the value that is fitted under a hypothesised model.

4.5 DATA COLLECTION

4.5.1 Procedure

Data collection followed a multi-faceted approach that included in-depth interviews, observations and a set questionnaire, which, as mentioned previously, was aimed at obtaining both quantitative and qualitative information from respondents. This methodology was consistent with that of Gupta & Wilemon (1990), who argued that a combination of questionnaires and interviews facilitate a clearer and better understanding of the research issues at hand.

Interviews complement structured questionnaires by eliciting remarks and anecdotal evidence that lead to useful insights regarding quantitative data collected from respondents: not only do they allow asking of additional questions and issues not covered in the questionnaire, but they also have the ability to probe into interesting issues that arise during the course of interviews. In addition, interviews allow the researcher to "check" respondents' scores against those of previous respondents on the same project, during data collection: in this way, *seeming discrepancies* between "expected" and assigned scores are investigated if one respondent's scores departed markedly from those of other respondents on the project[9].

Despite this, the researcher's influence during the interview was limited as much as possible, since the aim of the study was respondents' subjective understanding and knowledge of the innovation process. In so doing, the respondent's own understanding of causes and effects guided the actual interview. To strengthen the validity of the qualitative research, interviews were conducted on employees' own turf, as suggested by Kirk & Miller (1986) – this was achieved by being based at the organisation for the total period of time over which interviews lasted. Individual interviews, which were scheduled a number of days in advance, lasted between 30 minutes and an hour – interviews with project leaders typically used the maximum time allotment, due to the fact that they were asked to provide the background information to their respective

[9] Intra-project variances in respondent scores were checked and found to be within reasonable limits, based on the normality-tests of the data. Median values of the replicates were used for ANOVAs, since this technique minimises the effect of scores that differ markedly from the average of other scores given per enabler and per project (as mentioned later in this chapter).

projects and identify additional team members for interviewing, where necessary. *All* interviews were recorded and transcribed to ensure the accuracy of qualitative results.

4.5.2 Problems experienced

Very few problems were encountered relating to respondents' willingness to co-operate, arguably due to the high degree of senior management involvement in, and support of, the study: indeed, not one person approached for an interview declined to participate. Although some respondents were wary to have their interviews recorded, issues relating to the sensitivity of information passed were addressed by having a confidentiality agreement in place.

The classification of projects according to Booz-Allen & Hamilton's (1982) scheme presented one difficulty. In a few cases, projects that were associated with additions to existing product lines or processes (number 3 on the scheme) were perceived to be incremental by respondents[10], although theoretically they should have been classified as radical. In such cases, respondents' perceptions regarding the radicalness of projects in such cases were checked against the opinion of the Head of Process Development, and were re-classified as incremental when necessary. Given this complication, it may be argued that the scheme of Booz-Allen & Hamilton, though widely known and accepted for classification of product innovations, is not wholly appropriate for *process innovations*. In this regard, it is suggested that a simple taxonomy for the innovativeness of process innovations be developed, based on key principles such as function or architecture of the innovation.

[10] Such perceptions were typically based on the perceived technological challenge posed by the project, or the fact that it licensed technology from appropriate vendors.

4.6 DATA ANALYSIS

4.6.1 Factor Analyses

Factor analysis represents a means of reducing a set of observable variables (enablers) in terms of a smaller number of variables (called "constructs" or "latent dimensions") via identification of the interrelationships among variables. Such factors are analogous to key themes of enablers, such as those proposed by Craig & Hart (1992), except that they are derived from statistical analysis and not conceptualised beforehand.

Analogous to the factor analysis technique used in the exploratory study, principal component extraction[11] was performed on the combined list of projects. The number of constructs chosen to represent the data was not chosen arbitrarily, but was determined via inspection of the compositions of constructs extracted by the statistical package. Since a Scree-test[12] did not yield a definitive answer regarding the number of constructs to use, it was left to the statistical package to determine the optimum amount of constructs to extract. Six constructs were identified in this manner. However, for constructs 5 and 6 only a single variable loaded significantly onto the construct, obviating their classification as constructs. Therefore, only four constructs[13], explaining 61% of the variance in the data, was used. All factors exhibited eigenvalues greater than one[14]. Given that (1) factor analysis is used to characterise the structures of relationships between variables, and (2) that 18 of the 20 variables were associated with the four constructs, the use of four constructs was deemed satisfactory for the purpose of determining the contexts in which the trends of individual enablers associated with the constructs, could be interpreted. Data regarding the eigenvectors and rotated factor loadings associated with each of the factors are provided in Appendix B2.

A cluster analysis[15] of the data was also performed to check the validity of results suggested by factor analysis. In this regard, correlation coefficients were calculated between pairs of enablers, which, in turn, was used to "link" enablers. In essence, therefore, enablers that showed strong correlations with another were grouped together.

[11] Using Varimax rotation
[12] A way of determining the amount of constructs to use by ordering them by variance and plotting the variance against factor number.
[13] A cut-off value of 0.57 for factor loadings was determined by inspection.
[14] In other words, the factor has greater explanatory power than a single variable.
[15] Single-linkage clustering, using Pearson product-moment correlation.

Although subtle differences can be noted between the results of the two techniques, results obtained via cluster analysis largely support those of factor analysis. Appendix B3 presents the tree-diagram of variables as generated by the cluster analysis.

4.6.2 Analyses of variance (ANOVAs)

As was the case for the exploratory study, it was necessary to bifurcate project maturity prior to ANOVA tests, due to the nature of hypotheses regarding this moderator. Classification of the five stages of development into *initiation* and *implementation* was based on the type of work and activities associated with each stage and hence, indirectly, with the functional environments *most closely* associated with these activities. Therefore, consistent with the dichotomy adopted for functional environments in the organisation and their involvement during the innovation process as discussed in Chapter 3, stage 3 was classified as relating to initiation, since it represented the last stage of R&D-dominated activities (as depicted by the R&D Stage Gate Model) aimed at establishing a working prototype, the performance of which would dictate decisions regarding its implementation. On the other hand, stage 4 was associated with *implementation* due to the functional role that mainly Engineering plays in the particular stage. Therefore, for the purpose of ANOVAs, stages 1 – 3 were grouped under *initiation*, whilst stages 4 – 5 together represented *implementation*.

In addition, separate ANOVA tests were also performed to prove that no significant inter-group differences existed at the project level, for projects with one or more respondents. Findings in this regard proved that this was indeed the case. In the case of projects for which there were more than one respondent per project, the median of the replicates were used for analyses: this technique minimises the effect of scores that differ markedly from the average of other scores given per enabler and per project.

Having performed the necessary data-preparation and validity checks[16], factorial ANOVAs[17] were performed on the average scores of enablers. Appendix B4 provides a summary of results of these ANOVAs: enablers of which the importances are

[16] This essentially amounted to testing the extent to which data was normally distributed. In the experience of Dr Kidd, no serious problems that could influence the interpretation of results were detected. This was confirmed by Shapiro-Wilk tests ($p < 0.01$) of the data.
[17] Using univariate tests of significance and sigma-restricted parameterisation.

significantly moderated by either project radicalness or maturity (or a combination of the two) are marked in bold, with asterisks reflecting the levels of significance (p-levels) of the results.

4.7 SUMMARY

The primary objective of this chapter was to present the methodology followed in (1) collecting a representative sample of quantitative and qualitative data on the perceived importance of enablers for projects of varying degrees of radicalness and maturity, and (2) classification and analysis of this data for empirical testing of hypotheses forwarded in Chapter 3. In this regard, it was discussed how a single-organisation perspective was adopted for demonstrating the internal validity of a model derived (in part) from a multi-organisation perspective. Based on a modified version of the classification scheme of Booz-Allen & Hamilton (1982) for the radicalness of projects and a coalesced version of the two innovation process management programs employed by the organisation, it was shown how data was classified and bifurcated in terms of project radicalness and maturity in preparation for statistical analysis. The results of these analyses are presented and discussed in the following chapter.

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CHAPTER 5

Results and Discussion

5.1 INTRODUCTION

In Chapter 3, a number of hypotheses were forwarded regarding the roles of project radicalness and maturity in moderating the importance of enablers of innovation. The primary objective of this chapter pertains to the testing of these hypotheses by way of the results of statistical analysis of data (factor analysis and analysis of variance). A secondary objective relates to the identification of constructs of enablers in the empirical data, since conclusions in this regard represent important implications for the conceptualisation and development of a framework for the contingency model of the importance of enablers.

5.2 RESULTS: FACTOR ANALYSIS

Although the primary purpose of this chapter relates to the results of ANOVA tests, it is important to *first* consider the results of the factor analysis, based on the following reasons:

1. If conclusions are to be made regarding the importance of constructs of enablers, it must be kept in mind that the framework of themes of enablers adopted in Chapters 2 and 3 is purely theoretical. Thus, the accuracy of conclusions made regarding these themes is dependent on the degree to which constructs in empirical data reflect these themes. This is established by means of factor analysis.
2. Constructs of enablers (also called 'latent variables') identified via factor analysis may also be subjected to analysis of variance tests, as for individual variables. Hence, a complete discussion of the results of ANOVA tests should only be done once the results of the factor analysis have been presented.

As discussed in Chapter 4, factor analysis revealed that four constructs of enablers are sufficient to characterise the structure of relationships between the enablers. Table 5.1

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provides a summary of the specific construct-enabler associations. The following section discusses the conceptualisation of the key concepts underlying each of these four constructs.

Table 5.1 Construct-enabler associations highlighted by factor analysis

CONSTRUCT 1	**CONSTRUCT 2**
Tenacity	Creativity
Cross-functionality	Leadership
Planning & Procedures	Risk-taking
Tenure of team members	Experimenting
Suppliers of Technology	Competitors
	Benchmarking

CONSTRUCT 3	**CONSTRUCT 4**
Learning from the past	Reward & Recognition
Quality	Informal Communication
Benchmarking[1]	Championing
Customers	Team autonomy

5.2.1 Construct 1

It may be argued that enablers associated with Construct 1 closely relate to the management function in the classical distinction between "management" and "leadership": whereas the management function is controlling, coordinative and directive and is aimed at managing complexity through planning, budgeting, staffing and allocation of resources, the leadership function is more inspirational (and transformational) and is aimed at coping with change through setting of direction and fostering a culture of innovation in the organisation. Based on this distinction, it is evident that the enablers associated with Construct 1 relate specifically to the complexity of the innovation and its management. Therefore, Construct 1 could be designated as complexity-related. However, Damanpour & Gopalakrishnan (1998) define complexity as

[1] Note that Benchmarking loads ambiguously upon Constructs 2 and 3. This is due to the dual role that it plays in enabling innovation, as will be explained in this section. However, according to the correlation matrix of Phase II, Benchmarking should be associated most closely with Construct 2.

relating to specialisation, functional differentiation and professionalism, but not formalisation (with which Planning & Procedures is typically associated in the literature, although not operationalised as such in this study). Therefore, consistent with the terminology of Shenhar et al. (2002), which designates scope as encompassing elements of both complexity *and* control[2], Construct 1 is designated as scope-related for the purposes of consistency with terminology used in the literature.

It may be argued that Tenacity has very little relevance in this construct and should be associated more closely with Construct 4, which pertains to the Individual. However, this study suggests that the enabler acts as a surrogate variable for project coordination. In attempting to measure the interaction between the importance of intrinsic and extrinsic motivation of individuals[3], Tenacity was defined as the degree to which team members are intrinsically motivated by the challenge and effort (difficulty) inherent in the project which, in turn, may relate either to (1) the technical difficulty of the project, or (2) the coordination and execution thereof (the logistical challenge), as echoed by a number of respondents. Given Tenacity's strong correlation with enablers such as Cross-functionality ($r = 0.64$, $p < 0.05$)[4] and Planning & Procedures ($r = 0.57$; $p < 0.05$), the notion that Tenacity is closely associated with project scope and coordination is supported.

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5.2.2 Construct 2

Construct 2 represents the creation and acquisition of new knowledge. Choo (2001b) suggests that new knowledge is created (or acquired) by (1) knowledge conversion, (2) knowledge building, and (3) knowledge linking. In knowledge conversion, the team continuously creates new knowledge by converting between the personal, tacit knowledge of individuals who develop creative insight, and the shared, explicit knowledge by which the organisation develops new innovations. Creativity plays an important role in this – through it, existing paradigms and frameworks of knowledge in the organisation are challenged. Knowledge building, on the other hand, is derived from

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[2] As defined by Damanpour & Gopalakrishnan (1998), control is related to (1) formalisation, (2) centralisation, and (3) vertical differentiation.
[3] Intrinsic motivation comes from within – internal forces create desire; extrinsic motivation comes from outside – external forces create desire.
[4] A correlation coefficient (r) of 0.4 and higher is considered to represent a relatively strong correlation.

activities such as shared problem solving, experimenting (and concomitant risk-taking) and prototyping. Through this process, the organisation extends its existing capabilities and builds new ones for the future. Finally, knowledge linking refers to the derivation of knowledge from other teams (Benchmarking), organisations (Competitors) and other incoming flows of knowledge from Suppliers, Customers and partners[5]. This process is enabled by the transfer and interpretation of knowledge from the environment by Leadership, especially in terms of the ways leaders frame opportunities within the team and organisation (Schrader et al., 1993)[6].

Together these processes constitute learning in an organisational context (so-called organisational learning), as defined by Garvin (1993). Shrivastava & Grant (1985) propose an analogous definition of the concept, viz. *"the autonomous capacity of organisations to create, share and use strategic information about themselves and their environments for strategic decision-making"*[7], which is consistent with the modern distinction between internal and external learning, as suggested by Kessler et al. (2000). Therefore, given the fact that the concept of learning encompasses all the processes associated with knowledge creation and acquisition[8], Construct 2 is conceptualised as being learning-orientated for the purposes of this study.

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5.2.3 Construct 3

The key concept underlying Construct 3 may be interpreted in terms of Excellence. In this regard, it may be argued that Quality and Benchmarking are widely recognised as critical drivers of excellence (Jarrar & Zairi, 2000; Ho & Fung, 1994; Camp, 1989). More recently, Chapman et al. (2001) and Zairi & Whymark (2000) have stressed the importance of organisational learning as another driver of excellence. Roche (2002) argues that: *“As a prerequisite to pursuing business excellence, companies build*

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[5] It may be noted that such knowledge is sourced externally, whereas knowledge conversion and building relates more to the internal generation of knowledge.

[6] The framing of an opportunity in different ways (Schrader et al., 1993) has an important effect on the ways in which problems are solved. This has important implications for the type of learning that individuals in a team will undergo.

[7] More modern texts recognise the distinction between information and knowledge (and data) and argue that knowledge is derived from information (references). However, for the purpose of this discussion, it is sufficient to note that new information and knowledge are drivers of learning.

[8] A number of models on the importance of learning also exist in the literature, which will facilitate a comparison of experimental results.

learning organisations; therefore companies that want to transform their organisations to a continuous improvement philosophy need to embrace the notion of organisational learning, whether they like it or not". Customers also have a role to play in driving business excellence, particularly in the framework of Quality Function Deployment (QFD). This is evident in the following definition of QFD: *"Quality function deployment (QFD) is a structured approach to seek out customers, understand their needs, and ensure that their needs are met. QFD is probably the most important management tool developed to assure quality in new or improved products and services" (Han et al., 2000)*. Given the above evidence, it may therefore be argued that Construct 3 is centred on Excellence.

5.2.4 Construct 4

Finally, it may be argued that Construct 4 relates to the role of the Individual in innovation, and the way he/she is motivated. Informal Learning and Championing are inextricably bound to the intrinsic qualities and motivation of the individual and largely reflect the degree to which an individual, by his/her own need or conviction, learns from personal contact with fellow employees or takes initiative in raising a project. Reward & Recognition and Autonomy, on the other hand, represent external "inputs" to the motivation of individuals through the initiatives of management and team or organisational structures. The designation of Construct 4 as individual-centric is further confirmed by the results of the correlation matrix between the four constructs, as presented in Table 5.2. Given the fact that Constructs 1 and 4 are closely, but inversely, related, it may be argued that results of Table 5.2 further confirm the Individual (versus group) nature of Construct 4.

Table 5.2 Correlation matrix for Constructs

	Construct 1	Construct 2	Construct 3	Construct 4
Construct 1	–			
Construct 2	0.00	–		
Construct 3	0.07	-0.13	–	
Construct 4	-0.48*	0.15	0.00	–

Level of significance: *p < 0.10

At this point it is interesting to note how the role of the individual emerges at the project level, whereas at the level of the functional environment, this is not prevalent. Appendix A4 presents the results of a factor analysis on data of the exploratory study, which show that enablers related to the individual are "obscured" in a general people-centric theme (Theme 1) [9]. Thus, it may be argued that the roles of Individuals are perceived to be more distinct at the project-level.

In summary, factor analysis indicates that four constructs of enablers may have significance in explaining the relative importance of enablers for different types of projects. These constructs relate to:

1. Project Scope,
2. Learning,
3. Excellence, and
4. The Individual

The following sections present the results of analysis of variance tests on constructs and individual enablers for validation of hypotheses forwarded in Chapter 3. Based on the congruency of results between hypotheses and experimental outcomes, conclusions are made regarding the roles of project radicalness and maturity in moderating the importance of these constructs. These conclusions form the basis for development of a contingency model for enabler importance.

5.3 RESULTS: ANALYSIS OF VARIANCE

Tables 5.3 and 5.4 summarise results of ANOVA tests for Constructs 1 to 4 and the enablers associated with each. Such ANOVAs were performed to determine whether significant differences existed for the importance of enablers between (1) radical and incremental innovation, and (2) initiation and implementation of innovations. Analogous to the convention used for Table 3.1, directions of differences are designated by "+" and "– " signs: a positive sign indicates an increase in relative importance for an increase in project radicalness or maturity, whereas a negative sign denotes a decrease in relative

[9] The designation "Theme" is used to avoid confusion with the Constructs discussed in this section.

importance for an increase in project radicalness or maturity. Cases where moderators do not govern the importances of enablers are designated by N/A (not applicable).

Interactions between the moderating roles of project radicalness and maturity on enabler importance were also investigated. These results are provided under the heading *radicalness*maturity* and reflect cases where, for example, an enabler may significantly increase in importance from initiation to implementation for *incremental projects*, but remain of constantly high importance from initiation to implementation for *radical projects*[10]*.* The directions of such cases are provided in brackets, indicating that such a direction applies only to a specific radicalness-maturity configuration.

Table 5.3 Results of ANOVAs for Constructs 1 to 4

Moderator	**Construct**	**F (ANOVA)**	**Direction**
Radicalness			
	Construct 1	3.7890*	+
	Construct 2	8.5019***	+
	Construct 3	0.3495	N/A
	Construct 4	0.00095	N/A
Maturity			
	Construct 1	6.5395**	+
	Construct 2	2.9114*	–
	Construct 3	0.5810	N/A
	Construct 4	0.3427	N/A
*Radicalness*Maturity*			
	Construct 1	0.15237	N/A
	Construct 2	3.7311*	(–)
	Construct 3	0.0963	N/A
	Construct 4	1.2695	N/A

Legend: Significance of difference: *p < 0.10, **p < 0.05, ***p < 0.01.

[10] An example of such a condition is represented by Figure 5.2.

Table 5.4 Results of ANOVAs for individual enablers that showed moderated importances (non-significant results are not shown).

Moderator	Enabler	F (ANOVA)	Direction
Project radicalness			
	Tenacity	9.8682***	+
	Planning & Procedures	3.3186*	+
	Creativity	9.5578***	+
	Leadership	3.2273*	+
	Benchmarking	9.3887***	+
	Competitors	6.6708**	+
Project Maturity			
	Tenacity	9.8682***	+
	Planning & Procedures	8.9763***	+
	Suppliers	4.2598**	+
	Risk-taking	3.2661*	–
	Experimenting	9.6378***	–
	Benchmarking	4.2937**	–
	Competitors	5.4527**	–
*Radicalness*Maturity*			
	Tenacity	3.9416*	(+)
	Planning & Procedures	3.9661*	(+)
	Benchmarking	3.2674*	(–)
	Competitors	7.6587**	(–)

Legend: Significance of difference: *p < 0.10, **p < 0.05, ***p < 0.01.

The following sections present and discuss the roles of project radicalness and maturity in moderating the importance of enablers, according to Constructs 1 – 4. In this framework, the validity of the hypotheses is evaluated and discussed.

5.3.1 Construct 1 – Project Scope

From Table 5.3 it is readily apparent that Project Scope is moderated by both project radicalness and maturity, albeit only with marginal significance in the case of project radicalness. Based on trends in the results for this construct, the following conclusions may be made:

1. Project Scope plays an important role in enabling radical, but not incremental, innovation.
2. Project Scope plays an important role in enabling the implementation, but not initiation, of innovations[11].
3. Interactions between project radicalness and maturity do not govern the importance of Project Scope (Figure 5.1)[12].

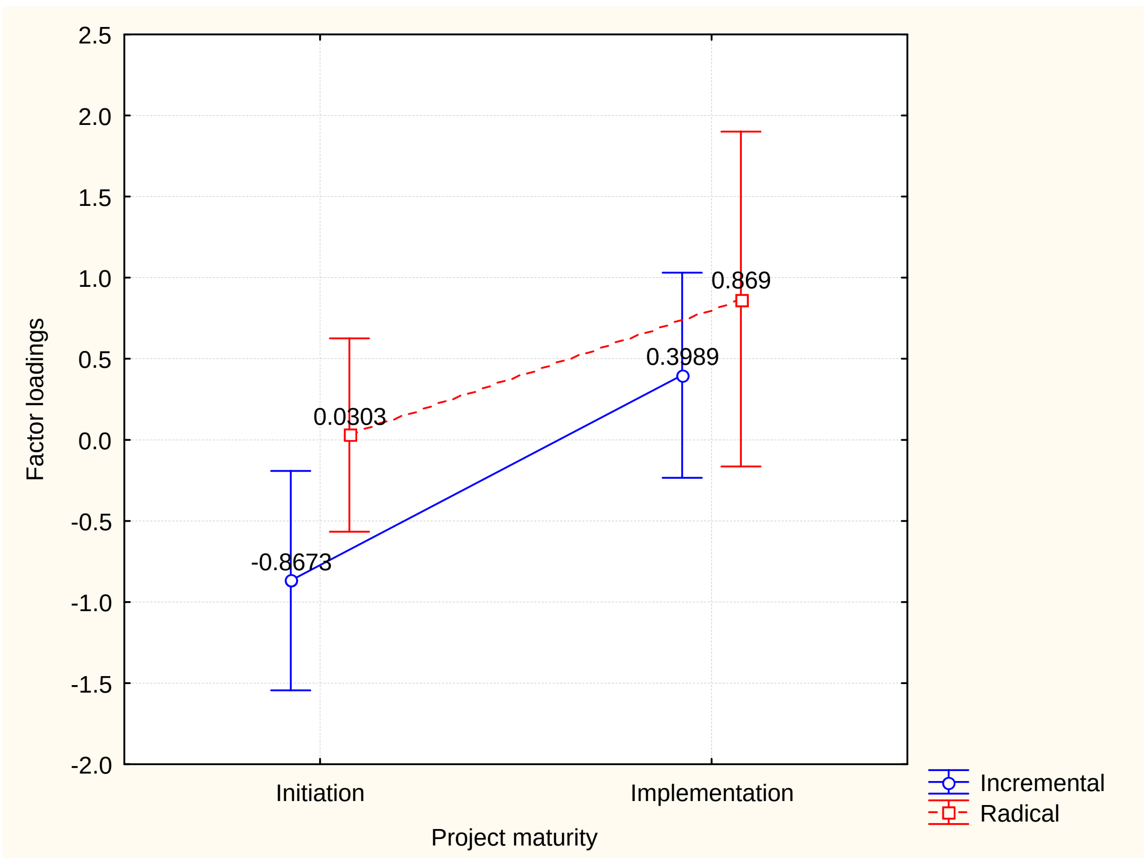

Figure 5.1 The relative importance of Project Scope in terms of project radicalness and maturity.

These conclusions have significant implications for the development of a contingency model of enabler importance, since they implicitly contribute to fixing the scope and structure of such a model. However, it is evident from Table 5.4 that only Tenacity and

[11] Although these conclusions are expressed in absolute terms (i.e. important vs. not important), the reader is reminded of the fact that the importances of enablers are relative to one another. However, the term "importance" is used instead of "relative importance" for reasons of parsimony.
[12] If the lines representative of incremental and radical innovations run parallel to one another, no interaction effects prevail; the converse is true for trends that do not run parallel.

Planning & Procedures exhibit significant results at the level of individual enablers associated with this construct. Interaction effects between radicalness and maturity also govern the importance of these enablers. Thus, it is clear that results at the level of individual enablers qualify conclusions made in terms of constructs of enablers.

Based on the results of individual enablers, the following conclusions regarding the validity of hypotheses may be made:

- ⇒ Hypothesis H2a is supported, but not H2b (*Tenure of team members*).
- ⇒ Hypotheses H5a2 and H5b2 are supported (*Cross-functionality*).
- ⇒ Hypothesis H12a is supported, but not H12b (*Suppliers of Technology*).
- ⇒ Hypotheses H14a is not supported, but H14b is (*Planning & Procedures*).
- ⇒ Hypothesis H16a is supported, but not H16b (*Tenacity*).

In terms of Hypothesis H2b, it may be noted that the trend in the importance of the enabler is consistent with that of the hypothesised direction (Appendix C, Figure C4), but that these results are not statistically significant ($p = 0.28$). Results for Hypotheses H12b, H14a and H16b, on the other hand, seem to indicate that the role of coordination is perceived to be of significantly higher importance in radical than incremental projects (if the effect of project maturity is not taken into account). This may possibly be attributed to the fact that diversity and contact breadth is more important than depth for radical innovation[13]. This is discussed in greater detail below.

Although factor analysis did not identify Specialisation as a constituent enabler of Construct 1, it may be argued that this enabler is closely associated with it, given (1) its high correlation with Construct 1, and (2) its association with complexity, as defined by Damanpour & Gopalakrishnan (1998)[14]. In this regard, it may be noted that hypotheses H5a1 and H5b1 are falsified, i.e. not supported by experimental data. This may most probably be attributed to the fact that Specialisation acts as a surrogate variable for the experience of individuals (based on the fact that specialisation requires experience) and that experienced individuals are always deemed necessary to "fit the pieces of the

[13] This notion is consistent with McKee's (1992) argument for the difference in learning strategies between radical and incremental innovations.

[14] Since Specialisation is not "associated" with any of the constructs, discussion of results pertaining to this enabler is most apt in the context of Construct 1.

puzzle together"[15]. This result is consistent with that exhibited by Learning from the past (which is directly related to experience)[16].

In terms of the interactions between radicalness and maturity in governing the importance of these enablers, it is evident from Figures 5.2 and 5.3 that the moderating role of project radicalness on the importance of Tenacity and Planning & Procedures is limited to the initiation of projects. In terms of the implementation of projects, these enablers do not exhibit significantly different levels of importance.

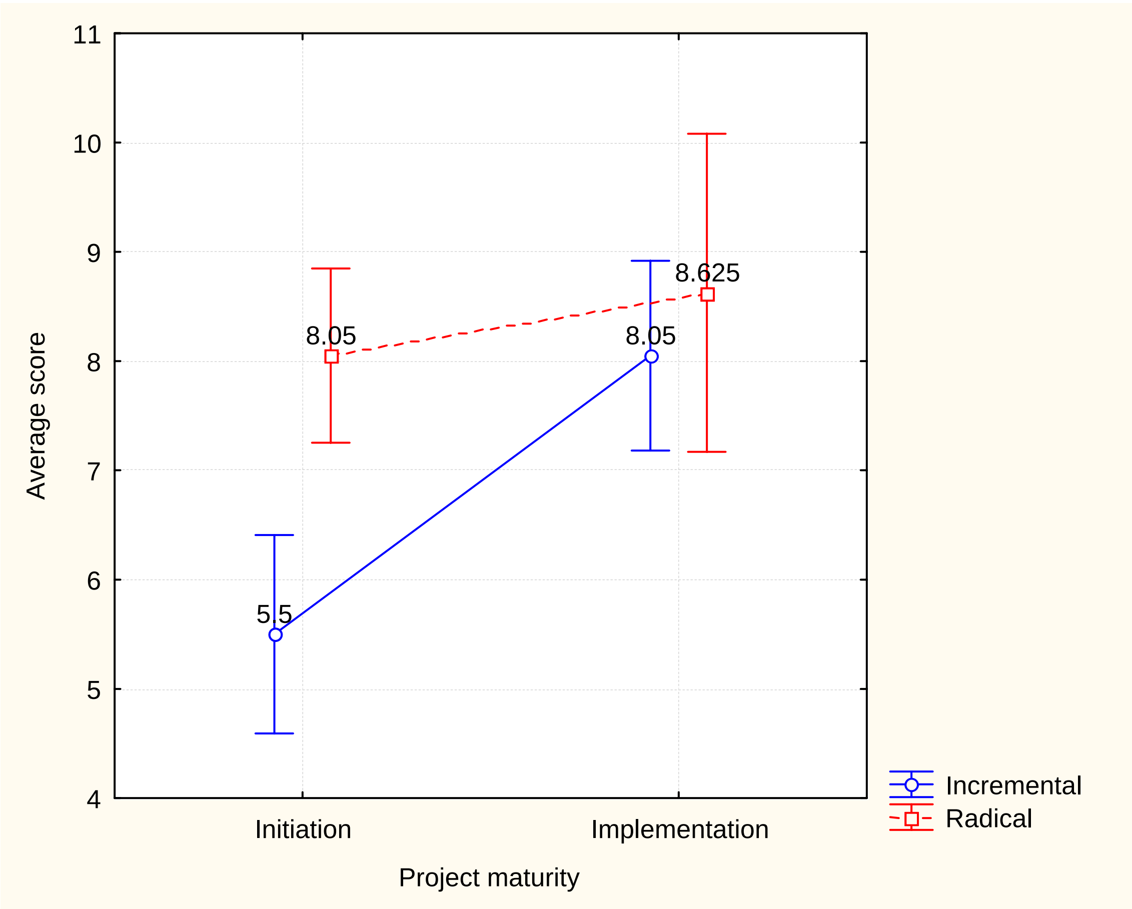

Figure 5.2 The relative importance of Tenacity in terms of project radicalness and maturity.

[15] As noted by a respondent.
[16] Discussed in section 5.3.3.

In this regard, it may be argued that the initiation of radical projects involve higher levels of Tenacity than incremental projects, based on the fact that knowledge associated with this innovation type is typically new to the organisation and not derived from existing organisational practices and experience. In terms of Planning & Procedures, it may be argued that higher levels of formalisation during the initiation of radical innovations are necessary to (1) effectively coordinate the large diversity and scope of people and resources (typically on an international basis) involved in the project, and (2) ensure awareness and buy-in from other organisational functions and units, considering the pervasive impact that these types of innovation will have on existing practices throughout the organisation.

On the other hand, based on the fact that these enablers are equally important during the implementation of projects, it may be argued that issues such as the coordination and integration of functions (and external entities) are always perceived as presenting significant logistical challenges to the project team, irrespective of the radicalness of the project. This is exemplified by the fact that Suppliers of Technology play a more important role during the implementation of projects for both radical and incremental innovations.

Based on the above discussion, conclusions 1 to 3 made at the start of this section in terms of the construct Project Scope may be qualified in terms of individual enablers that constitute the construct. In this regard, trends in experimental data suggest that:

1. *Tenacity and Planning & Procedures are*:
    a. equally important for the initiation and implementation of radical innovations.
    b. equally important for the implementation of radical and incremental innovations.
    c. important for the implementation of incremental innovations, but not for the initiation thereof.
2. *Suppliers of Technology are*:
    a. equally important for radical and incremental innovations, i.e. project radicalness does not moderate the importance of this enabler
    b. important for the implementation of innovations, but not for the initiation thereof.

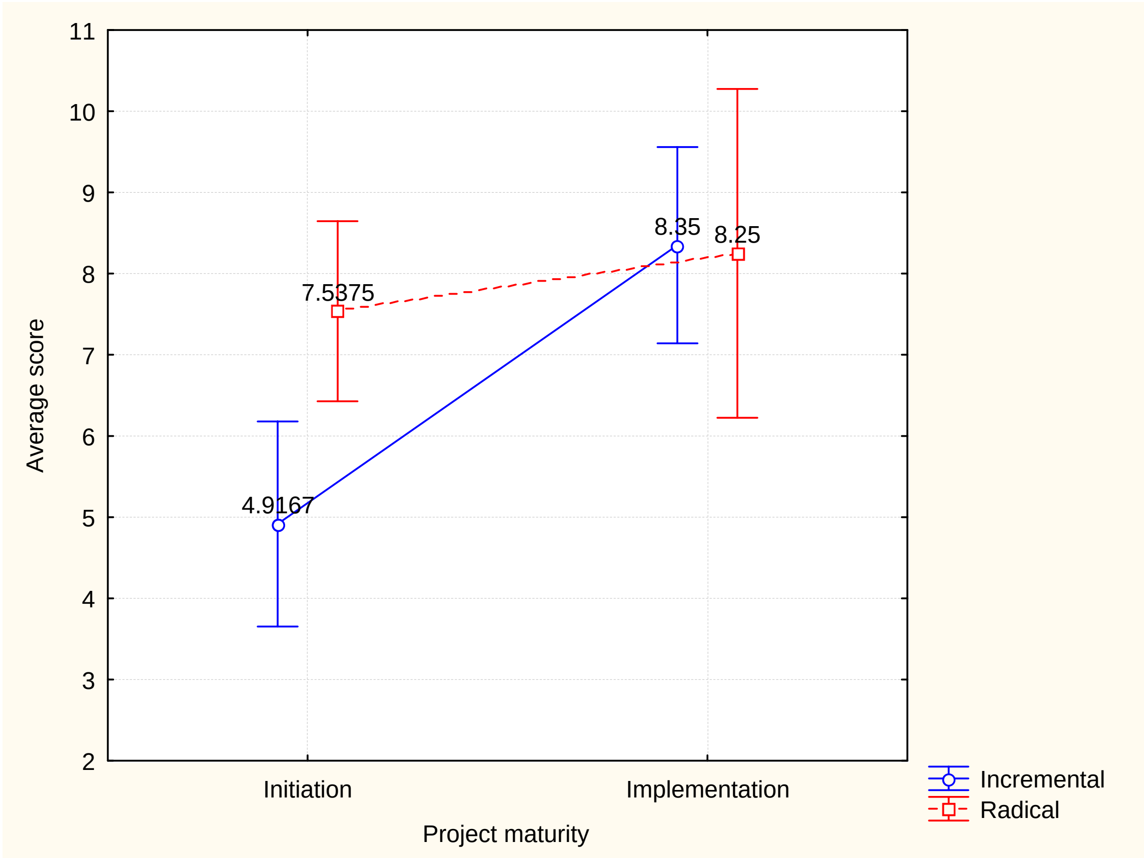

Figure 5.3 The relative importance of Planning & Procedures in terms of project radicalness and maturity.

5.3.2 Construct 2 – Learning

It is evident from Tables 5.3 and 5.4 that both project radicalness and maturity[17] play significant roles in moderating the relative importance of Learning. Based on trends exhibited by this construct, the following conclusions may be made:

1. Learning plays an important role in enabling radical, but not incremental, innovation.
2. Learning plays an important role in enabling the initiation, but not implementation, of innovations.
3. Interactions between project radicalness and maturity govern the importance of Learning (Figure 5.4). It is:

[17] Although with marginal significance only, $p < 0.10$.

a. important for the initiation, but not implementation, of incremental innovations.
b. important for the initiation and implementation of radical innovations.

Given these conclusions, the question may be asked why Learning appears to be unimportant during the implementation of incremental innovations. Surely learning must also occur during the implementation of incremental innovations? In this regard, it must be noted that Learning, as defined in this study, is derived from new knowledge, either via open-ended processes or new (external) sources of knowledge. Learning in the case of the implementation of incremental innovations, on the other hand, is principally based on existing knowledge and experience of the team. When this distinction is kept in mind, trends in the importance of Learning are adequately explained.

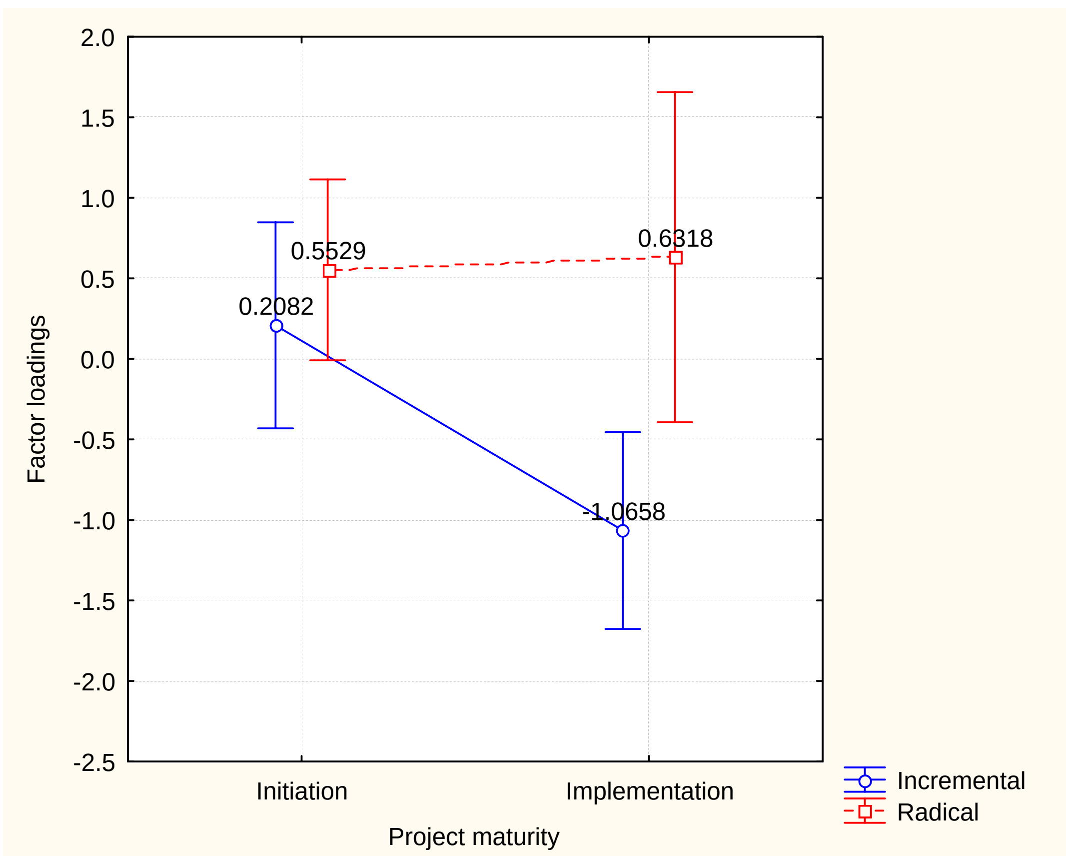

Figure 5.4 The relative importance of Learning in terms of project radicalness and maturity.

As in the case of Project Scope, results at the level of individual enablers qualify conclusions made in terms of the construct that they constitute. Given that Learning is based on problem-solving (Garvin, 1993) and different modes of problem-solving are required for different situations (as will be elucidated later in this section), results at the level of individual enablers may have significant implications for the relative importance of different modes of learning for different attributes of projects.

Trends in the importances of individual enablers related to this construct allow the following conclusions to be made regarding the validity of hypotheses:

- ⇒ Hypothesis H1a is supported, while H1b is not supported (*Leadership*).
- ⇒ Hypothesis H4a is only supported in terms of *Creativity*, but not *Experimenting* or *Risk-taking*; the converse is true for H4b.
- ⇒ Hypotheses H9a and H9b are not supported (*Benchmarking*).
- ⇒ Hypotheses H10a and H10b are supported (*Competitors*).

Let us first consider the results for enablers associated with Hypotheses H1 (Leadership) and H4 (Internal learning), and then those which pertain specifically to external learning (Benchmarking and Competitors), for reasons of consistency with the literature. From experimental data it may be concluded that the trends exhibited by Leadership and Creativity are markedly different from those exhibited by Experimenting and Risk-taking, despite belonging to a common construct: whereas the importance of the first group is moderated only by project radicalness (and not maturity), the importance of the second group is dependent on project maturity but not radicalness. It is the contention of this study that this “apparent” discrepancy may be explained in terms of the distinction between equivocality and uncertainty, first proposed by Weick (1979).

Uncertainty, on the one hand, is reflected in the absence of answers to explicit questions and may be defined as *“the difference between the amount of information required to perform the task and the amount of information already possessed by the organisation”* (Galbraith, 1977). It exists in closed-form problems, where the problem solution process is typically known and there is one valid solution. In this, Experimentation is key – information obtained from each step in the experimentation process reduces the level of uncertainty associated with the problem.

Equivocality, on the other hand, originates from ambiguity and confusion in the presence of multiple and conflicting interpretations about a particular situation or problem and therefore cannot be reduced by asking specific questions. In equivocal situations, participants are generally not sure even *which* questions to ask[18] - hence, open-ended processes play an important role in knowledge creation and learning. As Daft & Lengel (1986) argues, it is *"often seen in the messy and paradoxical world of organisational decision-making"*. In essence, uncertainty is generally reduced by acquiring *more information*, whereas equivocality may actually increase when more data is considered – in this case, managers need to *enact* a solution through shared interpretation of conflicting inputs. In engineering practice, closed-form problems tend to be sub-problems of an overall open-ended (equivocal) situation.

According to the work of Gales et al. (1992), Gales & Mansour-Cole (1995) and Sicotte & Langley (1997), radical innovations involve considerably higher levels of equivocality than incremental innovations[19]. Based upon this premise, it may be argued that the importance of enablers related to a reduction in equivocality will be moderated by project radicalness. On the other hand, based on the notion that the initiation of projects involves considerably higher levels of uncertainty than their implementation (Shenhar, 2001), trends in the data seem to indicate that the relative importance of enablers related to a reduction in uncertainty will be moderated by project maturity[20]. In the following sections, it is proved from the literature that Experimenting and Risk-taking are associated with a reduction in uncertainty, while Leadership and Creativity relate to the resolution of equivocality. Evidence in this regard lends support to the above contentions.

[18] Expressed otherwise, there is no clear, predefined sequence of steps to arrive at a solution.
[19] McKee (1992) argues that, while incremental innovation occurs within stable product-market and technological domains, the domain of radical innovation is inherently ambiguous.
[20] Chapter 6 discusses the implications of the distinction between uncertainty and equivocality in characterising and modelling the relative importance of enablers in finer detail.

5.3.2.1 Experimenting and Risk-taking

Based on these definitions of uncertainty and equivocality, it is a rather straightforward conclusion that Experimenting is more closely associated with a reduction in uncertainty than equivocality, based on the fact that (1) it involves generation of more (additional) data of approximately the same type, and (2) reduces, by each step, the gap between the amount of information needed by the team and that which it already possesses.

Risk-taking, however, is more difficult to associate with either uncertainty or equivocality: does it pertain more to a lack of information or to a lack of clarity regarding what the problem is, or what to do? In this regard, it may be noted that according to Smith (1997), the body of work on organisational decision-making recognises three distinct types: decision making under risk, decision making under uncertainty, and decision making under equivocality. Owen (1982) notes that information theory and decision theory view uncertainty as characteristic of situations where the set of possible future outcomes is identified, but where the related probability distributions are unknown, or at best known subjectively. Shubik (1982), on the other hand, describes decision-making under risk, as constituting the condition where information is unavailable, but where a probabilistic description of the missing information is available, i.e. where the related probability distributions are known.

Therefore, based on the fact that decision-making under risk involves *more* knowledge than in the case of uncertainty, it is evident that Risk-taking is more closely associated with the reduction of uncertainty than equivocality. Hence, given the fact that both Experimenting and Risk-taking relate to a reduction in uncertainty, the relative importance of these enablers should be moderated by project maturity, supporting the contention on the previous page. The following section aims to come to an analogous conclusion regarding the relationship between project radicalness and equivocality in governing the relative importance of two other Learning-related enablers, namely Leadership and Creativity.

5.3.2.2 Leadership and Creativity

Daft & Lengel (1986) argue that the task of resolving equivocality is a function of hierarchical level. Top managers must confront ambiguous and conflicting cues about the environment, and then create and maintain a shared interpretation among themselves[21]. Choo (1991a) argues that it is the responsibility of leadership to analyse and interpret the environment and to develop goals and strategies for the organisation based on ambiguous inputs. Hence, it is evident that Leadership is an important enabler of equivocality resolution. In fact, Smircich & Morgan (1982) argue that strategic leadership's effectiveness is judged by the extent to which top management deals with the equivocality that permeates the environment.

The need for creativity in an ambiguous environment has been pointed out by a number of researchers, including Weick (1979) himself. Choo (2001a) argues that individual intuition and creativity is important in problem framing since it governs the kinds of enactments (strategies) to be pursued, while the interpretation of such enacted information depends on personal insight and instinct. This notion is supported by McGrath's (1991) equivocality and task circumplex conceptualisation, which highlights the generative power of creativity. Fiol (1995), on the other hand, notes that *"contradiction is the home of creativity"*: given that equivocality is defined by Daft & Macintosh (1981) as the existence of multiple and conflicting interpretations about a situation, creativity's importance in resolving equivocality is further underlined.

Therefore, given both Leadership and Creativity's critical roles in the reduction of equivocality, an analogous proposition to the one forwarded above can be made, i.e. that the relative importance of Learning-related enablers, which play an important role in the resolution of equivocality, should be moderated by project radicalness.

The distinction between equivocality and uncertainty may also be used to interpret the interaction effects of radicalness and maturity in governing the importance of these Learning-related enablers. It may be argued that, while both incremental and radical projects involve varying degrees of uncertainty, only radical projects involve a significant degree of equivocality. Therefore, while uncertainty for both incremental and radical innovations are significantly reduced from initiation to implementation through Experimentation and Risk-taking, radical projects retain a large degree of equivocality, even during their implementation – hence the importance of Creativity and Leadership in these situations.

[21] Defined as problem-framing (Schrader et al., 1993).

It may be noted that, in the above discussion, only the trends in the enablers Leadership, Creativity, Experimenting and Risk-taking were considered. The following section considers the trends in the importance of the remaining two enablers associated with Construct 2, namely Benchmarking and Competitors. They are treated separately as representative of External Learning, in the interests of consistency with terminology and models used in the literature.

5.3.2.3 External learning – Benchmarking and Competitors

When considering External learning, it may be noted that Suppliers of Technology and Customers also represent external sources of information and therefore should also be included in this section. This study, however, asserts that the classical distinction between internal and external sources of information should not be employed, but rather that the distinction between "internal" and "external" should hinge upon the degree of control that the team has over the external source (or its level of involvement in the team). In other words, despite being classified as representing external sources of information by Craig & Hart (1992), enablers such as Customers and Suppliers are subject to significantly more control or influence from the team than in the case of Competitors or other teams within the organisation[22]. Thus, whereas the enablers Competitors and Benchmarking represent *truly external* sources of information, Customers and Suppliers of Technology may be considered to be relatively more "internal" to the team.

This notion is not only supported by Balachandra & Friar (1997)[23], but is also evident from the structure of enablers in the exploratory study, as presented in Figure 5.5[24]. Note specifically the two distinctly separate groups[25] associated with Theme 2 (an knowledge-centric construct): group A consists of Strategic Scanning, Competitors,

[22] Chapter 3 relates how customers and suppliers become partners in the innovation process.
[23] Balachandra & Friar (1997) also argue that the *orientations* (or perspectives) of researchers (marketing vs. technical) often involve a bias in the scope (internal vs. external focus) of enablers investigated. Hence, it may be argued that the orientations of researchers to a large extent influence the interpretation and representation of results regarding the relative importance of enablers in terms of the distinction between internal and external information and learning. Thus, it is possible that a more clear-cut or normative definition of the terms "internal" and "external" could reduce the degree of variability of results in the literature.
[24] Appendix A4 presents the results of the factor analysis on the data of the exploratory study – Themes 1 and 2 each represent a different construct.
[25] Based on the fact that they are "geographically" removed from one another.

Benchmarking and New Markets, whereas group B consists of Customers, Strategy, Vision and Information Systems. Although both groups generally relate to external factors, it may be argued that group A exhibits a "more external" nature than group B: whereas the organisation (or team) has a degree of direct control over its strategy, vision and customers[26], it has little very little control over the actions of those enablers representative of group A. In this illustration, the importance of distinguishing between different types or sources of external information is highlighted, lending credibility to the above assertion.

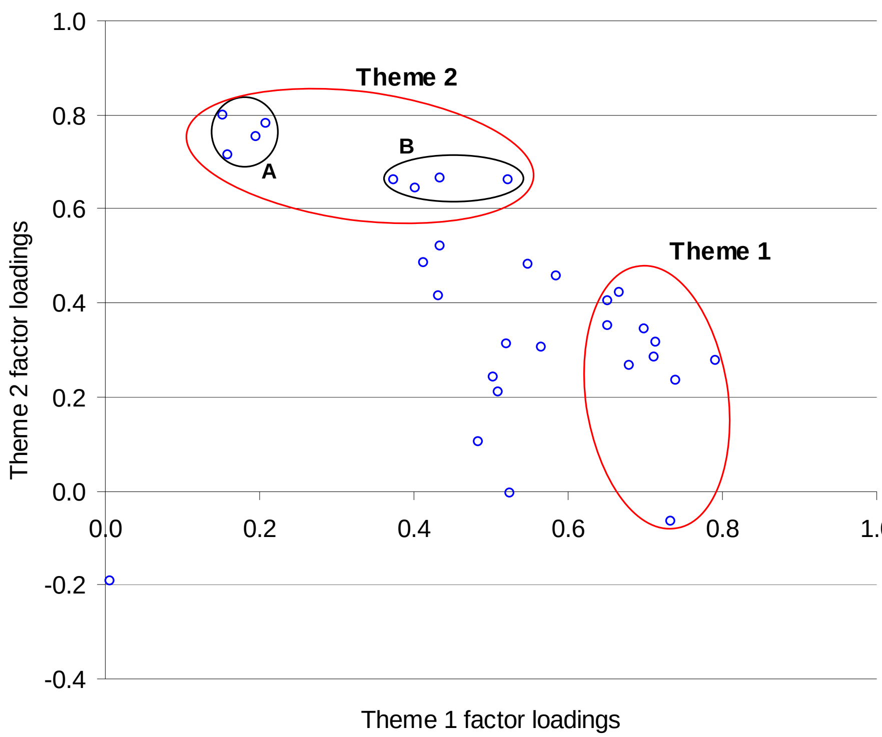

Figure 5.5. Clusters reflecting two distinctly different types of enablers, traditionally classified as representing external sources of information.

In light of this classification, it may therefore be concluded that the relative importances of *truly external* sources of information and learning (designated *Strategic Learning*) are moderated by both project radicalness and maturity. From Table 5.4 it is also evident

[26] Apart from Customers' involvement in the innovation process, they are also subject to subtle control in terms of customer relationships, advertising and branding.

that project radicalness and maturity exhibit interaction effects in governing the importance of these enablers (Figures 5.6 and 5.7).

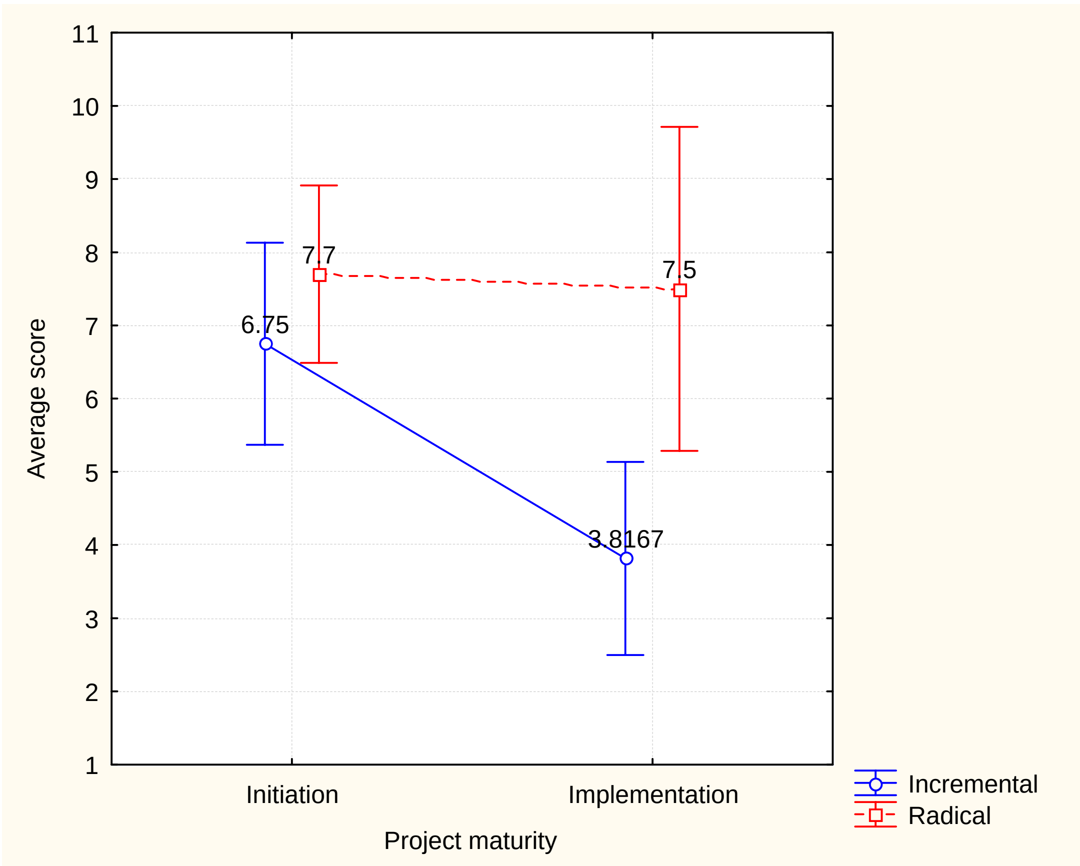

Figure 5.6 The relative importance of Benchmarking in terms of project radicalness and maturity.

These effects indicate that Strategic Learning is not important for the implementation of incremental innovations; for radical innovations, however, this enabler remains consistently important, even during implementation. The importance of Strategic Learning for the implementation of radical innovations may be attributed to two reasons. The first is that the organisation has a very limited base of past learning and experience, necessitating a more *external focus*. The second is that radical innovations require a constant survey and evaluation of the external environment for interpretation of the equivocal circumstances that typically surround them. In the case of incremental innovations, such equivocality is virtually absent: thus, external information is only necessary during initiation for (1) ideation and opportunity identification, and (2) setting the strategy and direction of such projects.

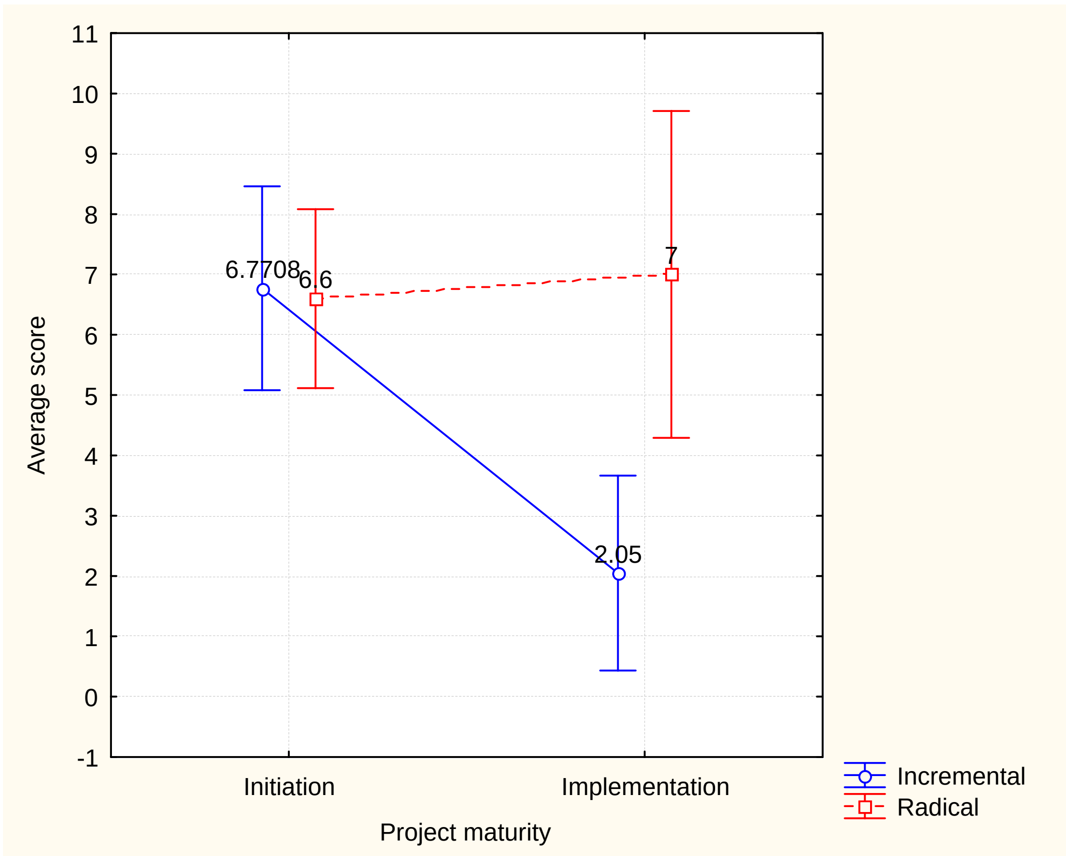

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Figure 5.7 The relative importance of Competitors in terms of project radicalness and maturity.

Based on the above discussions, conclusions made regarding Learning may be qualified in terms of individual enablers that constitute this construct. In this regard, the following conclusions may be made:

1. *Leadership* and *Creativity*, which relate to the resolution of equivocality, are:
    a. important for radical innovations, but not for incremental innovations.
    b. of equal importance for the initiation and implementation of innovations, i.e. project maturity does not moderate the importance of these enablers.
2. *Experimenting* and *Risk-taking*, which relate to the reduction of uncertainty, are:
    a. important for the initiation of innovations, but not their implementation.

b. Of equal importance for radical and incremental innovations, i.e. project radicalness does not moderate the importance of these enablers.

3. *Strategic Learning is*:
   a. equally important for the initiation and implementation of radical innovations.
   b. equally important for the initiation of radical and incremental innovations.
   c. important for the initiation of incremental projects, but not for the implementation thereof[27].

The above analysis has illustrated that it is essential to accurately define the unit of analysis when presenting results. In other words, it is important to note whether findings relate to the context of the team or the organisation, since factors external to the team may still be "internal" to the organisation. As shown in the discussion, a precise definition of the unit of analysis may prove instrumental in explaining trends in the importance of internal and external sources of learning.

5.3.3 Construct 3 - Excellence

From Table 5.3 and Figure 5.8 it is readily apparent that no *significant* differences exist between the importance of Excellence for radical and incremental innovations, and their maturities. Hence, the following conclusions may be made:

1. Project radicalness does not moderate the importance of Excellence.
2. Project maturity does not moderate the importance of Excellence.

[27] Although results for the interactions between radicalness and maturity are only marginally significant in terms of Benchmarking, they are assumed to be valid, given $p < 0.07$.

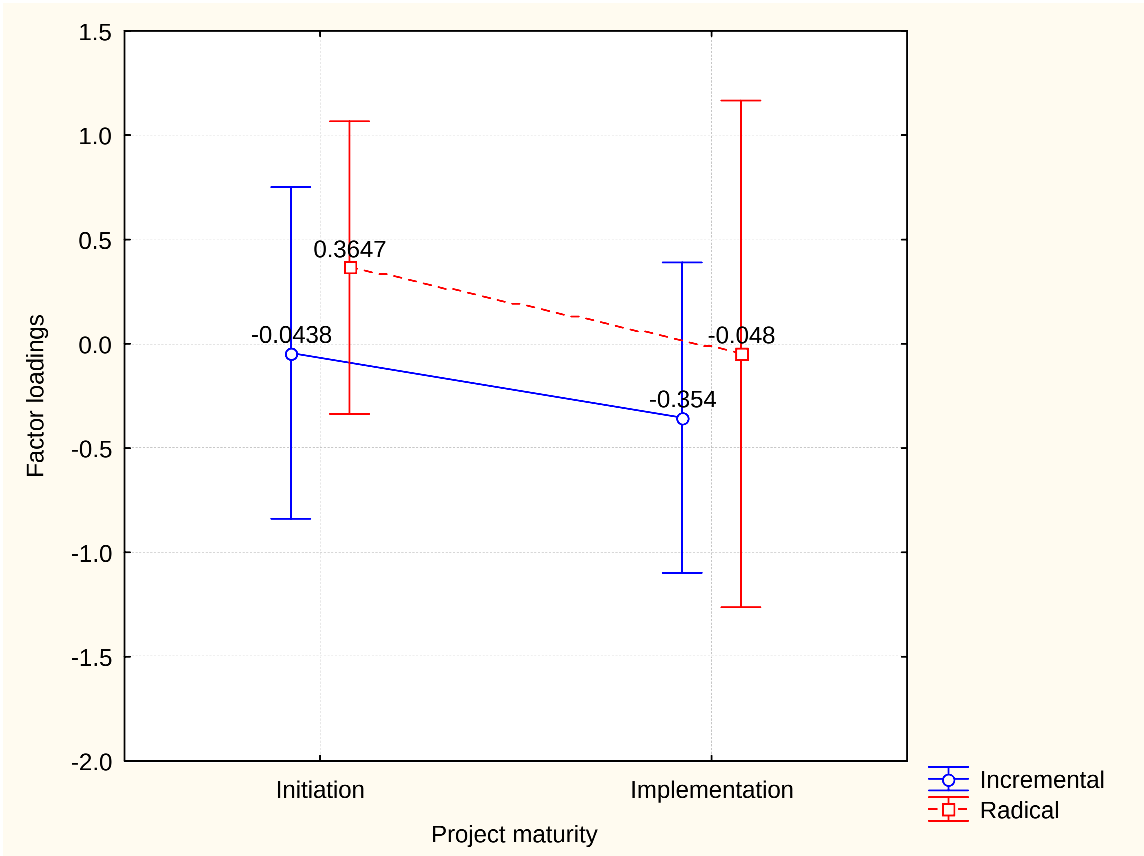

Figure 5.8 The relative importance of Excellence in terms of project radicalness and maturity.

Based on the results of individual enablers, the following conclusions regarding the validity of hypotheses may be made:

⇒ Hypotheses H8a and H8b are supported (*Learning from the past*).

⇒ Hypotheses H9a and H9b are not supported (*Benchmarking*)[28]

⇒ Hypothesis H11a is not supported, but H11b is (*Customers*).

⇒ Hypotheses H13a and H13b are not supported (*Quality*).

Given the falsification of Hypothesis H11a, it is evident that the involvement of Customers in the innovation process is as important for radical projects as it is for incremental projects. This may probably be attributed to formalised requirements regarding the role and involvement of the Customer in the product development process of the organisation sampled. In this regard, the stage gate model employed by the

[28] Possible reasons for the inconsistency between predicted and actual outcomes for this enabler have been discussed in section 5.3.2.

organisation dictates that in stages 3 and 4 samples of the new product should be made for customer evaluation and acceptance, upon which the continuation of the development effort is contingent. Given such formalisation, the perceptions of team members may be an inaccurate measure in distinguishing between the importance of customer involvement between radical and incremental projects.

Finally, the pervasive role of quality in enabling innovation may be explained in terms of the quality of the innovation process. Given that (1) Cooper & Kleinschmidt (1995) found that a high quality innovation process is the most important success factor of any business, and (2) the quality and thoroughness of the process underpins the quality of the project, it may be concluded that Quality enables both radical and incremental innovations throughout their life cycles.

5.3.4 Construct 4 – The Individual

Table 5.3 and Figure 5.9 present the results of the roles of project radicalness and maturity in governing the importance of the Individual in innovation. Based on trends in experimental data for this construct, it may be concluded that:

1. Project radicalness does not moderate the importance of the Individual.
2. Project maturity does not moderate the importance of the Individual.

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Trends in the results of individual enablers allow the following conclusions to be made regarding hypotheses:

- ⇒ Hypothesis H3a is not supported, but H3b is (*Reward & Recognition*).
- ⇒ Hypotheses H6a and H6b are not supported (*Team autonomy*)
- ⇒ Hypotheses H7a2 and H7b2 are not supported (*Informal communication*).
- ⇒ Hypotheses H15a and H15b are not supported (*Championing*).

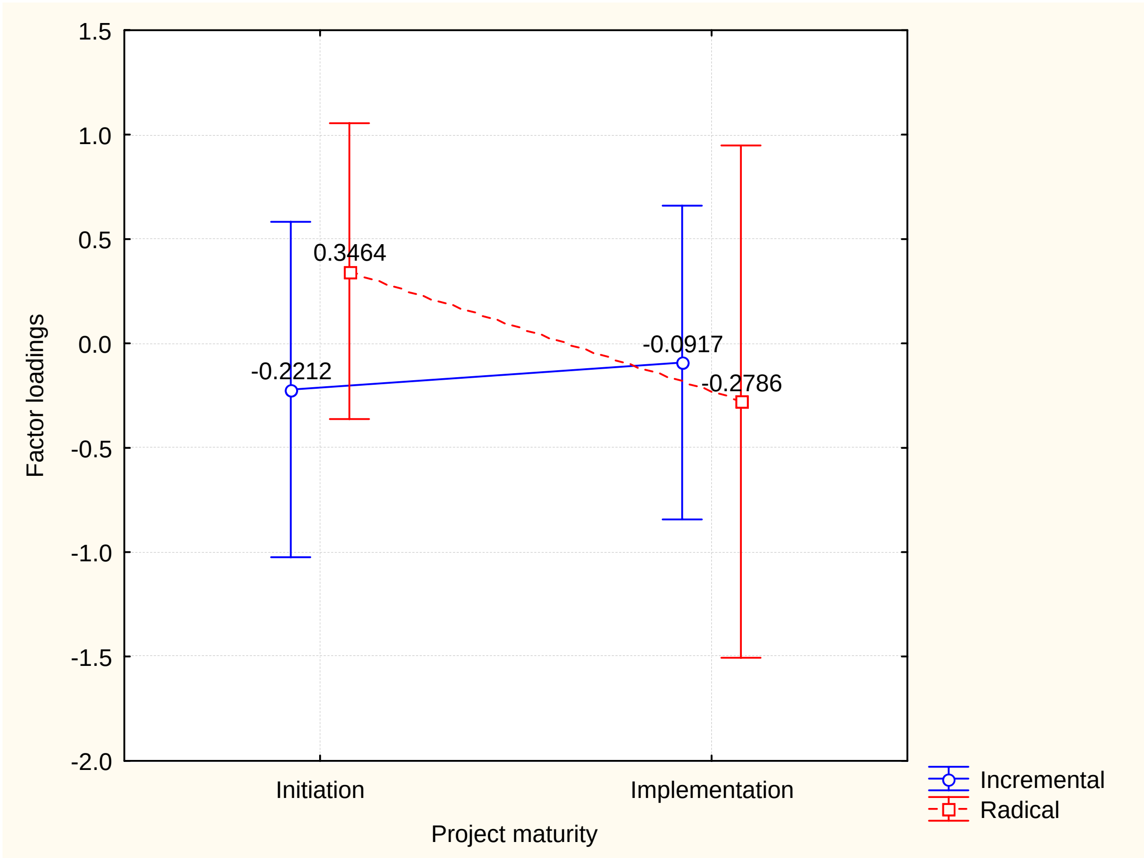

Figure 5.9 The relative importance of the Individual in terms of project radicalness and maturity.

A possible reason for the rejection of Hypothesis H3a may lie in the fact that a large part of incremental innovations surveyed represented plant support projects. These kinds of projects typically involve significant time constraints and therefore should be incentivised from the business/marketing side in order to (1) obtain buy-in from R&D personnel in order to get the project on foot, and (2) attract the necessary number of competent people in order to expedite the project. Therefore, Reward & Recognition of team members on incremental projects are just as important as in the case of radical projects, albeit for different reasons.

The outcomes of Hypotheses H6a and H6b contradict the general notion in the literature that project radicalness and maturity moderate the importance of enablers relating to bureaucratic control. Three possible explanations may be forwarded for this:

1. The degree of autonomy afforded the development team is related more to the management style and personality of the project leader (and senior managers) than the attributes of the project, as intoned by one respondent.
2. Issues pertaining to decentralisation and autonomy are less prominent at the level of the project team[29]. It may be argued that team members, in the context of their project, do not perceive the effects of centralisation as severely as do project leaders or higher-level senior managers.
3. Autonomy or decentralisation may not be necessary when high degrees of formalisation are prevalent, as suggested by Nord & Tucker (1987). In this argument, the inverse relationship between the roles of decentralisation and formalisation is implied: this is supported by the significant negative correlation ($r = -0.43$, $p < 0.05$) between these variables (Appendix B5).

In light of the falsification of Hypotheses H7a2 and H7b2, and for that matter also H7a1 and H7b1[30], it may be concluded that the distinction between rich and less rich media of communication cannot be used to model the relationships between different types of communication and attributes of innovations. This may be attributed to two possible reasons, based on anecdotal evidence gleaned from respondents during interviews:

1. The predominant type of communication associated with a project is not a function of its attributes, but more a function of the types of people (and their personalities) involved in the project. In this regard, one team leader noted that informal learning in his team could directly be attributed to the easy-going personalities of his team members[31].
2. Formal and informal communication are inextricably linked to one another and hence, collectively, exhibit high levels of importance in all contextualities[32]. This argument is supported by statements from respondents such as: “100% of knowledge is never covered on paper – you need people to carry the knowledge”. In fact, one respondent made the interesting comment that the need

[29] In this regard, it must be kept in mind that structure-innovation models presented in the literature generally relate to the organisational level of analysis.
[30] Although Information and Communication Systems is not a constituent enabler of Construct 4, its results are discussed here in the context of the distinction between rich and less rich media of communication, as presented in Chapter 3.
[31] Conversely, it could be argued that individuals who are less socially apt would prefer using more formal means of communication (such as e-mails) to obtain and share information.
[32] I.e., it is not a case of one or the other, but rather a combination of the two.

for personal interaction and learning is high based on the fact that, when reading a document or consulting a database, it is often very difficult to discern what is really important.

Finally, it may be argued that Hypotheses H15a and H15b are rejected on the premise that respondents generally perceived the level of championing necessary for a project as relatively low, irrespective of its radicalness or maturity[33]. This phenomenon may be an artefact of (1) the supportive culture for innovation in the organisation, (2) the fact that the championing of projects was chiefly performed by their sponsors (typically a senior manager) and hence the need for it was not perceived as strongly by members of the team, or (3) the fact that, once in the stage gate process, championing no longer related to its traditional meaning, but was rather associated with the lobbying for resources that need to be shared amongst projects.

These results point to the ubiquitous nature of individuals in enabling innovation, irrespective of the context in which this occurs. Indeed, Vloeberghs (1998) argues that organisations are increasingly realising the importance of the role of the individual as one of the critical success factors for achieving their long term strategies – in this argument, the capabilities, expectations and availability of the individual are modelled as the foundation for achieving this[34]. This argument is consistent with the knowledge-based view of the organisation of Leonard-Barton (1992), which dictates that knowledge and skills are *embodied* in employees.

[33] Although Championing displayed a decrease in *average* importance between initiation and implementation, the difference between these stages was not significant ($p = 0.14$).

[34] Finding supplementary evidence for this argument from the literature is limited by a lack of research on this topic. Jensen & Harmsen (2001) argue that "few researchers have been interested in the role and importance of the individual employee (as opposed to manager), and as a consequence the understanding of this [knowledge] dimension is limited".

5.4 SUMMARY

Experimental data suggests that four constructs of enablers characterise innovation at the project level, namely: Scope, Learning, Excellence and the Individual. Their attributes, and the distinctions between them, may be used to model the importance of enablers in terms of project radicalness and maturity. Based on the results of ANOVAs, it was concluded that the importance of Project Scope and Learning are significantly moderated by these moderators. In addition to this, it was shown how interactions between the two moderators play important roles in governing the importance of these enablers. On the other hand, Excellence and the Individual are not contextually important.

It was shown that the distinction between equivocality and uncertainty may to a large extent be used to predict whether radicalness or maturity would govern the importance of an enabler. A more appropriate distinction between internal and external learning was also suggested, based upon which the contextual importance of learning strategies were characterised. The following chapter discusses the derivation of a contingency model for the importance of enablers of innovation in terms of project radicalness and maturity, based on conclusions made in this chapter. In the context of this model, a number of implications related to the literature and the management of innovation are highlighted.

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CHAPTER 6

A contingency model for the importance of enablers

6.1 INTRODUCTION

Results from the previous two chapters suggest that several enablers of innovation are not universally important, but that their importances are contextual. Both the significance and direction of influence[1] of these enablers are contingent upon the type of the project and its attributes.

Contingency theory (e.g. Shenhar, 2001) views the effectiveness of an action as being dependent on the congruence between the action, and other elements of the system. It recognises that solutions are situational rather than absolute, and that they in fact may become inappropriate under different conditions. Given that the importance of enablers are situational, a contingency model for the importance of enablers of innovation is developed, which takes into account the fact that different types of projects might involve different enablers, and that the outcome of the project is contingent upon the congruence between the project and its enablers. In this model, project attributes (radicalness and maturity) are modelled as moderators of the importance of enablers.

Earlier in this dissertation, a number of concepts were identified that showed significance in capturing the contextual natures of enablers of innovation. These include (1) constructs of enablers and the distinctions between them, (2) the distinction between uncertainty and equivocality, and (3) interactions between project radicalness and maturity in governing the importance of enablers. It is the purpose of this chapter to integrate these concepts into the contingency model for facilitation of a better understanding of the unique managerial implications associated with different types and attributes of innovations. Major implications of the model for the literature and the management of innovation are discussed.

[1] Referring to an increase or decrease in importance along the radicalness and maturity scales.

6.2 A CONTINGENCY MODEL FOR THE IMPORTANCE OF ENABLERS

Given that conclusions regarding the contextual importance of enablers form the basis for development of the contingency model, the following sections aim to address two objectives, viz.:

- To summarise the most significant of these, in order to define the scope of the model.
- To *construct* a framework in which the contextual importance of enablers may be portrayed.

6.2.1 Project Scope

For enablers pertaining to Project Scope, the following conclusions were made:

1. *Suppliers of Technology are*:
    a. equally important for radical and incremental innovations, i.e. project radicalness does not moderate the importance of this enabler
    b. important for the implementation of innovations, but not for the initiation thereof.
2. *Tenacity and Planning & Procedures are*:
    a. equally important for the initiation and implementation of radical innovations.
    b. equally important for the implementation of radical and incremental innovations.
    c. important for the implementation of incremental innovations, but not for the initiation thereof.

These conclusions may be represented graphically by defining a two-dimensional framework (Figure 6.1) in which the moderators of enabler importance each represent an axis: project maturity corresponds to the horizontal axis, whereas project radicalness is portrayed on the vertical axis[2]. The four quadrants therefore represent the scope of contexts (radicalness-maturity configurations) that may govern the importance of enablers.

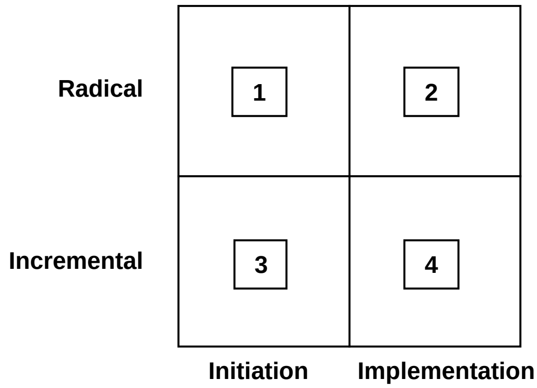

Figure 6.1 A two-dimensional framework for the importance of enablers in terms of project radicalness and maturity.

Implementation of the model may be illustrated in terms of conclusions 1(a) and 1(b). Given that Suppliers of Technology appear to be equally important for radical and incremental projects, but only during their implementation, this enabler is only represented as important in the contexts defined by radical-implementation (quadrant 2) and incremental-implementation (quadrant 4). Such contexts are indicated by shaded quadrants in Figure 6.2.

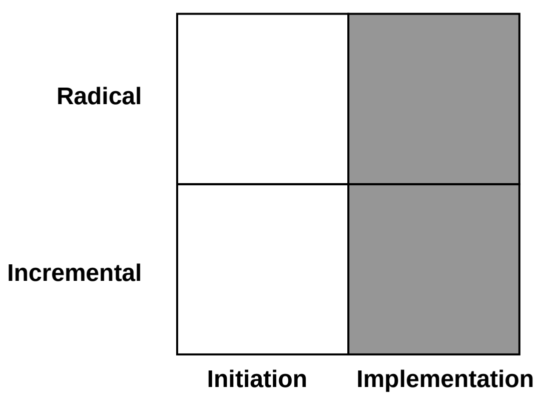

Figure 6.2 The contextual importance of Suppliers of Technology.

[2] This convention is adopted for reasons of consistency with graphs presented in the previous chapter.

Figure 6.3 represents conclusions 2(a-c) in an analogous fashion. Conclusions 2(a) and 2(b) suggest that Tenacity and Planning & Procedures are of equally high importance in the contexts defined by (1) radical-initiation, (2) radical-implementation, and (3) incremental-implementation. Given that these enablers are important for the implementation of incremental innovations, but not their initiation (conclusion 2(c)), it is evident that quadrants 1, 2 and 4 should be shaded, but not quadrant 3. Note how the interaction between radicalness and maturity is portrayed in the framework. Where interaction effects do not govern the importance of Suppliers of Technology, only two quadrants are shaded (on the vertical axis – i.e. project radicalness does not moderate the importance of this enabler[3]). When interactions are prevalent, three quadrants are shaded.

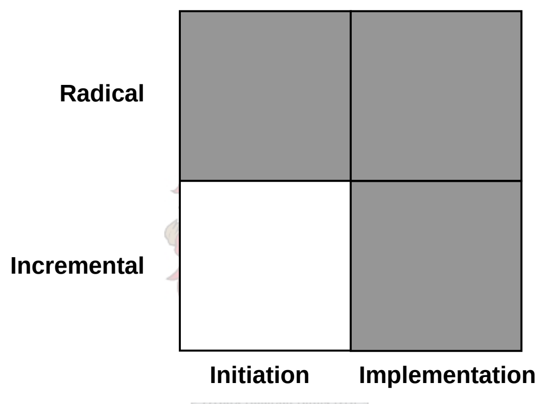

Figure 6.3 The contextual importance of Tenacity and Planning & Procedures

Based on this discussion, it is evident that the radicalness-maturity framework facilitates identification of the contexts in which enablers have been found to be important. In the following sections, analogous methodologies are followed for the remaining enablers in order to finally arrive at an integrative model of the contextual importances of enablers.

[3] When two quadrants are shaded on the horizontal axis, project maturity does not moderate the importance of an enabler.

6.2.2 Learning

For enablers related to Learning, the following conclusions were made:

1. *Leadership and Creativity*, which relate to the resolution of equivocality, are:
    a. important for radical innovations, but not for incremental innovations.
    b. of equal importance for the initiation and implementation of innovations, i.e. project maturity does not moderate the importance of these enablers.
2. *Experimenting and Risk-taking*, which relate to the reduction of uncertainty, are:
    a. important for the initiation of innovations, but not their implementation.
    b. of equal importance for radical and incremental innovations, i.e. project radicalness does not moderate the importance of these enablers.

Given these conclusions, frameworks representative of contexts in which these enablers are important may be constructed. Since Leadership and Creativity are only important for the initiation and implementation of radical innovations, quadrants 1 and 2 along the horizontal axis are shaded, but not 3 and 4 (Figure 6.4). On the other hand, based on the conclusion that Experimenting and Risk-taking appear to be important for the initiation of innovations, but that project radicalness does not moderate the importance of these enablers, quadrants 1 and 3 are shaded, but not 2 and 4 (Figure 6.5).

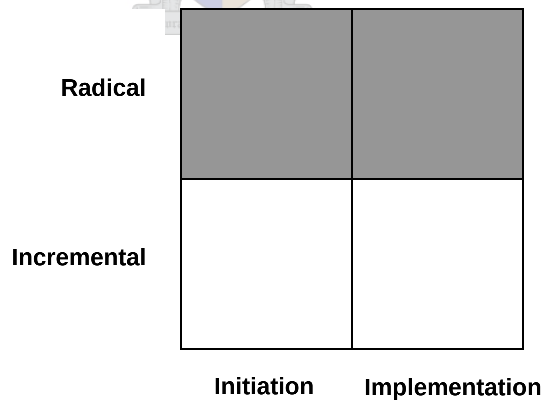

Figure 6.4 The contextual importance of Leadership and Creativity.

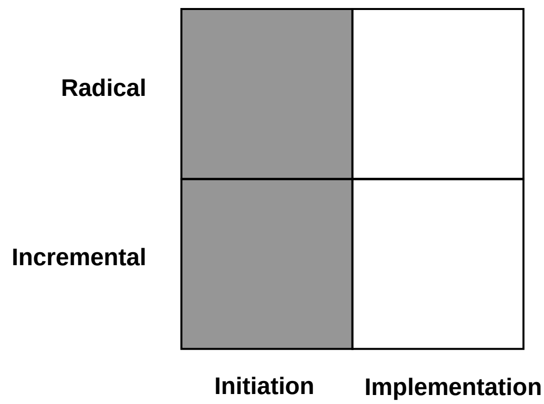

Figure 6.5 The contextual importance of Experimenting and Risk-taking.

In Chapter 5, Strategic Learning was defined as learning from truly external sources of knowledge over which the team has very little or no control. Conclusions made in this regard are summarised below:

1. *Strategic learning is*:
   a. equally important for the initiation and implementation of radical innovations.
   b. equally important for the initiation of radical and incremental innovations.
   c. important for the initiation of incremental projects, but not for the implementation thereof.

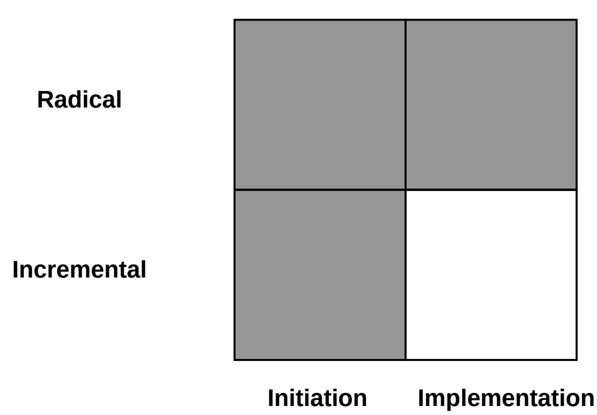

Figure 6.6 The contextual importance of Strategic Learning.

Figure 6.6, which represents the contextual importance of Strategic Learning, may be derived according to the methodology used for Tenacity and Planning & Procedures. Since Strategic learning is important for the initiation, but not implementation of incremental innovations, quadrant 3 is shaded and not 4.

6.2.3 Excellence and the Individual

Results from Chapter 5 showed that neither project radicalness, nor maturity, moderate the importance of enablers related to Excellence and the Individual. Based on the fact that these enablers are not significantly more important in any one particular context[4], none of the four quadrants of the matrix should be shaded. Therefore, in order not to detract from the impact of the model for characterising the importance of enablers that are indeed contextual, Excellence and the Role of the Individual are not represented in it.

6.2.4 Integration of the models

Frameworks representative of the contextual importance of enablers (or constructs thereof) may now be integrated to form a contingency model for the importance of enablers of innovation. This is represented in Figure 6.7 – enablers that have been found to be important in a specific context are shaded and marked in bold, while those with low importance appear in regular type and are not shaded. It is readily apparent that the model facilitates the identification of contexts in which enablers have been found to be important in terms of project radicalness or maturity. The following section discusses the implications of this model for managers of innovation and the significance that it has for the modelling of innovation in the literature.

[4] Although conclusions regarding the importance of enablers have been expressed in absolute terms (i.e. important vs. not important), the reader is reminded of the fact that these importances are relative to one another.

	Initiation	Implementation
Radical	**Project Scope (te, pp)**	**Project Scope (te, pp)**
	Project Scope (su)	**Project Scope (su)**
	Learning (lp, cy)	**Learning (lp, cy)**
	Learning (rt, ex)	Learning (rt, ex)
	Strategic Learning	**Strategic Learning**
Incremental	Project Scope (te, pp)	**Project Scope (te, pp)**
	Project Scope (su)	**Project Scope (su)**
	Learning (lp, cy)	Learning (lp, cy)
	Learning (rt, ex)	Learning (rt, ex)
	Strategic Learning	Strategic Learning

Figure 6.7 A contingency model for the importance of enablers of innovation[5].

6.3 IMPLICATIONS OF THE MODEL

In the interests of simplicity and comparison with models presently available in the literature, the implications of the model are discussed firstly in terms of the moderating role of project radicalness, and then maturity. These are presented in terms of (1) their contribution to the literature, and (2) the management of innovation. In order to keep the discussion as parsimonious as possible, attention is focused on enablers that have been found to be contextually important.

[5] Note that enablers related to Excellence and the Individual are not shown in the interests of clearly presenting the importance of enablers that are contextual. Abbreviations in brackets represent individual enablers – see Appendix B1.

6.3.1 The moderating role of project radicalness

From Figure 6.7 it may be concluded that project radicalness plays a distinctive role in moderating the importance of enablers, much more so than project maturity. This is reflected in the fact that radical innovations seem to involve a much larger set of critical success factors than incremental innovations. In this result, the importance of taking a more project-specific approach to the management of projects is highlighted. Although different projects are generally developed under different strategies, organisations tend not to take into account other contingencies associated with projects. The contingency model suggests that the specific project type also dictates the importance of a number of enablers related to Project Scope and Learning. Adding a formalised step for project classification to the front of the innovation project management program used by the organisation may go a long way in addressing these issues.

6.3.1.1 Project Scope

Managerial implications

Figure 6.7 shows that enablers related to Project Scope – specifically Tenacity and Planning & Procedures – are important throughout the project life cycle of radical innovations, but only during the implementation of incremental innovations. This finding represents important implications for (1) team heterogeneity and (2) project planning and coordination. In terms of team heterogeneity, it may be argued that radical innovations generally embody a wider array of functions and areas of expertise. Such diversity not only fosters creativity, but also is also more suitable for the interpretation of equivocal than unequivocal problems, as argued by Putnam & Sorenson (1982). For this purpose, it is suggested that leaders of radical projects put a premium on facilitating interaction between functional disciplines, specialisations and external sources of knowledge. For incremental projects, this appears to be less important – McKee (1992) refers to this as trading off analytic breadth for depth.

Trends in experimental data also seem to indicate that rigorous planning is required for radical innovations, even during their initiation. This is an important consideration, given the importance of (1) taking into account the pervasive impact that the innovation will have on existing technologies and processes of the organisation, and (2) minimising major changes and delays in the downstream stages of its development. For this purpose, it is suggested that planning for radical projects take the form of work breakdown structures and schedule-monitoring techniques. On the other hand, planning of incremental projects may involve significantly more control in terms of monitoring budget expenditures and technical performance goals, since these goals are less prone to change and may be predefined to a large extent[6].

Also, ambiguous interpretations regarding what the innovation is envisioned to constitute are addressed through planning. Kessler & Chakrabarti (1999) find that clarity of product concept is more important in the case of radical than incremental projects, since ambiguous project concepts may add to the ambiguity surrounding radical innovation and increase speculation and conflict about what is to be produced[7].

Implications for the literature

A comparison of experimental results with findings in the literature is hampered by the following:

1. The majority of models pertaining to the relationship between structural aspects of innovation and the radicalness thereof, do so from the perspective of organisational complexity and not project scope.
2. Shenhar et al. (2002), who do employ the conceptualisation of scope, do not state an explicit relationship between project scope and radicalness[8].

However, for the purposes of comparison, it may be argued that project scope may be viewed as an analogue for organisational complexity, since both concepts relate to specialisation[9], functional differentiation and experience within the unit of analysis. Although research to date does not provide a consistent view of the relationship between project complexity and radicalness (Damanpour & Gopalakrishnan, 1998), results exhibited by this study are consistent with the view of Damanpour & Gopalakrishnan

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[6] These suggestions are based on the recommendations of Shenhar et al. (2002) for projects of high technological uncertainty, which may, to some extent, be related to circumstances of high equivocality.

[7] Thus, enablers related to Project Scope also have a significant role to play in resolving equivocality.

[8] It is interesting to note that Shenhar et al. (2002) models project scope as a moderator of the importance of activities associated with a project – hence, Project Scope may be seen as a tertiary moderator of the importance of typical activities associated with project management.

[9] Although specialisation, operationalised as the diversity of specialties necessary in the team, is not a constituent enabler of Factor 1, it is highly correlated with it ($r = 0.46$, $p < 0.10$).

(1998), which predicts that complexity facilitates radical innovation more than incremental innovation.

Therefore, despite the constraints within which the findings of the study are valid, they do seem to point toward the fact that the relationship between complexity and innovation radicalness at the project level is analogous to that at the organisational level. It represents a step towards empirical validation of the direct positive relationship between complexity and innovation radicalness at the project level.

6.3.1.2 Learning

Managerial implications

From Figure 6.7 it is evident that learning-related enablers that pertain to (1) the resolution of equivocality, and (2) strategic learning (as defined in Chapter 5), appear to be significantly more important for radical than incremental innovations. This was attributed to the fact that incremental innovations usually are associated with very low or zero levels of ambiguity, compared to radical projects, which are generally veiled in ambiguity (even during their implementation). Based on this notion, results on the relative importance of learning-related enablers may have important implications for (1) the ways in which opportunities are framed, (2) decision-making processes, and (3) modes of information processing in different types of innovation.

Schrader et al. (1993) argue that leaders' management and decision-making styles are not only shaped by personal experiences, personality characteristics and the organisational environment, but also by the ways in which they frame ambiguity and uncertainty into their understanding of the problem or opportunity[10]: in framing an opportunity or problem, leaders will either (1) favour problem solutions that are related to past solutions, or (2) favour outcomes that are potentially a break with the past. In addition, leaders can consciously manage problem-framing by their subordinates through shaping the relevant organisational context and resource mix available to them.

[10] Schrader et al. (1993) argue that projects are not characterised by inherent levels of ambiguity and uncertainty, but that leaders or problem solvers choose these levels in the problem-framing process.

Hence, it is suggested that leaders be matched to projects, especially in terms of their ability and willingness in coping with ambiguity. Current research on the relationship between the radicalness of the project and the attributes of the project leader is limited to his/her tenure, age and hierarchical power.

Problem-framing, in turn, presents a number of managerial implications for decision-making (and hence problem-solving processes), since decision-making is precipitated by a choice situation, where the team and organisation are expected to select a course of action (enactment of a solution). Choo (2001b) argues that, depending on the degree of uncertainty about the goals to be pursued (i.e. a situation involving equivocality), and the degree of uncertainty about the methods and procedures available to attain these goals, the team adopts one of four decision-making modes, viz. (1) the boundedly rational mode, (2) the process mode, (3) the political mode, and (4) the anarchic mode. Of specific relevance in the context of the relationship between decision-making modes and the radicalness of innovations, is the choice between the boundedly rational and process modes[11].

Decision-making in the boundedly rational mode may occur when goal and procedural clarity are relatively high – in such cases, choice is based more upon performance programs and standard operating procedures, which reflect the decision rules and routines that the organisation has accumulated from past experience. Decision-making in the process mode, on the other hand, is a dynamic process of search and development marked by iterations: it has a general structure[12], which begins with problem identification, followed by development of alternatives, and ends with the evaluation and selection of an alternative.

Given this distinction, it is suggested that project leaders and team members of radical projects employ dynamic decision-making styles that are congruent with the

[11] In the political mode, decisions and actions result from the bargaining among players pursuing their own interests and manipulating their available instruments of influence. The anarchic mode, on the other hand, prevails in circumstances of high goal and procedural uncertainty and decision-making happens *"through chance and timing, when problems, solutions, participants and choices coincide"* (Choo, 2001b).

[12] This notion is consistent with that of Schrader et al. (1993), who argue that problem-solving under ambiguity (equivocality) is content-independent and may be described in general terms only.

circumstances of the project – this has important implications for the ways in which problems are solved (and thus learning occurs) within the team. It may also, at an organisational level, imply that competing technologies, representing a set of enactments of the environment, should be developed concurrently within the organisation[13]. This may be achieved through internal development alone or via a partnership or joint venture. When it is found that one such enactment is no longer congruent with cues from the environment, it can be discontinued (or shelved) in favour of other technologies in the development pipeline. In this way, the organisation possesses a large degree of flexibility in reaping first-to-market advantages. This notion is supported by Birkinshaw & Lingblad (2001), who propose that an increase in environmental equivocality will increase the likelihood of emergent establishment of intra-organisational competition.

Finally, based on the notion that radical innovations generally involve much higher degrees of equivocality than incremental innovations, the model of Daft & Lengel (1986) may be applied to suggest appropriate modes of information processing for radical and incremental innovations. Since this has significant implications for the ways in which teams learn (especially from the environment – strategic learning) and is linked to different modes of decision-making, it is briefly discussed here. According to the model of Daft & Lengel (1986), the most significant distinction between information processing modes for radical and incremental innovations lie in the richness of media required: for high equivocality, rich media is necessary; for low equivocality, media of lower richness is sufficient. Hence, when gathering information from the external environment, it may be suggested that leaders and managers of radical innovations employ face-to-face or personal exchange of information, as via frequent meetings, external contacts and professional associations[14]. On the other hand, managers of incremental innovations may rely more on surveys, studies, formal reports and scanning services to learn from the external environment.

[13] Cf. the concept of organisational slack, introduced in Chapter 5.

[14] These modes of information processing facilitate rapid feedback and are therefore more suitable to the iterative style of decision-making associated with radical innovations, as suggested above. This notion is supported by Choo (2001b), who argues that *"a continuous stream of equivocal cues necessitates iterative cycles of information processing"*.

The model of Daft & Lengel therefore represents significant managerial implications for suggesting appropriate information processing modes for projects of varying degrees of radicalness. By linking this information processing model to the radicalness of innovations via the association of equivocality with radical innovations, this study suggests that radical and incremental innovations not only require different team learning strategies (i.e. based on different sources of information), but that they should also acquire information from the environment via different modes.

Implications for the literature

The contribution of the findings of the study to the literature may most appropriately be gauged against three prominent models in the literature, which characterise the relationships between types of learning (internal vs. external), and innovation radicalness, viz.:

- The organisational learning model of McKee (1992),
- Balachandra & Friar's (1997) model for success factors in R&D projects, and
- Lynn's (1998) model of team learning strategies.

The model proposed by McKee (1992) suggests that different types of organisational learning skills are involved in different types of innovation. It is argued that one of the major differences between learning for incremental innovation and learning for radical innovation is based on the distinction between interfunctional and environmental contact. Given the fact that incremental innovation typically does not involve fundamental changes in the norms or technological base of the organisation, McKee (1992) argues that interfunctional, and therefore *internal*, contact is more important for incremental innovation.

Radical innovation, on the other hand, represents the organisation's attempts at redefining the way it fits into its environment and hence requires a change in the organisation's norms: therefore, contact for radical innovation is mostly *external* (or *environmental*). This notion is supported and extended to the level of the industry by Gilbert (1994), who references a number of studies indicating that radical innovations tend to be introduced by organisations *outside* an industry or by newcomers rather than by industry incumbents. In essence, therefore, the organisational learning model of McKee (1992) suggests that the distinction between internal and external learning may be used to model the relative importance of learning-related enablers for different types of innovation – whereas internal learning is more important for incremental innovation, external learning plays a more major role in enabling radical rather than incremental learning.

Table 6.1 The findings of Balachandra & Friar (1997) and Lynn (1998) for the contextual importance of internal learning.

	Balachandra & Friar (1997)	**Lynn (1998)**
Type of innovation	**Organisational factors**	**Internal learning** (With-in Team Learning)
Incremental	Important – Very Important	Extensive
Radical	Important – Very Important	Extensive

Table 6.2 The findings of Balachandra & Friar (1997) and Lynn (1998) for the contextual importance of external learning.

	Balachandra & Friar (1997)	**Lynn (1998)**
Type of innovation	**Market and environmental factors**[15]	**External learning** (Cross-Team and Market Learning)[16]
Incremental	Important – Very Important	Moderate – Extensive
Radical	Less important – Important	Restricted - Moderate

Tables 6.1 and 6.2 summarise the findings of Balachandra & Friar (1997) and Lynn (1998) on the relative importance internal and external learning for different types of innovation. A comparison of these tables allows the following conclusions to be made:

1. The importance of internal learning is not moderated by project radicalness, i.e. internal learning is important for both incremental and radical innovations.

[15] Note that these importance values represent Balachandra & Friar's "*best guesses*", and are, therefore, not empirically based.
[16] Since Benchmarking is included under strategic learning, Lynn's Cross-Team Learning is included under external learning. Balachandra & Friar make no distinction between Cross-Team Learning and external learning.

2. External learning plays a more significant in enabling incremental than radical innovation.

A comparison of these two models with that of McKee (1992) reveals that they propose diametrically different trends in the importance of types of learning for incremental and radical innovations (especially in terms of external learning). Two reasons may be suggested for this inconsistency of findings:

1. The distinction between internal and external is too broad a conceptualisation to accurately model the relative importance of enablers for different types of learning.
    a. In Chapter 5 it was shown that a distinction should be made between external sources of information over which the team or organisation has some degree of control or influence (Customers and Suppliers of Technology), and those over which it has very little (Competitors). Given that project radicalness only moderates the importance of Competitors and not Customers, it may be argued that lumping these two types of external learning together obscures the results of these studies. It is therefore suggested that this study contributes to an understanding of the relationship between external learning and the radicalness of innovations by making a distinction between different sources of external information, based on the degree of control that the team has over them or the degree to which they are involved in the project.
    b. It has also been shown that a distinction should be made between different enablers normally associated with internal learning, according to their ability to reduce or resolve uncertainty and equivocality. In this regard, it may be noted that Tidd & Bodley (2002) mention that a growing number of studies indicate that perceptions of environmental uncertainty (i.e. equivocality) influence how new product development is organised and managed. For example, Hauptman & Hirji (1999) investigate the role of ambiguous information in the management of the integration and coordination of cross-functional teams. Souder et al. (1998), on the other hand, determine the effects of technical and market uncertainty and R&D/marketing integration on NPD effectiveness. Therefore, it may be suggested that this study contributes to the validity of this notion and

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extends current knowledge on the topic to a wider array of enablers of innovation.

2. The findings of these studies are not empirically based, but rather founded in conceptualisations of innovation, estimates (see footnote 14) or anecdotal evidence. Although the findings of the study are based on a very small sample size, they do present empirical evidence for the relationships between the importance of types of learning and the radicalness of an innovation.

6.3.2 The moderating role of project maturity

Project maturity appears to play a lesser role than project radicalness in moderating the importance of enablers, based on the observation that the set of critical success factors for the initiation of innovations does not differ substantially from that for the implementation of innovations. Although published findings on the relationship between enabler importance and project maturity are scant, the following sections compare these findings with those available in the literature and present a number of implications for the innovation manager.

6.3.2.1 Project Scope

Managerial implications

Results represented in Figure 6.7 suggest that Tenacity and Planning & Procedures are not important for the initiation of incremental innovations. This finding holds a number of managerial implications in terms of their planning and coordination. Based on the premise that incremental innovations generally involve engineering consulting firms early in their life cycles (given that the majority of these innovations relate to plant support and are therefore subject to significant time pressures, even during initiation), it is suggested that the majority of design and resource planning during initiation be performed by the consulting firm. Once, however, implementation of the project commences, the need for coordination between the contractor and contracting team is heightened and a more formal, rigid style of management becomes necessary.

Radical innovations, on the other hand, typically involve a greater degree of internal development during their initial phases and hence require significant amounts of (internal) planning and coordination during these phases too. These notions are supported by Kessler & Chakrabarti (1999), who argue that radical innovations require proper planning during their initiation to prevent (1) misunderstandings of product targets that can result in major changes and delays in the downstream stages of the project, and (2) speculation and conflict about what is to be produced, which can result in time-consuming adjustments and debates. On the other hand, they argue that vagueness regarding the product concept lends a degree of functional flexibility to incremental innovations.

Although the roles of Suppliers of Technology were found to be unimportant during the initiation of innovations (although with marginal significance only), it has been argued in Chapter 5 that contractors (and customers) should not be considered as “external” to the development team, but rather be seen as integral parts thereof. Hence, it is suggested that these entities should be involved in the project right from the word go. To resolve this apparent discrepancy between arguments, it may therefore be suggested that (1) a representative from the contractor or customer’s side be co-opted onto the team, or (2) when limited resources restrict this option, regular face-to-face meetings be facilitated.

In this way, the reservations of Brown & Eisenhardt (1995) are addressed, i.e. that teams with a short history together tend to lack effective patterns of information sharing and cooperation, resulting in a limitation of the amount and variety of information that can be communicated among team members. This phenomenon may be the reason why Kessler et al. (2000) and Kessler & Chakrabarti (1999) find that utilising external sources of ideas and technologies slowed down innovation. By co-opting contractors and suppliers onto the project team at the initiation of the project (however small their role may then be), the efficiency of external learning (Bierly & Chakrabarti, 1996) may be improved through a greater sense of ownership and understandability *from the side of the contractor or customer*.

Implications for the literature

The findings of the current study have meaningful implications for extending the model of Kessler et al. (2000) for internal vs. external learning to include the influence of project radicalness. In this model, the conclusion is made that the effects of external sourcing (i.e. involvement of suppliers of technology) on speed of innovation and competitive advantage are contingent on the stage of development of a project[17]. Although the study does not consider the moderating role of project radicalness on the effects of external sourcing, it suggests that its findings may be extended to the type of innovation involved: internal sourcing may be particularly effective with projects that involve tacit, systemic and complex knowledge (i.e. more radical projects), whereas external sourcing may be appropriate for projects containing explicit and autonomous knowledge (i.e. more incremental projects). Results of the current study, however, suggest that the importance of external sourcing of technology is not moderated by project radicalness, in effect falsifying these propositions. This finding represents a contribution to the literature for understanding the possible roles that project type and maturity play in the importance of external sourcing.

Finally, it may be noted that the findings of the current study suggest trends contradictory to those predicted by the ambidextrous theory of innovation[18], which proposes that complexity facilitates the initiation of innovations. This contradiction may be attributed to the fact that the ambidextrous theory was developed for the adoption, and not generation, of innovations. Whereas the adoption of innovations involve a greater deal of "homework" regarding the suitability of the innovation *early* in the project, the generation of innovations involve a growing need for coordination of, and buy-in from, different stake holders as the project matures. Nord & Tucker (1987) consider this distinction between adoption and generation as a major caveat in specifying structural characteristics for the design and implementation phases of innovations. They argue that, for borrowed innovations, the design phase is less important and may be accomplished by a very small number of people, hence supporting the trends exhibited by this study.

It is therefore evident that the results of this study may have important implications for the literature, given the fact that the only existing model characterising the relationship between project complexity and maturity was derived for the adoption of innovations,

[17] It must be noted that Kessler et al. (2000) find that outsourcing is detrimental to project completion time, especially during the technology development phase. Although the results of this study do not echo such findings, the general premise that the relative importance of outsourcing is contingent upon the stage of development of a project remains valid.

[18] The ambidextrous theory of innovation arguably represents the only model in the literature that characterises the relationship between complexity and project maturity, albeit at an organisational level.

and not the generation thereof. Although the results of the study are constrained within the domain of process innovations, they do suggest that using the ambidextrous theory of innovation for predicting the importance of enablers during the generation of innovations will lead to erroneous results.

Another possible reason for the inconsistency between experimental data and the ambidextrous theory may lie in the level of analysis at which research was performed: whereas experimental data relate to the project level of analysis, the ambidextrous theory is organisation-based. In this regard, it may be argued that issues relating to planning and coordination are more directly (strongly) perceived in the context of the project than at the level of the functional environment or organisation. This is evidenced by the fact that complexity and coordination are borne out as an underlying dimension of project-level data, while absent at the functional level (see Appendix A4).

Therefore, in the context of the innovation project, complexity is more closely associated with planning and coordination, than the exchange of information and knowledge from different functions or specialisations for ideation at an organisational level. This result appears to indicate that existing models of the relationship between complexity and maturity are invalid at the level of the project. Hence, the contingency model presented in the current study represents a step towards a novel characterisation of the complexity-maturity relationship at the project level.

6.3.2.2 Learning

Managerial implications

Analogous to the results on the contextual importance of learning-related enablers for projects of varying degrees of radicalness, findings of the study may have important implications for (1) modes of problem-solving[19], and (2) modes of information processing most suited to different stages of the innovation process.

[19] Based on the notion that problem-solving lies at the heart of organisational learning (Garvin, 1993).

Arguably the most significant implication of the findings of the study is that problem-solving during the implementation of innovations, especially radical innovations, must not be restricted to closed-form solutions, but that open-ended processes also be employed. Although open-ended processes are typically used for (and associated with) idea generation and opportunity discovery, the importance of such processes during the implementation of innovations have thus far been neglected in the management literature. Given that the implementation of radical innovations generally entails limited prior knowledge or experience, creative problem solving and related open-ended techniques may be a crucial ingredient for the successful implementation of these innovations.

Findings of the study serve as a warning against solving problems only within the framework of existing mental models of the organisation (even during implementation), since these models specify the functional relationships between variables and dictate which information is needed and how it is applied. In this regard it may be suggested that, due to the ambiguity associated with the domain of radical innovation, problems during the later stages of radical innovations (post idea generation) also be solved with inputs from the environment, since these cues afford the project leader the opportunity to continuously check the basic beliefs and assumptions of the project against evolving frames of reference and standards in the environment.

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Based on the premise that technical problem-solving relates primarily to the reduction of uncertainty (Shenhar, 2001), the information-processing model of Daft & Lengel (1986) may be used to suggest different mechanisms through which information may be obtained from the environment. Daft & Lengel contend that the most significant difference in the mode of information processing between circumstances of high and low uncertainty lies in the amount of information necessary. Hence, it is suggested that strategic scanning and technology forecasting techniques (traditionally used for ideation and identification of new opportunities) be supplanted for learning via casual information exchange between managers, meetings of professional associations and irregular external contacts during latter stages of the project. Though less information is acquired during these stages, information acquired via these rich media facilitate a better understanding and interpretation of cues from the environment.

Implications for the literature

Experimental findings on the relationship between learning-related enablers and project maturity are relatively unique: although a number of models have emerged for the relationship between different types of learning and the *radicalness* of an innovation (as discussed earlier), no prominent model exists for the importance of this construct in terms of the *maturity* of innovations. Hence, this study contributes to the knowledge on the contextual importance of different types and sources of organisational learning by suggesting a preliminary model for their relationship with the maturity of an innovation.

The only model that could possibly serve as a basis for comparison of results in this regard is that of Kessler et al. (2000), which investigates the effects of internal vs. external learning on speed, costs and competitive advantages of new products during their idea generation and technology development stages. However, since the study pertains specifically to the sourcing of technology, it has greater relevance in terms of Project Scope and the importance of Suppliers of Technology. This study has received prior attention in section 6.3.2.1.

6.4 SUMMARY

Shenhar (2001) argues that while contingency theory has largely been used to characterise the relationships between structural and environmental attributes at the level of the organisation, its application in the context of the project has much less been investigated. This chapter has contributed to the validity of classical contingency theory arguments in the context of the project, by presenting the development of a contingency model for the importance of enablers of innovation at the project level. Despite the orientation of the study towards process innovation and the relatively small sample size from which conclusions were drawn, it does represent a step towards capturing the contextual importance of enablers in terms of project radicalness and maturity via contingency theory.

The contingency model reflects the two most significant conclusions of this study. The first is that the interactions between moderators of enabler importance need to be taken into account when modelling innovation, since these have important implications for the management of different types of projects. Given (1) the vast impact of these interactions on enabler importance, and (2) the fact that no normative statements regarding the roles of radicalness and maturity in governing the importance of enablers can be made, it is concluded that the formulation of middle-range theories of innovation radicalness or maturity is not possible[20]. This finding supports the notion that the modelling of innovation should follow a contingent approach.

The second is that the distinction between uncertainty and equivocality may be used to account for the roles of project radicalness and maturity in governing the importance of enablers. Although a growing number of studies indicate that the degree of ambiguity or equivocality prevalent in a project influences the ways in which it is organised and managed, this study contributes to this field of knowledge by (1) investigating its effect on a wider array of enablers of innovation than has previously been reported, and (2) linking it to project radicalness to predict and model the contextual importance of enablers for radical and incremental projects.

In essence, the contingency model contributes to the literature in that it represents an integrative model of the contextual importance of a number of generic enablers of innovation, that have previously been investigated independently.

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[20] Cf. Chapter 1: Introduction.

CHAPTER 7

Final Conclusions and Future Research

The overall objective of this thesis was the development of a contingency model for the importance of enablers of technological innovation in terms of project radicalness and maturity. This chapter summarises the most pertinent conclusions derived from each chapter and relates how these contribute to the derivation and interpretation of this model. In this way, a concise overview of the thesis is facilitated. However, the character of research is such that a project is never considered fully completed – hence, the limitations of the study are discussed in order to suggest a number of directions for future research.

7.1 CONCLUSIONS OF THE CURRENT STUDY

In Chapter 1, it was related how a multitude of factors deemed critical for success in innovation are reported in the literature, while researchers pay little attention to the context(s) in which these factors are valid (or at least significant). This phenomenon was cited as a probable cause for continued failure in innovation, despite 25 years of research into why new products succeed.

In order to validate this contention, it was necessary for the study to (1) determine the validity of the proposition that the importances of enablers are contextual, and (2) derive a model that could capture the significance of these contextualities. Based on the work of Damanpour & Gopalakrishnan (1998), project radicalness and maturity were defined as important moderators of enabler importance. Given the lack of empirical research on the moderating effects of these project attributes and the scantiness of relevant models in this regard (compared to those at an organisational level), it was concluded that sufficient scope existed for this study to make an original contribution to the existing body of knowledge on the management of innovation.

Chapter 2: Selection of variables

In order to fix the scope of variables for the study, an exhaustive review of the literature on all possible factors enabling success in innovation was performed. Chapter 2 presents a summary of the most prominent of these, gleaned either from case studies, anecdotal material, management opinion or rigorous empirical studies. From this review, it was concluded that all related studies point to a relatively consistent, though expansive, list of enablers. Findings in this regard are presented according to the framework of Craig & Hart (1992), since it was deemed to be compatible with most of the other frameworks used for classification of enablers in the literature.

Chapter 3: Theoretical model and hypotheses

Chapter 3 details the formulation of a number of hypotheses regarding the roles of project radicalness and maturity in moderating the importance of enablers of innovation, the outcomes of which would form the basis for development of the contingency model. Hypotheses were derived from knowledge gained from two sources, viz. (1) a literature survey of findings pertaining to the contextual importance of enablers, and (2) the results of a multi-organisation exploratory survey on the importance of enablers in different functional environments of organisations.

In terms of the literature survey, two major conclusions were made. The first was that evidence in the literature pertaining to this field of research is generally either controversial, or lacking in empirical proof (based on anecdotal evidence or the experience of researchers). Thus, an empirical investigation into the contextual importance of a broad set of enablers of innovation was further justified.

The second conclusion made in this regard was that evidence in the literature, which pertains specifically to the project-level of analysis, is scarce. Hence, a number of inferences regarding the importance of enablers in terms of project radicalness and maturity were made, based on findings reported for functional environments in organisations and activities associated with them. For this purpose, a number of studies highlighting the differences in the natures of activities associated with R&D and Production (or research and development) yielded valuable insights.

Based on the premise that inferences regarding the contextual importance of enablers may be derived from knowledge of the propensities of different functional environments for radical and incremental innovation, and their involvement during stages of the project life cycle, the results of a multi-organisation exploratory survey on the importance of enablers in different functional environments were used for hypothesis development. The most important conclusion derived from results of this study was that a number of enablers exhibited significant differences in importance between functional environments, supporting the proposition that the importances of a number of enablers are contextual.

Chapter 4: Research methodology

The research philosophy of this study was dictated by the need to understand how the radical innovation process differs from that of incremental innovation, and the role of project maturity in this. For this purpose, a multiple case comparison of actual projects was performed, employing both qualitative and quantitative means for data collection. This enabled the researcher to obtain a thorough understanding of the contextual importance of enablers.

The research sample consisted of an array of projects within a single organisation. Given that the purpose of the study was aimed at the validation of a theoretical model of enabler importance (based in part on findings from a multi-organisation exploratory survey) it was concluded that sacrificing some level of external validity of the model for the necessity of demonstrating its internal validity was justified. Based on the fact that practically the entire portfolio of projects of the organisation was sampled, and that the projects investigated were representative of typical projects generally undertaken by the organisation (and its direct competitors), it was concluded that findings of the study were at least generalisable to other organisations pursuing similar types of innovations, within analogous industries.

Chapter 5: Results and discussion

The primary objective of this chapter was aimed at the testing of hypotheses regarding the contextual importance of enablers. In addition to this, factor analysis of data was also performed in order to identify structures in the relationships between enablers.

Conclusions in this regard would serve as a foundation for development of a contingency model of the moderated importances of enablers.

Factor analysis of data showed that four underlying constructs of enablers characterise innovation at the project level, viz. Project Scope, Learning, Excellence and the Individual. Project Scope pertains to the coordination and complexity of the project, whereas Learning relates to the creation and acquisition (either internal or external to the team) of new knowledge and the learning derived from it. Excellence, on the other hand, relates to aspects associated with the thoroughness of the innovation process, while the individual-centric factor pertains to the role of the individual and the way he/she is motivated.

Based on trends in the results of ANOVAs on factors and individual enablers, it was concluded that project radicalness and maturity play significant roles in moderating the importance of enablers related to Project Scope and Learning, but that the importances of Excellence and the Individual are not contextual in nature. In terms of Project Scope, it was concluded that Tenacity and Planning & Procedures are important throughout the project life cycles of radical innovations, but only important during the implementation of incremental innovations.

Enablers associated with Learning revealed a number of insights. It was found that, whereas the importance of Creativity and Leadership are moderated only by project radicalness (and not maturity), Experimenting and Risk-taking exhibited dependence on project maturity but not radicalness. It was concluded that these phenomena could be attributed to the ability of each of these sets enablers to reduce (or resolve) different types of uncertainty associated with projects, viz. equivocality and uncertainty.

In terms of external learning, it was concluded that the traditional distinction between internal and external sources of learning was inadequate to characterise the moderating effects of project radicalness and maturity on the importance of enablers. Based on the results of ANOVAs at the project level, and a factor analysis of data at the functional level, it was suggested that the distinction between “internal” and “external” should hinge upon the degree of control that the team has over the external source (or the level of involvement thereof in the team).

Designating learning from sources over which the team has very little control as *strategic learning*, it was concluded that strategic learning is important throughout the project life cycles of radical innovations, but only important during the initiation of incremental innovations.

Finally, results at the functional[1] and project levels reveal a fair degree of consistency between hypothesised and experimental outcomes for the importance of enablers related to Learning and the Individual. Although the hypothesised *direction* of importance of External Learning was not supported by results at the project-level, it may be argued that the general congruence between the results of the studies lends a large degree of external validity to results obtained from a single organisation.

Chapter 6: A contingency model for the importance of enablers

Shenhar (2001) suggested that *"more research seems appropriate to establish additional validity of contingencies in projects and to further explore the 'one-size-does-not-fit-all' paradigm"*. In this study, empirical evidence of the contextual importance of enablers is provided; hence, it contributes to theory building on contingencies in projects.

Unlike previous middle-range theories of innovation, the contingency model does not suggest any normative conclusions regarding the roles of project radicalness and maturity in governing the importance of enablers. Rather, it takes into account the mutual interactions between moderators and predicts the importance of enablers for specific configurations of these. As such, the notion that the modelling of innovation should follow a more contingent approach is supported.

The contingency model contributes to the literature regarding the importance of complexity in terms of the radicalness and maturity of innovations at the project level. Given that current models of these relationships generally relate to the organisational level of analysis, the model presents preliminary information on the characterisation and quantification of the direct positive relationship between complexity and innovation radicalness at the project level. Based on the fact that the only existing model of the relationship between project complexity and maturity was derived for the adoption of innovations (and not the generation thereof), the contingency model further represents a

[1] I.e. results obtained from the exploratory study

step towards a novel characterisation of the complexity-maturity relationship at the project level.

In addition to this, the model reveals a number of insights regarding the contextual importance of so-called team learning strategies. It contributes to an understanding of the relationship between external learning and the radicalness of innovations by making a distinction between different sources of external information, based on the degree of control that the team has over them or the degree to which they are involved in the project. It also contributes to the validity of the notion that perceptions of environmental uncertainty (i.e. equivocality) influence how new product development is organised and managed, and extends current knowledge on the topic to a wider array of enablers of innovation.

In summary, the contingency model integrates a number of concepts in the management of innovation and presents them in a coherent framework in which the contextual importances of enablers are captured.

7.2 LIMITATIONS OF THE STUDY AND FUTURE RESEARCH

Although the study has to a large extent succeeded in achieving its objectives, it does have a number of limitations. These limitations mainly arise from the scope of the study and the research methodology followed in collecting data. Based on these limitations, and a number of observations made in the previous chapter, suggestions for future research are made.

The most significant limitation of the study arguably relates to the fact that it does not employ a cross-section of a large number of organisations, but that data collection followed a case study approach at a single organisation. Although it has been proven that (1) the organisation used for the main study is arguably one of South Africa's most innovative[2], (2) the methodology is consistent with the objective of demonstrating internal validity of the model, and (3) that a fair degree of congruence is evident between the results of the exploratory and main studies, it may be argued that data from a

[2] Certainly in its specific industry

broader sample of organisations may yield more representative results. Thus, it is suggested that the external validity of this model be justified by applying it to other organisations in the industry, specifically at an international level.

Pavitt et al. (1989) argue that industry and sector are strong determinants of organisational innovation. Not only are organisations in certain industries more innovative than those in other industries, but differences between industries also imply differences in the basic characteristics of organisations and the rate, speed, types and sources of their innovations. Given that the model was derived from data in the Chemicals and Mining & Minerals Processing industries, it is suggested that the external validity of the model further be tested in other industries with divergent organisational and innovation characteristics.

It is also important to note that, as an artefact of the industries sampled in this study, results and conclusions are generally more representative of *process innovations*. As such, the model does not explicitly take into account factors relating to issues such as market timing, product positioning and advantage. Given the preponderance of research on product innovation in the literature, it is suggested that the model be extended to include the possible contextual importance of such factors or determine whether they act as moderators of the importance of enablers.

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In this vein, it may be suggested that the effects of other possible moderators of enabler importance be investigated. Shenhar (2001), for example, suggests that market uncertainty and project pace represent additional dimensions of project contingency. Preliminary evidence from this study also suggests that innovation source (technology push vs. market pull) plays a significant role in moderating the importance of enablers and that it exhibits mutual interactions with other moderators.

From observations regarding deficiencies in the state of knowledge in areas of the management of innovation, the following areas are earmarked for future research.

Attributes of the project leader

Past and current research into the relationship between leader characteristics and different types of projects has been limited to the role that the experiences of the leader play in shaping his/her management and decision-making styles. However, personal characteristics also play significant roles in this[3]. Hence, it is suggested that future research on the relationship between project leader characteristics and type of project also take into account the thinking styles of project leaders. An empirical investigation into this might yield a number of valuable insights into the failure or success of past projects.

The Individual

Jensen & Harmsen (2001) argue that few researches have been interested in understanding the role and importance of the individual employee as opposed to manager. This argument has been supported in the current study – in Chapter 5 it was noted that plausible explanations for the importance of the individual in innovation are not readily available. Hence, it is suggested that the role of the individual in innovation be researched more intensively in order to shed light on his/her importance in innovation.

The relationship between information processing modes and attributes of innovations

In Chapter 6, it was related how the information processing model of Daft & Lengel (1986) could be applied to identify appropriate *modes of information processing* for radical and incremental innovations and the stages of development thereof, via the equivocality-uncertainty perspective. In this regard, a number of suggestions were made for avenues that project managers could follow in acquiring information from the environment. Since these suggestions are based on the assumptions of the study, it is proposed that their validity be determined experimentally in future studies.

Project typologies

Finally, it may be suggested that an effort be made to standardise project classification schemes or typologies. A major obstacle in comparing the results of studies in the innovation and project management literature has been the disparity between theoretical constructs traditionally used to classify projects in these fields. Although innovation

[3] Schrader et al. (1993)

studies often use the distinction between incremental and radical, the project management literature has been slow in adapting a similar approach[4]. Standardisation of theoretical constructs of projects between these highly interrelated fields will not only increase the comparability of findings between studies, but will also accelerate an understanding of the important issues underlying the management of innovation projects.

Despite the limitations thereof, this dissertation suggests that the importances of a number of enablers are contextual. By presenting a contingency model of these contextualities, it has presented a more integrated and advanced theory of the importance of enablers than is presently available.

[4] Shenhar et al. (2002)

CHAPTER 8

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APPENDIX A1

Research Methodology

Due to the exploratory nature of this study, as large a sample as possible was needed: in this regard, mainly quantitative techniques were used in light of resource limitations. Appendix A1 presents the research design and implementation of the survey instrument, as well as methodologies followed for analysis of data collected.

A1.1 RESEARCH DESIGN

In order to obtain *relative values* of the importance of enablers in different functional environments, a standard audit of innovative capabilities was applied to both the R&D and Production environments of organisations. The audit was developed to incorporate measurement of each of the enablers identified in Chapter 2 and was derived from an innovation audit developed by Dr. Victor Ross of De Beers[1], which in turn, was based upon the design philosophies of other innovation audits presented in the literature, the most prominent of which include those of Chiesa et al. (1996) and Tang (1999).

Innovation audits of this nature usually embrace a model that sets out the scope of what is to be audited and develop a set of detailed measures around this model to enable the auditor to determine where good practices and capabilities are in place (Chiesa et al., 1996). Based on this, Chiesa et al. (1996) suggest a framework for auditing the organisation's innovation capability, based on a process model of innovation that is enabled by a number of core processes (concept generation, product development, process innovation and technology acquisition) and enabling processes (leadership, resource provision and systems and tools). By auditing the drivers (e.g. creativity, teamwork, continuous improvement and funding) that underlie each of these processes, innovative capabilities are measured.

Tang (1999), on the other hand, presents an *Inventory of Organisational Innovativeness (IOI),* based on a suggested integrative model of innovation in organisations (Tang, 1998), which considers six mutually interacting constructs, i.e. (1) project raising and

[1] Personal communication: DebTech Innovation Audit, August 2000.

doing, (2) knowledge and skills, (3) behaviour and integration, (4) information and communication, (5) guidance and support and (6) the external environment. Analogous to the approach of Chiesa et al. (1996), organisational innovativeness is measured via the performance of the key concepts that underlie these constructs.

In much the same fashion as Tang (1999), the audit developed for this study measures the significance of enablers (analogous to Tang's *constructs*) by the key *actions* and *capabilities* (analogous to Tang's *key concepts*) that underlie them. No *a priori* model of enablers is, however, assumed beforehand, since it is the purpose of the audit to facilitate development of such a model. The progression of statements in the questionnaire does, however, reflect the four *domains* that influence the process and collectively determine the nature of innovation (Ross, 2000). These are (1) the *Individual*, (2) the *Organisational context* in which he/she works (this includes individual business units, functions or departments), (3) the *Business environment* (industry) in which the organisation operates, and (4) the *External environment* (government, factors and trends that influence innovation in a less or more direct manner). In this way, a better understanding of the contexts in which particular statements should be interpreted and evaluated is facilitated amongst respondents.

A1.2 DESIGN OF THE QUESTIONNAIRE

A1.2.1 Measurement Scales and Item Development

The purpose of the survey questionnaire is to represent each enabler of innovation by a number of declarative statements that respondents can *easily* comprehend and on which they can express their degree of agreement. Ease of understanding was of prime importance in this case, since the survey was not interactive. Since the same questionnaire was used in both R&D and Production, and respondents were asked to evaluate each of the statements according to how they were perceived or experienced in their *"particular work environments"*, significant effort was put into the phrasing of statements in order not to exhibit any degree of bias towards any one of the environments in which the audit was administered.

Each of these statements (termed *items*) are concerned with an action or capability related to the particular enabler, as mentioned above. The average of the scores of a group of such items is another variable, termed a *scale*, which directly represents the strength or performance of an enabler of innovation. Based upon its simplicity, ease of use and widespread application in related studies, a 5-point Likert-type scoring system was used and defined as follows:

1. *We do this badly; never or very seldom is this the case*
2. *Seldom the case*
3. *Normally the case; on average*
4. *True most of the time and in most cases*
5. *We do this all the time; always true; only with rare exception is this not the norm*

Measurements are therefore based on perceptual self-assessments of respondents. Such data is appropriate for the study of management practices, based upon the common premise that behaviours follow perceptions. Souder & Jenssen (1999) do warn that care must be taken in the interpretation of results derived from such Likert-type scores which are based upon self-assessment, since they are not ratio-level measurement scales and, therefore, do not provide absolute measures; however, this warning has limited application in the study, since it is only aimed at obtaining *relative* scores between two contexts.

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A1.2.2 Questionnaire format

The survey was divided into two parts, i.e.

- *Biographical details*. The primary objective of this section was not to obtain personal details about respondents (in the interests of confidentiality respondents were allowed to withhold personal details such as name, age, sex and contact details), but rather to determine the respondent's organisation of reference, division/department and functional area (these were included as compulsory fields) in order to facilitate accurate classification of data according to their associated functionalities.
- *Performance Questionnaire.* This questionnaire accounted for the main body of the survey and measured respondents' perceptions regarding the strength of enablers in their particular work environments, as discussed above. In total, 64

items are used to measure the performance of 29 scales or enablers. This database was used as the *primary data source* for all statistical analyses.

A1.2.3 Pre-testing of the questionnaire

Having identified and compiled a number of potential survey statements, the questionnaire itself needed to be pre-tested before implementation. This was done by circulating it amongst academics and the innovation manager of one of the organisations audited, as well as via extensive personal interviews with a number of people at another one of the organisations studied. Statements that were found to be vague in meaning were rephrased to the satisfaction of the above critics or deleted.

For obvious reasons the questionnaire was limited to the minimum amount of statements (and therefore also, completion time): this not only keeps the respondent focussed on the issue at hand, but also improves the statistical validity of the questionnaire (for a given number of respondents). Therefore, test runs for time needed to complete the questionnaire were also undertaken – in this fashion, the length of the questionnaire was limited to an average completion time of approximately 30 minutes.

A1.3 RESEARCH SAMPLE

A1.3.1 Organisations

In order to make normative statements regarding the relative importance of enablers in different functional environments within organisations possible, it was important to select a sample of organisations for which the data collected would transcend the particular natures of functional environments (and the linkages between these) own to different organisations. In addition to this condition, organisations had to meet all of the following study criteria:

- Local headquarters – this criterion was introduced simply due to practical resource constraints
- Use of some form of successful new product development program, such as a Stage Gate or analogous system
- Involvement in fundamental (basic) research, and not just applied research or modifications of acquired technology – this criterion was practically translated

into organisations doing their own in-house R&D, and was necessary for research on the capabilities needed for development of radical innovations.

Due to resource constraints, the scope of the study was limited to organisations in the Chemicals and Mining & Minerals Processing Industries of South Africa. Organisations in these industries mostly innovate to refine and extend existing products and processes, but because the environment is continuously changing, they also emphasise radical innovations. Hence, these organisations adopt a *balanced rate* of radical and incremental innovations and thus are suitable for investigation in the context of this study. As a result of the study criteria, the sample consisted of large[2], well-established organisations that had proven new product development programs and exhibited a range of task and functional environments. From the original 11 organisations targeted, 8 agreed to participate in the study[3]. The participating organisations were characterised by annual sales revenues of 320 to 5,400 US$ (million) and employee numbers of 1,700 to 38,000[4]. R&D expenditures of these organisations were comparable with international industry standards, which typically amount to 2 to 4% of annual revenue in the Chemicals industry and approximately 1% in the Mining and Minerals processing industry.

It must be kept in mind that the way in which companies were selected means that the sample is not completely random. As a result, findings should be interpreted in the strictest sense as applying only to those organisations in the sample. However, because a relatively broad cross-section of organisations and functional environments was studied, the findings of the study may be generalisable to some degree to organisations in these industries. Given the idiosyncrasies of innovation between different organisations, results are more generalisable than single case studies of organisations.

[2] *Large* is defined as involving >500 employees, consistent with the classification of Chiesa et al. (1996).

[3] Non-participation by the remaining 3 organisations was typically attributed to time or other resource constraints or the fact that involvement in the study would not contribute significant value to the organisation.

[4] Names of specific organisations and specific rankings of sales and revenues are withheld due to confidentiality agreements; figures are taken from 2001 annual statements.

A1.3.2 Key Informants & Respondents

Having identified a set of organisations for sampling, it was necessary to establish an *entry point* (primary contact) into each. This was accomplished by identifying appropriate heads of functional units, divisional heads and human resource, technology and innovation managers who represented existing contacts and liaisons between this research institution and their particular organisations. Personal interviews with each of these contacts were scheduled to present the scope and objectives of the study, during which organisations' commitment to the study was secured.

All contact with respondents in any of the organisations was achieved *indirectly* via such liaisons. A link to the audit survey homepage (which is discussed in the next section) was sent to these individuals, who, in turn, distributed and implemented the audit in their respective organisations to all respondents who, based on their discretion, satisfied broadly defined requirements for participation pertaining to respondents' seniority. In this way, data was collected according to a top-down and bottom-up approach (Tang, 1996): information was gathered both from people whose work was directly related to innovative activities, as well as middle- and senior-level managers. By distributing the link to the questionnaire from the office of a high-level manager, senior management support of the survey was implicitly stated. This was an important *"incentive"* in light of the fact that participation in the audit was completely voluntary. In total, 128 responses were collected, 79 of which were useable[5].

A1.4 DATA COLLECTION

A1.4.1 Procedure

As mentioned earlier, the exploratory nature of the study necessitated as large a sample of respondents from as diverse a range of organisations (within the defined scope of the study) as possible. In light of this, it was decided to implement the survey not via mailed questionnaires, but via an *on-line questionnaire*, which was linked directly to a website containing the background, scope and objectives of the study, as well as necessary contact details of the researcher in case of any queries. The use of on-line questionnaires has several advantages:

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[5] Refer to *section A1.4.2 Problems experienced* for details in this regard.

- *Ease of distribution and access*. Since the audit questionnaire is available on the World Wide Web, no distribution of the questionnaire is necessary – it merely needs to be accessed. Therefore, the main factor limiting response to the questionnaire was respondents' own access to the Internet. This, however, was not foreseen as a significant obstacle since all organisations audited provided employees with access to the Internet.
- *Ease of use and completion*. Radio buttons were used to symbolise each point of the 5-point Likert-type scale used for scoring of statements. This has two distinct advantages:
    - Respondents indicate their score for a statement by simply clicking on the appropriate button associated with the particular score
    - If the respondent has clicked a button, but wishes to alter his/her score, clicking of another button in the scale automatically updates the score given and erases the previous one.

  On-line questionnaires also have the added advantage of providing an easy alternative to bulky questionnaires: since respondents can simply navigate through the questionnaire via the use of a mouse, completion of the questionnaire is achieved through less hassle. Some respondents even mentioned that it was *relatively more fun* to complete such questionnaires that deviated from the run-of-the-mill paper-based surveys.
- *Ease of data return and collection*. Respondents' scores are automatically transferred to a central database after completion of the survey. This not only eliminates respondents having to mail back a completed questionnaire (translating into a saving of time and money), but also has the added advantages of increased security and virtually instantaneous access to the data by the researcher.

Kessler et al. (2000), however, argue that in collecting data through mailed questionnaires or, for that matter, on-line audits, a trade-off is made with respect to efficiency (e.g. lower cost, time and staff requirements) versus accuracy (e.g. lower degree of objectivity in the data). According to Fowler (1988), low accuracy in data may be attributable to the fact that respondents:

- Do not know the information
- Cannot recall the information
- Do not want to report the information
- Do not understand the questions

However, in the context of self-assessment surveys that measure perceptions, the first two reasons have limited validity. By promising respondents general feedback on their inputs (a form of incentive offered for completion of the survey), and through thorough pre-testing of the questionnaire, it was hoped that issues highlighted by the last two reservations were adequately addressed.

A1.4.2 Problems experienced

The most significant problems experienced during the exploratory study did not relate to a lack of willingness to participate in the study (both at organisational and individual levels), as is usually the case in voluntary sociometric studies, but were rather related to technical aspects of the survey. In particular, several problems related to server availability, performance and database set-up were experienced; due to these problems, some respondents encountered difficulties in accessing the survey questionnaire. Although it seemed evident that a number of respondents were willing to repeatedly try accessing the server after initial failed attempts, it may be argued that most respondents encountering difficulties were completely discouraged to try again. In light of this, the potential response rate of the survey was severely diminished. Hence, despite the many advantages associated with on-line questionnaires, the use of mailed surveys may prove more advantageous in terms of simplicity. On the other hand, it may be argued that the problems experienced with the server could simply be attributed to the relative lack of experience of the researcher in implementing these kinds of surveys.

A1.5 DATA ANALYSIS

According to the objectives of the exploratory study, data analysis[6] was performed to (1) determine whether significant differences existed between the importances of various enablers in different functional environments (2) extract the latent variables underlying

[6] All statistical analyses were performed by Dr. Martin Kidd of the Centre for Statistical Consultation, University of Stellenbosch using the statistical package Statistica 6.

the importance of enablers in order to suggest a suitable framework for classification thereof. However, since multi-item scales were used to assess the perceived strengths of enablers, reliability of those measures first needed to be determined.

A1.5.1 Measurement Reliability

According to Tang (1999), there are two coupled criteria of goodness (or reliability) to be satisfied, i.e.:

- The items in a scale must be internally consistent, i.e. items belonging to one construct must measure the same thing; and
- An item's inter-scale correlation should be lower than its intra-scale correlation, i.e. an item should be associated with the correct group of variables or construct.

Internal consistency of scales, based on the combined database of respondents, were measured either with Cronbach's alpha, or, in the case of scales with only two items, correlation coefficients. Although a value of 0.7 is generally accepted as a minimum for internal consistency (Nunnally, 1978), DeVellis (1991) has shown that alpha values of 0.6 may also be acceptable, though undesirable, for exploratory research. A reliability analysis of the original items revealed that (1) a number of postulated assignments of items to scales resulted in alpha values of below 0.6, which necessitated re-assignment of such items to other scales, and (2) certain items could be regrouped in order to obtain higher levels of intra-scale reliability, even though these exhibited alpha values above 0.6. In total, the scales that were affected included:

- Organisational Structure
- Planning and Procedures (Formalisation)
- Quality
- Skills & Competences
- Teamwork

In order to satisfy both conditions for scale reliability, items that were identified to significantly reduce intra-scale correlation per construct were regrouped under other associated scales. This process was repeated iteratively until optimum values of intra- and inter-scale correlations were achieved. Accordingly, two new scales were formed, i.e. Cross-functionality (containing items previously belonging to Teamwork and Organisational Structure) and Information Systems (an amalgamation of Information &

Communication and Systems & Tools). Items that did not *"fit"* into any of the remaining scales were redefined as scales: as such, two new scales were formed, i.e. Continuous Improvement and Co-location. The resulting set of items and scales exhibited Cronbach alphas between 0.63 and 0.83 (which is consistent with values presented in other related studies, such as Lynn et al. (1999)). All correlations between two item scales were significant at the $p < 0.05$ level.

A further test of survey reliability was built into the questionnaire by placement of two pairs of basically identical statements in different places in the questionnaire. A high correlation between these items would indicate a high level of consistency in the way respondents scored similar statements and would therefore contribute to the validity of results. The average correlation coefficient for these items was found to be 0.84: this indicated a high level of confidence in the validity of respondent scoring. The final layout of scales and items used for further analysis of data is presented in Appendix A2.

A1.5.2 Analyses of variance

Analysis of variance tests were conducted for each scale (enabler) in order to determine whether significant differences existed in the strengths of enablers in different functional environments of the organisation[7]. Therefore, prior to commencement of these tests, data needed to be classified according to functional groups. Data representative of three main functional areas was obtained, viz.:

- R&D
- Engineering
- Production

Given the bifurcation of project radicalness and maturity for methodological and analytical reasons in the main study, it was important to classify these functional groups into two main groups too. Therefore, it was necessary to determine with which group Engineering was *most closely associated*. From a theoretical perspective, Engineering relates more to the implementation of innovation than the initiation (or conception) thereof and should therefore relate more closely to Production. This notion was supported by descriptive statistics of the three groups of data, which showed that

[7] These tests were, as in the case of the factor analyses, conducted on the combined database of organisations – no distinctions were made between functional environments of specific organisations.

Engineering was more similar to Production than R&D; these findings were supported by ANOVAs between the combinations of groups. Hence, the data for these two groups were lumped together under the term 'Production' for all further ANOVAs.

Having classified the data for analysis, descriptive statistics of both groups were calculated prior to ANOVAs. Results of these calculations revealed an interesting phenomenon regarding different groups' perspectives (or styles) in scoring items of the questionnaire, namely that the scores of respondents from Production were consistently higher than those of R&D. It is proposed that this phenomenon might be due to the following two reasons:

1. By their very nature, individuals in R&D are objective and critical of their work, and therefore also of their work environment. Hence, it may be argued that researchers give overly critical (low) scores to statements in the questionnaire.
2. On the other hand, it may be argued that the performance-orientated natures of Production environments give rise to overly optimistic scores, since audits such as the one implemented are often associated with some sort of performance appraisal.

Since these issues have important implications for the *directions* of ANOVAs (i.e. an *increase* or *decrease* in the importance of enablers from one functional environment to another), it was important to adopt a methodological approach that would circumvent these complications. Since the study was aimed at determining only relative values of importance of enablers, it was decided to rank enablers (from most to least important, based on scales' scores) according to the scores given in each environment and then do the ANOVAs on these rankings (relative positions). Since ANOVAs are strictly not applicable to such rankings, non-parametric tests[8] were also performed between groups in order to substantiate *tentative* conclusions regarding the relative importance of enablers in different functional environments based on ANOVAs of rankings.

Appendix A3 provides a summary of results of the ANOVAs performed on rankings of individual enablers. Enablers that showed significant differences between functional environments are marked in bold, with asterisks reflecting the levels of significance (p-levels) of the results.

[8] Using Mann-Whitney U tests

A1.5.3 Factor analyses

Factor analysis is a statistical technique used to (1) explore or confirm the structure of variables that underlie a large set of data, or (2) to summarise a large number of variables with a smaller number of derived variables called factors or *latent variables*. Factor analysis[9] was performed on the averages of scale scores of the *combined database of all organisations audited* (recomputed after the reliability analysis) to yield two factors that collectively accounted for 50.5% of the variance in the data[10]. Scales were grouped into factors by using a cut-off value for factor loadings of 0.58 – in this way, no ambiguous loadings were obtained.

Data regarding the eigenvalues and rotated factor loadings associated with each of the factors are provided in Appendix A4.

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[9] Principle component extraction, using Varimax rotation

[10] Factor analyses with 3 and 4 factors were also performed. However, these additional factors were not as coherent or meaningful as the original two factors. Hence, two factors were accepted as sufficiently descriptive of the data. The use of two factors is consistent with results of a Scree test for determining the number of factors needed.

APPENDIX A2

Scales and items of the exploratory survey, post reliability analysis

ITEM #	SCALES AND ITEMS
	Auditing
1	Post Completion Audits (PCA's) are an integral part of standard procedures.
2	The lessons learnt in these cases are well communicated to the rest of the organisation.
3	Technology audits provide key input to formulating and focusing technology strategy.
4	The organisation learns from past mistakes and rarely makes the same mistakes twice.
	Benchmarking
5	Technologies and processes used or developed by competitors are monitored and tracked closely.
6	The organisation frequently benchmarks itself against competitors and global best practices.
	Capital
7	Funds are generally available for sponsoring an innovative idea that someone would like to follow.
	Championing
8	People often take the initiative to raise new projects (championing).
	Co-location
9	Project teams are usually co-located.
	Competitors
10	The organisation is always on the lookout for new ideas among competitors.
	Continuous Improvement
11	A culture of "If it's not broken, don't fix it" is not prevalent in the organisation.
	Creativity
12	People are encouraged to use their creativity and imagination in their everyday work.
13	Regular brainstorming and workshops are undertaken to stimulate creativity and solve problems (creativity training).
	Cross-functionality
14	Technical and Marketing partnerships in the organisation are intimate.
15	The organisation emphasises cross-functionality in the way it structures its units/divisions.
16	There is wide use of multidisciplinary teams with involvement by all functional areas.
	Culture
17	People share a degree of institutional loyalty and sense of mission.
18	People are encouraged to share personal experiences of failures in projects.
19	Risk-taking is generally encouraged rather than penalised.

APPENDIX A2 (continued)

ITEM #	SCALES AND ITEMS
	Customers
20	Efforts are concentrated on launching new products and processes that really attract and satisfy customers.
21	Customer satisfaction feedback surveys are initiated regularly with feedback into the innovation process.
22	There are good relationships and direct links with customers and lead users to identify expressed and latent needs.
	Diversity
23	Exceptional individuals are able to fit into the organisation and are respected for their different views.
24	Diversity is fostered and managed in all aspects of the organisation; this leads to new insights and knowledge.
	Experimenting and Serendipity
25	The organisation allows people official work time to work on their own ideas.
26	People often 'tinker' with things, experimenting and trying out new things.
	Gatekeeping
27	There are people in the organisation who naturally collect and channel information to people around them.
28	These persons can be approached freely to find people with knowledge and experience in a certain field.
	Information Systems
29	Significant effort goes into gathering and distributing information by e-mail, intranet, etc.
30	People have access to a knowledge database where information (or holders thereof) can be found.
31	Information systems are actively used by everyone and geared to improve effectiveness and shorten product development times.
32	On-line tools are available for facilitation of idea communication and manipulation between divisions.
33	The organisation employs a continuous ideation program, where employees can submit ideas for new products/processes (e.g. Employee Suggestion System)

APPENDIX A2 (continued)

ITEM #	SCALES AND ITEMS
	Leadership
34	Senior managers in the organisation take innovation seriously and commit themselves visibly to the initiatives.
35	Innovation starts at the top - senior managers inspire people to be creative and innovative.
36	There is strong team leadership; the leader as well as the team is empowered to make important decisions that are accepted by management.
	Learning and Growth
37	The organisation invests a great deal in developing people.
38	People are exposed to areas other than their specialties (rotated) to promote interaction and learning.
39	People show genuine interest in each other's work.
40	People are rotated within the company to enhance their job knowledge.
	Management
41	People have easy access to management if an important decision needs to be taken urgently.
42	Management can be approached freely with new ideas and suggestions, and is known to act on useful ones.
43	Management encourages people to take calculated risks, and learn from them.
	Motivation and Challenge
44	Employees have a clear sense of purpose, and a passion for their jobs.
45	Jobs provide enough challenge for employees to develop and learn all the time.
	New Markets
46	The organisation maintains a constant survey of the external environment to identify and exploit external opportunities, such as diversification into new markets.
	NPD Process
47	Transfer processes between functional stages, and the requirements thereof, are clear and well documented.
48	The NPD (New Product Development) process can be best described as 'seamless and integrated'; nothing is 'thrown over the wall'.
	Organisational Structure
49	The organisational structure promotes innovation and networking - there is no unnecessary bureaucracy or procedures that hinder action.
50	Things get done - there is no unnecessary bureaucracy, systems or procedures that hinder action.
51	Procedures are flexible enough to allow small projects to move through quickly.

APPENDIX A2 (continued)

ITEM #	SCALES AND ITEMS
	Planning and Procedures
52	Product development procedures and objectives are clearly documented and accessible.
53	New product development is largely planned (e.g. use of a stage-gate process) and does not happen haphazardly.
	Quality
54	There is a focus on quality management (such as TQM), supporting innovation in achieving improved performance.
	Reward and Recognition
55	The organisation's recognition and reward system encourages a culture of innovation.
56	Innovative individuals are highly valued and publicly recognised for their contributions.
57	Employees' innovative behaviour is appraised, encouraged and rewarded.
	Skills and Competences
58	People are generally well matched to the type of job they are performing; becoming a manager is not the only way to get up the career ladder.
	Strategic Scanning
59	The organisation undertakes continuous scanning of the technological and other landscapes to provide visible input for strategic decision-making and positioning.
60	Explicit policies exist for sourcing technology, in-house R&D, licensing, partnerships and external linkages.
	Strategy
61	Innovation within the organisation is directed towards achieving competitive advantage.
	Suppliers
62	The organisation actively involves suppliers in the new product development cycle.
	Vision
63	The vision and strategy of the organisation is clearly understood and subscribed to by everyone.
64	Explicit and challenging goals are set by leadership with a clear indication as to how it would contribute to business strategy.

APPENDIX A3

Results of ANOVAs on enablers between functional environments

ENABLER	Non-parametric Mann-Whitney U Test		ANOVA	
	U	*p*	*F*	*p*
Auditing	527.5	0.1419	1.9669	0.1651
Benchmarking	386.5***	0.0024	9.7322***	0.0026
Capital	468.0**	0.0323	5.1723**	0.0260
Championing	620.0	0.6566	0.0574	0.8114
Co-location	624.0	0.6885	0.1988	0.6570
Competitors	610.5	0.5762	0.7427	0.3917
Continuous Improvement	557.5	0.2544	1.1205	0.2934
Creativity	578.5	0.3658	0.7306	0.3956
Cross-functionality	641.5	0.8373	0.0705	0.7913
Culture	635.0	0.7814	0.1275	0.7221
Customers	447.0**	0.0181	5.5725**	0.0210
Diversity	532.0	0.1554	2.8717*	0.0945
Experimenting	398.5***	0.0037	10.657***	0.0017
Gatekeeping	616.5	0.6282	0.2357	0.6288
Information Systems	635.5	0.7857	0.5125	0.4764
Leadership	523.0	0.1282	2.3355	0.1309
Learning and Growth	456.5**	0.0240	4.7499**	0.0326
Management	637.0	0.7895	0.1441	0.70536
Motivation and Challenge	653.5	0.9423	0.0821	0.7753
New Markets	478.5**	0.0362	4.9774**	0.0288
NPD Process	518.5	0.1163	2.6619	0.1072
Organisational Structure	539.0	0.1791	2.6085	0.1107
Planning & Procedures	537.5	0.1724	0.7126	0.4014
Quality	510.0*	0.0951	3.0831*	0.0834
Reward & Recognition	517.5	0.1138	3.2181*	0.0771
Strategic Scanning	517.0	0.1111	3.2004*	0.0779
Skills & Competences	486.0*	0.0532	2.6959	0.1050
Strategy	631.0	0.7398	0.0182	0.8930
Suppliers	442.5**	0.0156	5.7564**	0.0191
Vision	540.0	0.1822	2.3784	0.1275

Significance of difference: *p < 0.10, **p < 0.05, ***p < 0.01.

APPENDIX A4

Factor loadings for principle component factor analysis

ENABLER	THEME 1	THEME 2
Eigenvalue	13.08	2.07
% Total variance explained	43.6	6.9
Auditing	**0.7142**	0.3163
Benchmarking	0.1962	**0.7518**
Capital	0.4330	0.4131
Championing	**0.7338**	-0.0642
Co-location	0.5250	-0.0059
Competitors	0.2082	**0.7812**
Continuous Improvement	0.0074	-0.1920
Creativity	**0.5841**	0.4553
Cross-functionality	**0.6511**	0.4026
Culture	**0.7911**	0.2777
Customers	0.3731	**0.6613**
Diversity	**0.6979**	0.3432
Experimenting	0.4130	0.4838
Gatekeeping	0.5475	0.4827
Information Systems	0.5231	**0.6607**
Leadership	**0.6663**	0.4203
Learning and Growth	0.6792	0.2664
Management	**0.7116**	0.2826
Motivation and Challenge	0.5204	0.3123
New Markets	0.1596	**0.7144**
NPD Process	0.4351	0.5192
Organisational Structure	**0.7407**	0.2343
Planning & Procedures	0.5030	0.2422
Quality	0.5665	0.3052
Reward & Recognition	**0.6524**	0.3498
Strategic Scanning	0.1519	**0.7980**
Skills & Competences	0.5086	0.2094
Strategy	0.4024	**0.6451**
Suppliers	0.4845	0.1026
Vision	0.4354	**0.6666**

APPENDIX B1

Questionnaire used during interviews

ENABLERS*	ENABLER IMPORTANCE									
	LOW									HIGH
Management-related enablers										
Leadership (lp)	1	2	3	4	5	6	7	8	9	10
Reward & Recognition (rr)	1	2	3	4	5	6	7	8	9	10
Creativity (cy)	1	2	3	4	5	6	7	8	9	10
Risk-taking (rt)	1	2	3	4	5	6	7	8	9	10
Experimenting (ex)	1	2	3	4	5	6	7	8	9	10
Enablers related to the characteristics of the project team										
Specialisation (sk)	1	2	3	4	5	6	7	8	9	10
Cross-functionality (cf)	1	2	3	4	5	6	7	8	9	10
Tenure of team members (hr)	1	2	3	4	5	6	7	8	9	10
Team autonomy (em)	1	2	3	4	5	6	7	8	9	10
Information-related enablers										
Internal learning										
Informal learning (face-to-face) (il)	1	2	3	4	5	6	7	8	9	10
Information and Communication Systems (ic)	1	2	3	4	5	6	7	8	9	10
Learning from the past (au)	1	2	3	4	5	6	7	8	9	10
External learning										
Benchmarking (bm)	1	2	3	4	5	6	7	8	9	10
Competition (cm)	1	2	3	4	5	6	7	8	9	10
Customers (cn)	1	2	3	4	5	6	7	8	9	10
Suppliers of Technology (su)	1	2	3	4	5	6	7	8	9	10
Process-related enablers										
Quality (qy)	1	2	3	4	5	6	7	8	9	10
Planning & Procedures (pp)	1	2	3	4	5	6	7	8	9	10
Individual-related enablers										
Championing (ch)	1	2	3	4	5	6	7	8	9	10
Intrinsic Motivation (Tenacity) (te)	1	2	3	4	5	6	7	8	9	10

*Abbreviations of enablers in brackets are used in Appendix B5

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APPENDIX B2

Factor loadings for principle component factor analysis

ENABLERS	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
Eigenvalue	4.212	3.386	2.488	2.045
% Total variance explained	21.06	16.93	12.44	10.22
Autonomy	-0.1837	-0.0222	0.0418	**0.5780**
Benchmarking	0.0767	**0.5932**	**0.6047**	-0.0462
Championing	-0.2842	0.2161	-0.1048	**0.5876**
Competitors	-0.2569	**0.7841**	0.0749	-0.0517
Creativity	0.2962	**0.8161**	-0.0239	0.0362
Cross-functionality	**0.8627**	0.0750	-0.2225	-0.0018
Customers	0.2120	0.0178	**0.8304**	0.0252
Experimenting	-0.2805	**0.6283**	-0.0934	0.5151
Informal communication	0.2628	0.0739	0.2710	**0.7057**
Information and communication systems	-0.2628	0.1060	-0.0803	0.1825
Intrinsic motivation	**0.8336**	0.0524	-0.1030	0.1370
Leadership	0.2934	**0.6998**	-0.3283	-0.1740
Learning from the past	-0.2993	0.0639	**0.6166**	-0.0420
Planning and Procedures	**0.7062**	-0.1888	0.1260	-0.0556
Quality	0.3578	-0.2476	**0.6274**	-0.2673
Reward & Recognition	0.0266	-0.0769	-0.2385	**0.7094**
Risk-taking	-0.2175	**0.7357**	0.0943	0.1810
Specialisation	0.3225	0.3714	-0.5066	-0.4620
Suppliers of technology	**0.6287**	0.0590	0.0798	-0.2712
Tenure of team members	0.5727	0.0483	0.2560	-0.3879

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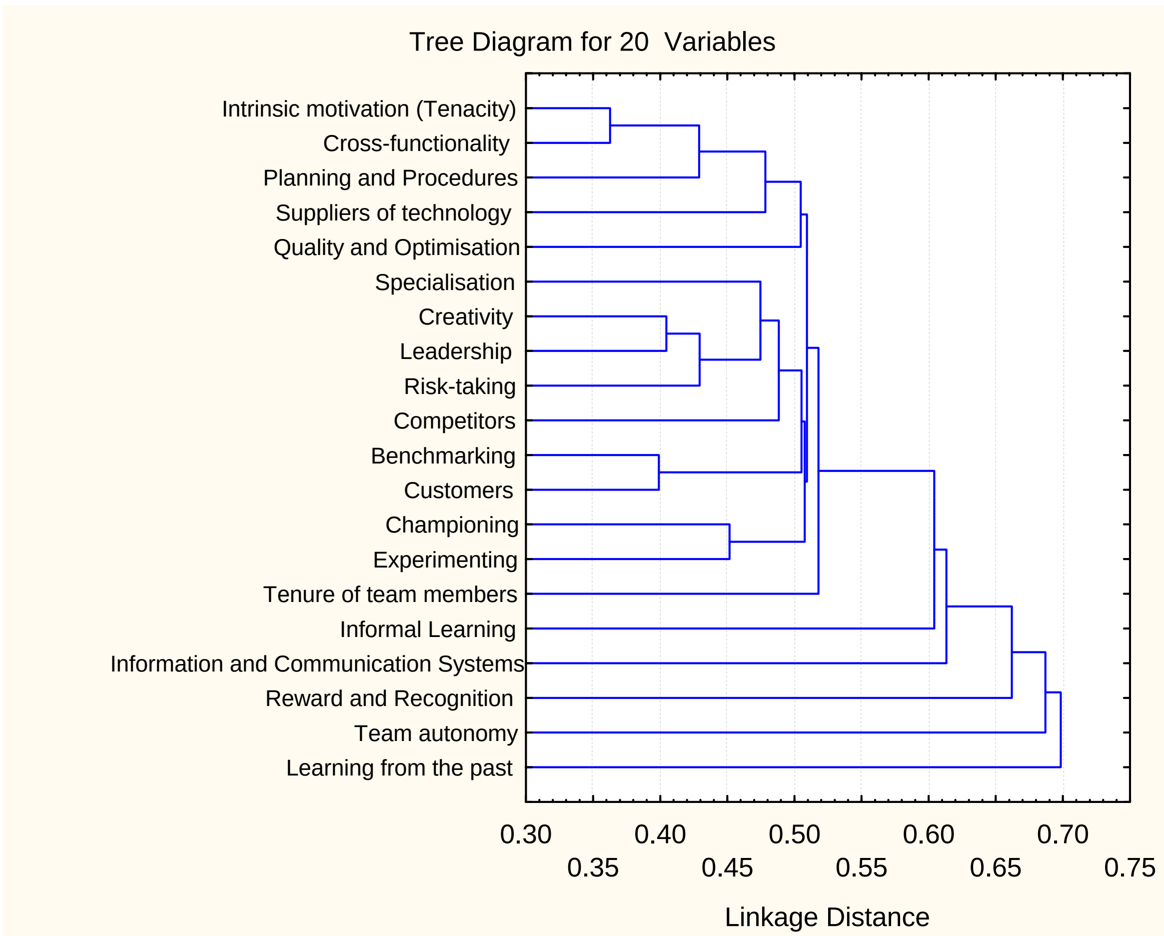
APPENDIX B3

Cluster analysis tree diagram



APPENDIX B4

Results of ANOVAs for the moderating effects of project radicalness and maturity on enabler importance

ENABLERS	Radicalness	Maturity	Radicalness* Maturity
Benchmarking	0.00639***	0.0521*	0.0865*
Championing	0.9335	0.1459	0.5189
Competitors	0.01824**	0.03066**	0.01226**
Creativity	0.00601***	0.8213	0.1823
Cross-functionality	0.1563	0.1464	0.7743
Customers	0.4521	0.5135	0.4197
Experimenting	0.6397	0.00584***	0.3085
Informal communication	0.7060	0.5288	0.2486
Information and Communication Systems	0.2832	0.6221	0.3912
Intrinsic motivation (Tenacity)	0.00538***	0.00538***	0.06173*
Leadership	0.08834*	0.8272	0.3237
Learning from the past	0.7476	0.4554	0.6571
Planning and Procedures	0.08428*	0.00743***	0.06405*
Quality	0.4501	0.2449	0.4188
Reward & Recognition	0.7773	0.6879	0.7977
Risk-taking	0.3593	0.08659*	0.4356
Specialisation	0.4840	0.6529	0.3466
Suppliers of technology	0.3324	0.05295*	0.5577
Team autonomy	0.4433	0.4399	0.8881
Tenure of team members	0.2760	0.4508	0.7790
Construct 1	0.06653*	0.01883**	0.70063
Construct 2	0.00887***	0.1043	0.06846*
Construct 3	0.5614	0.4553	0.7597
Construct 4	0.9757	0.5652	0.2739

Significance of difference: *p < 0.10, **p < 0.05, ***p < 0.01.

APPENDIX B5

Correlation Matrix of enablers

See AppendixCorrelationMatrix.doc

APPENDIX C

The average relative importances of enablers (with variances) for the initiation and implementation of radical and incremental innovations

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Project Scope

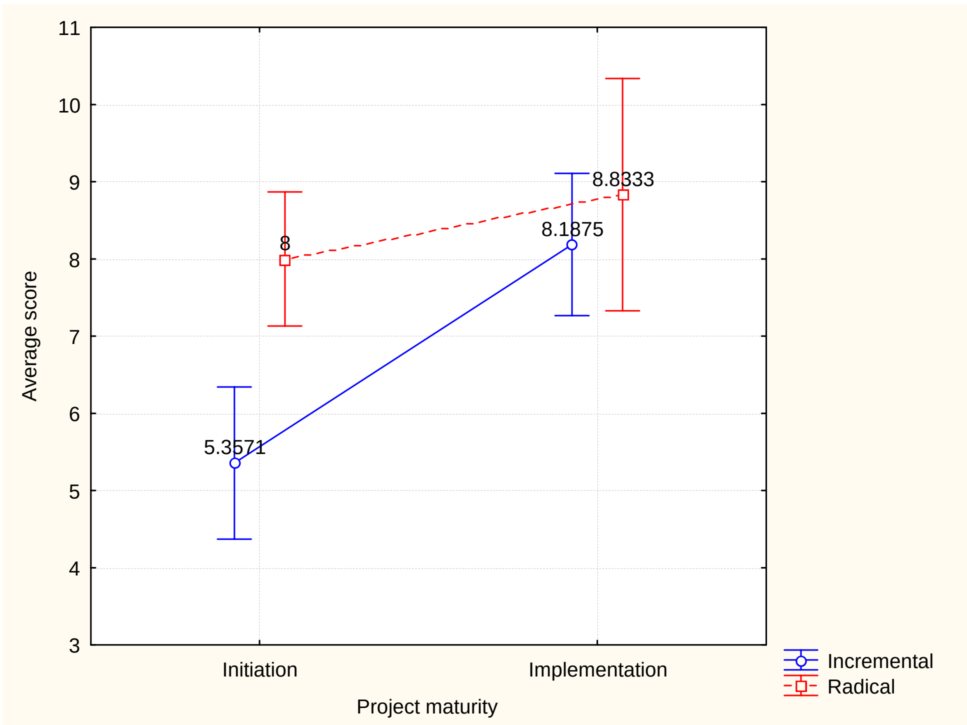

Figure C1 Tenacity

APPENDIX C (continued): Project Scope

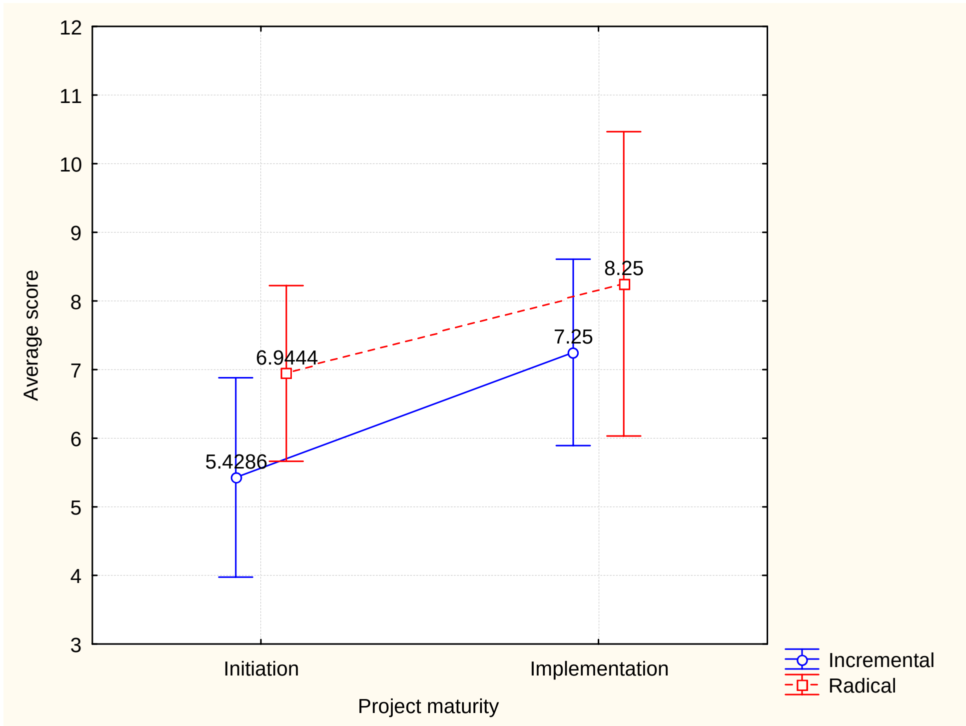

Figure C2 Cross-functionality

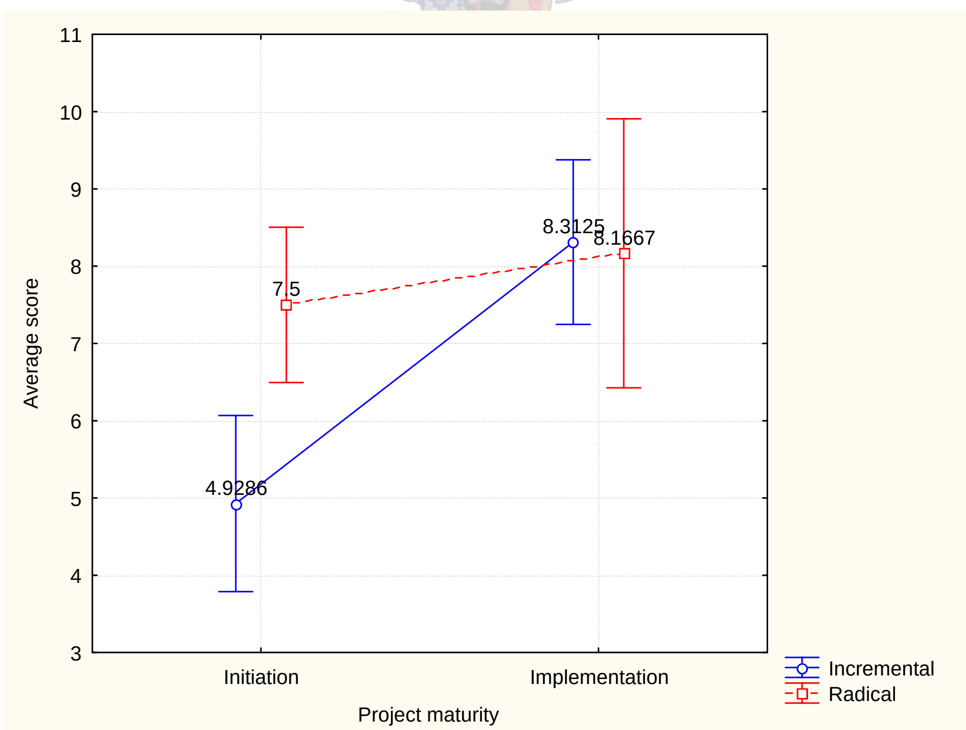

Figure C3 Planning & Procedures

APPENDIX C (continued): Project Scope

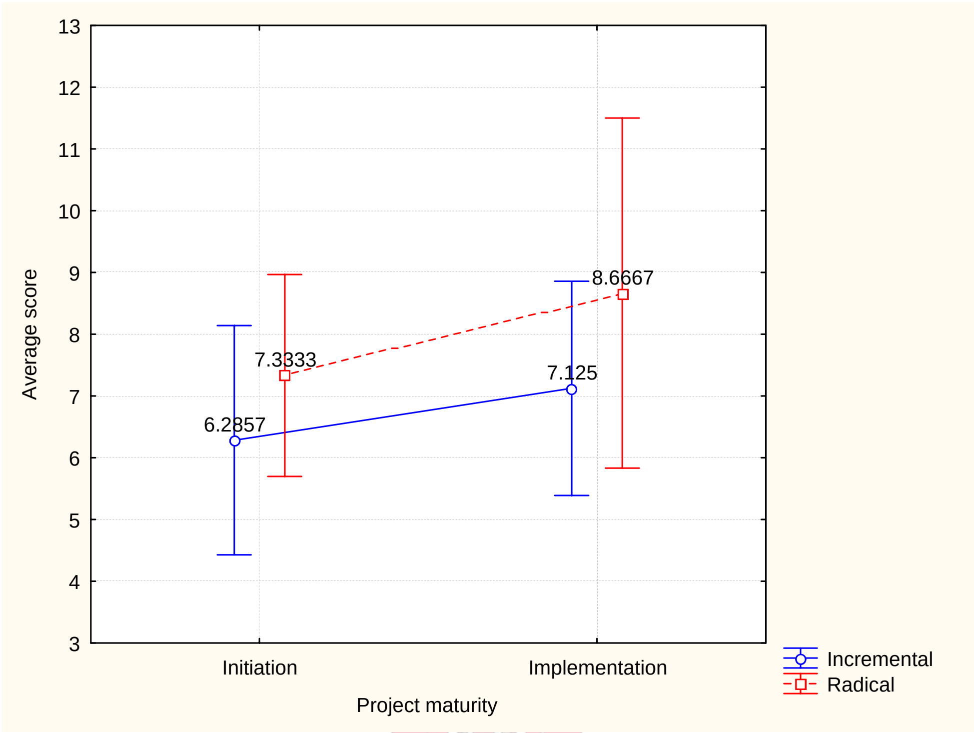

Figure C4 Tenure of team members

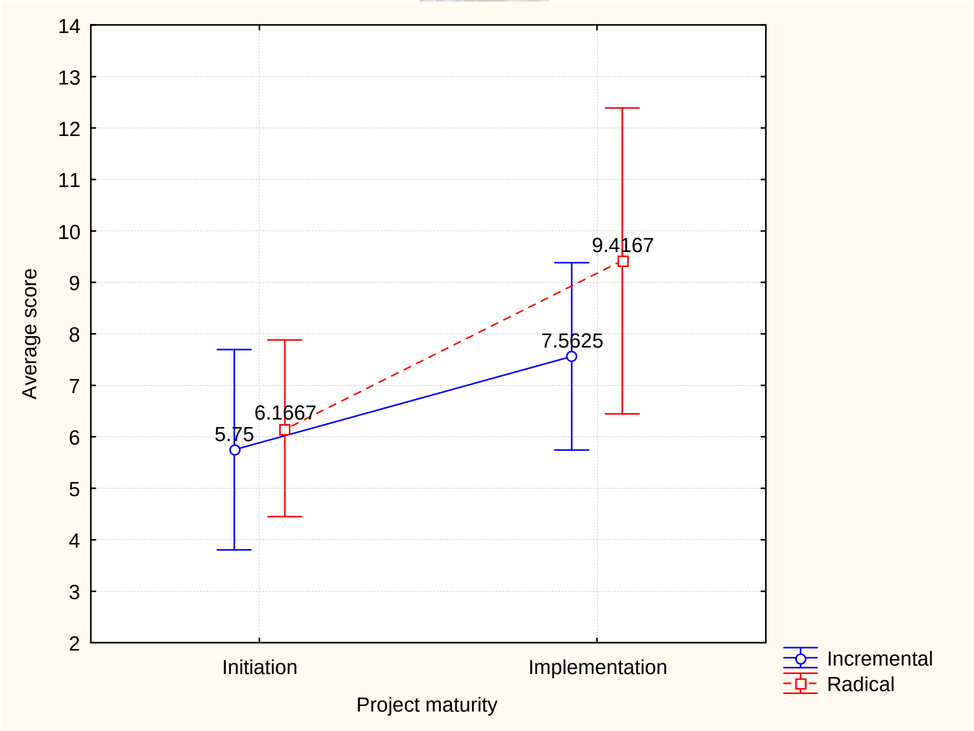

Figure C5 Suppliers of Technology

APPENDIX C (continued): Learning

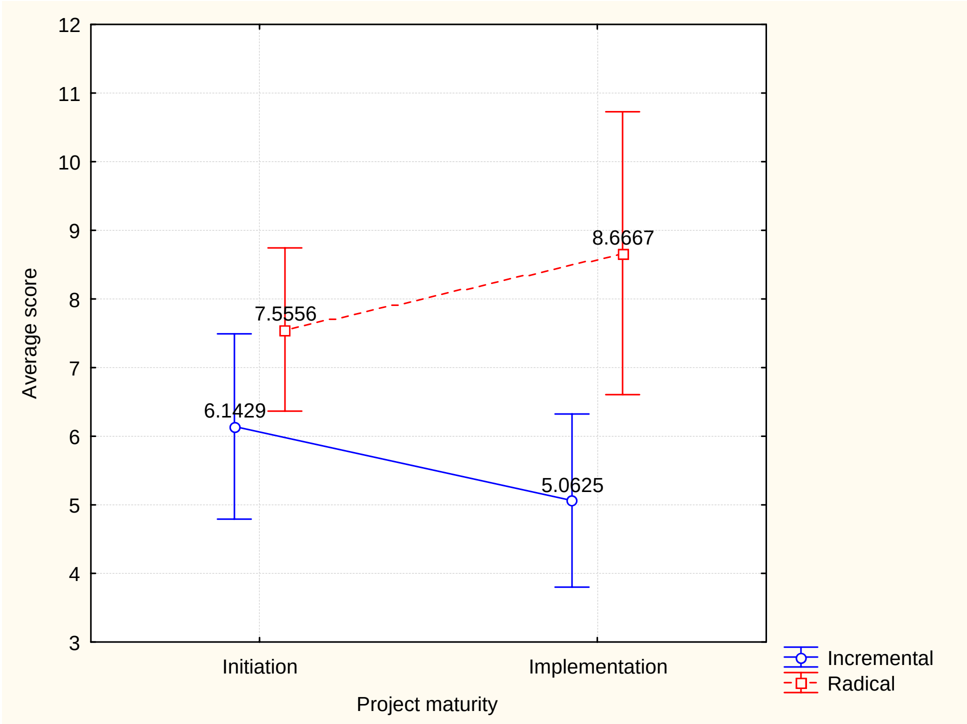

Figure C6 Creativity

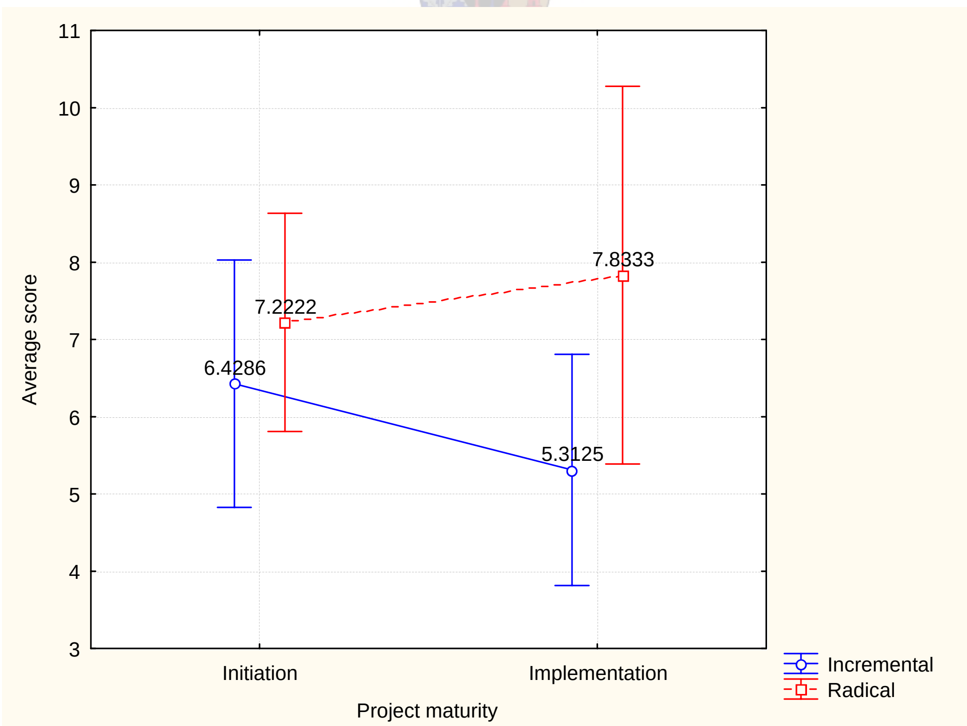

Figure C7 Leadership

APPENDIX C (continued): Learning

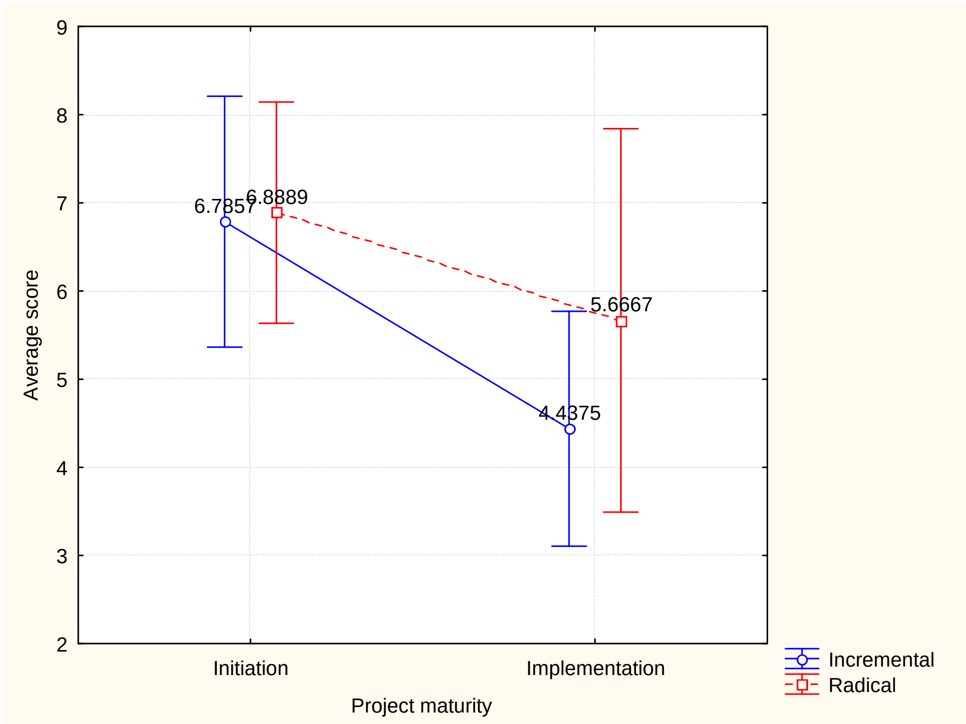

Figure C8 Risk-taking

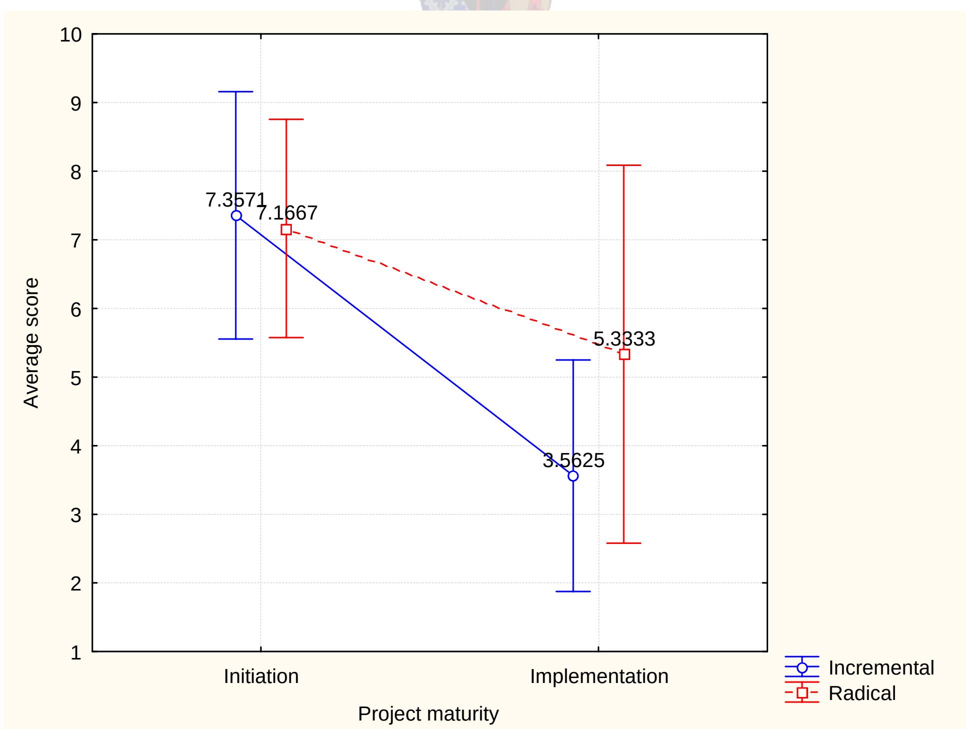

Figure C9 Experimenting

APPENDIX C (continued): Learning

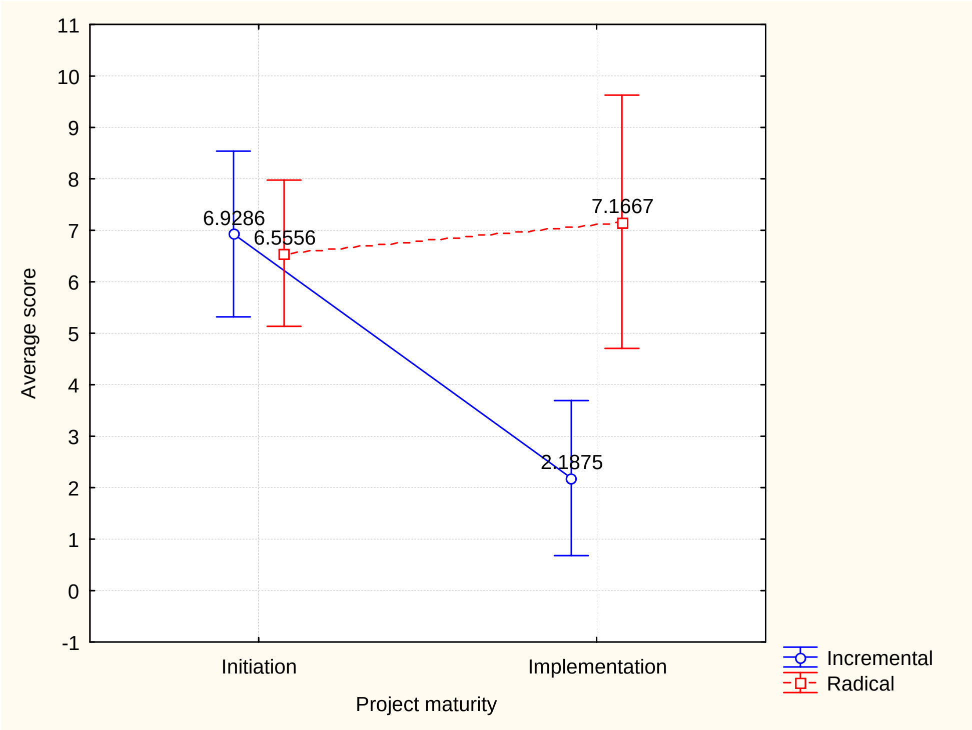

Figure C10 Competitors

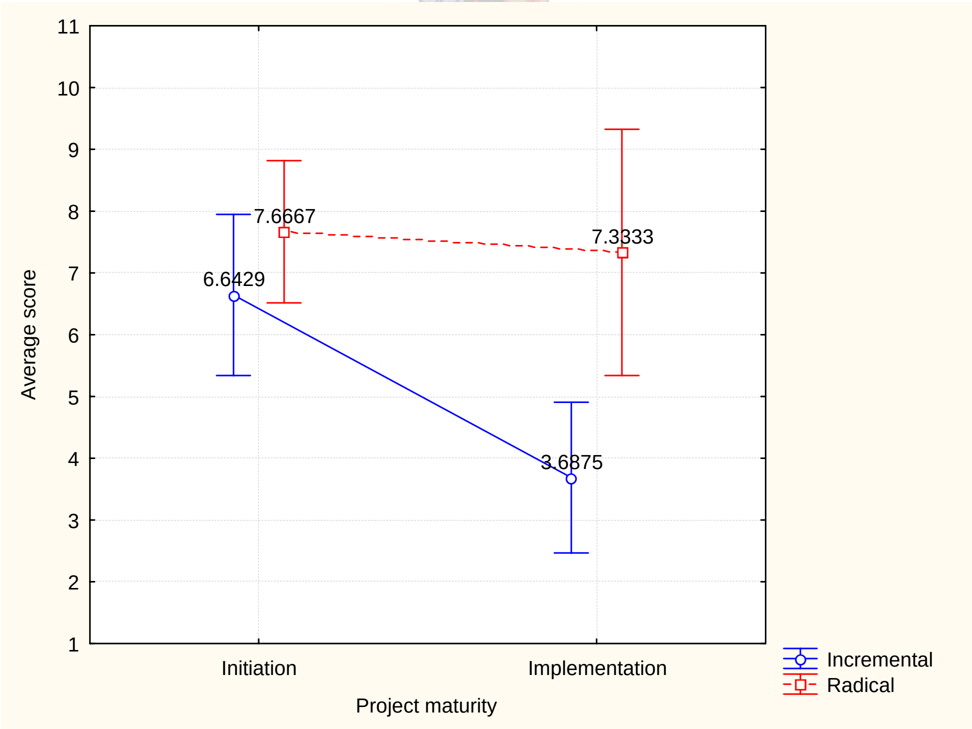

Figure C11 Benchmarking

APPENDIX C (continued): Excellence

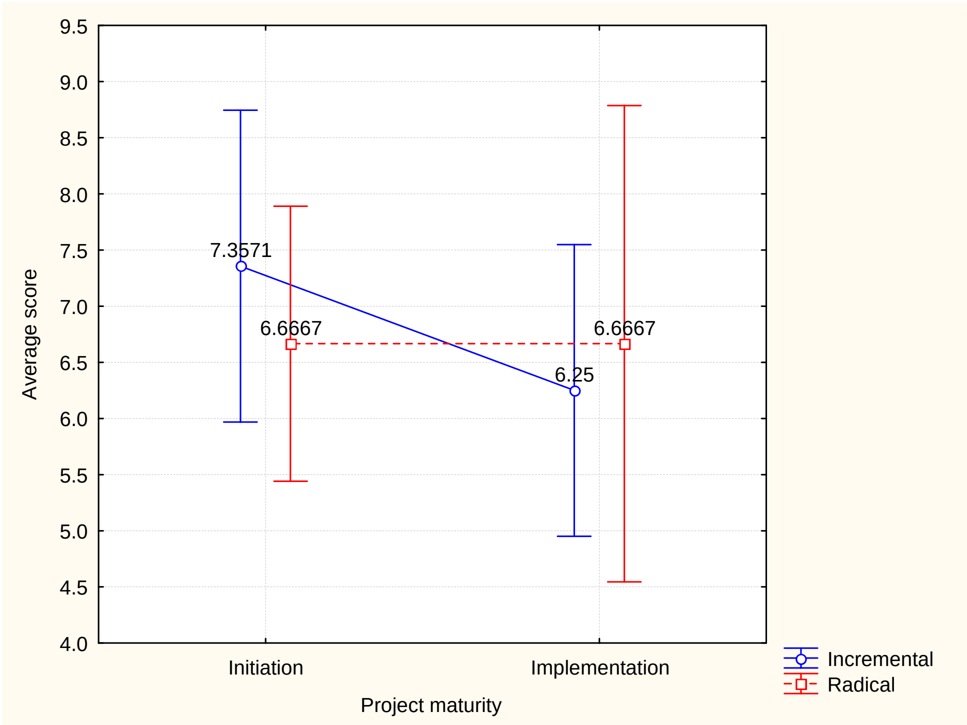

Figure C12 Learning from the past

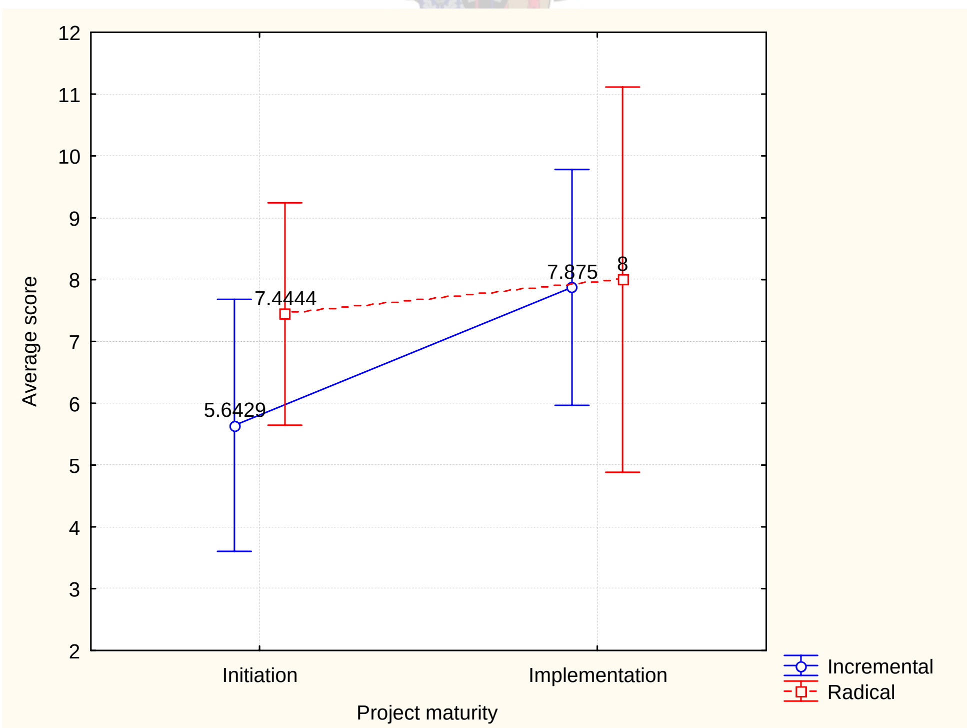

Figure C13 Quality

APPENDIX C (continued): Excellence

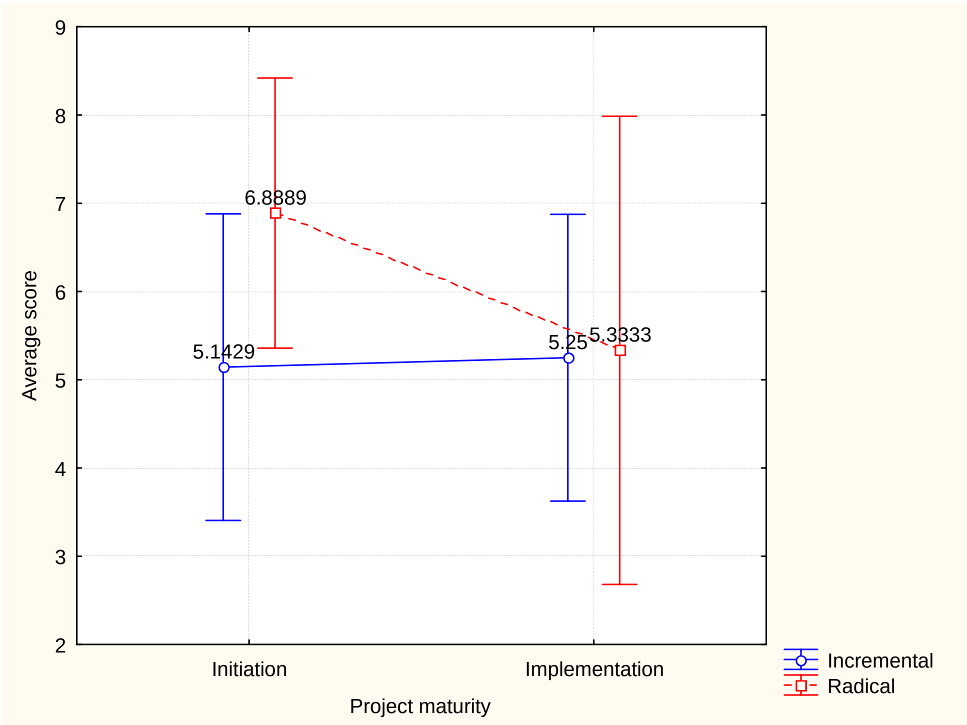

Figure C14 Customers

APPENDIX C (continued): The Individual

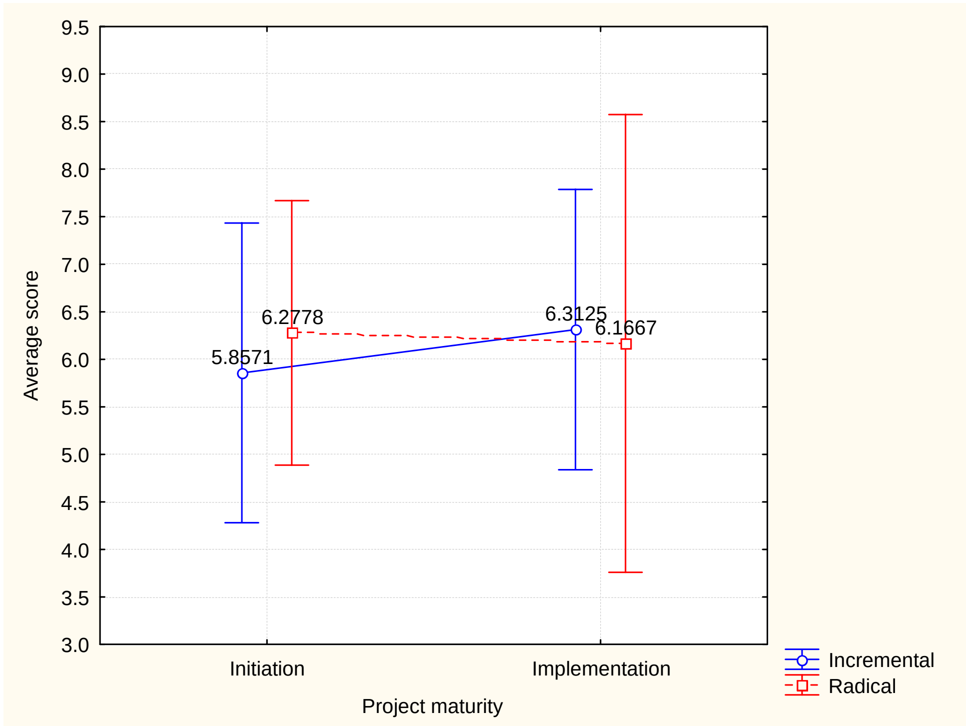

Figure C15 Reward & Recognition

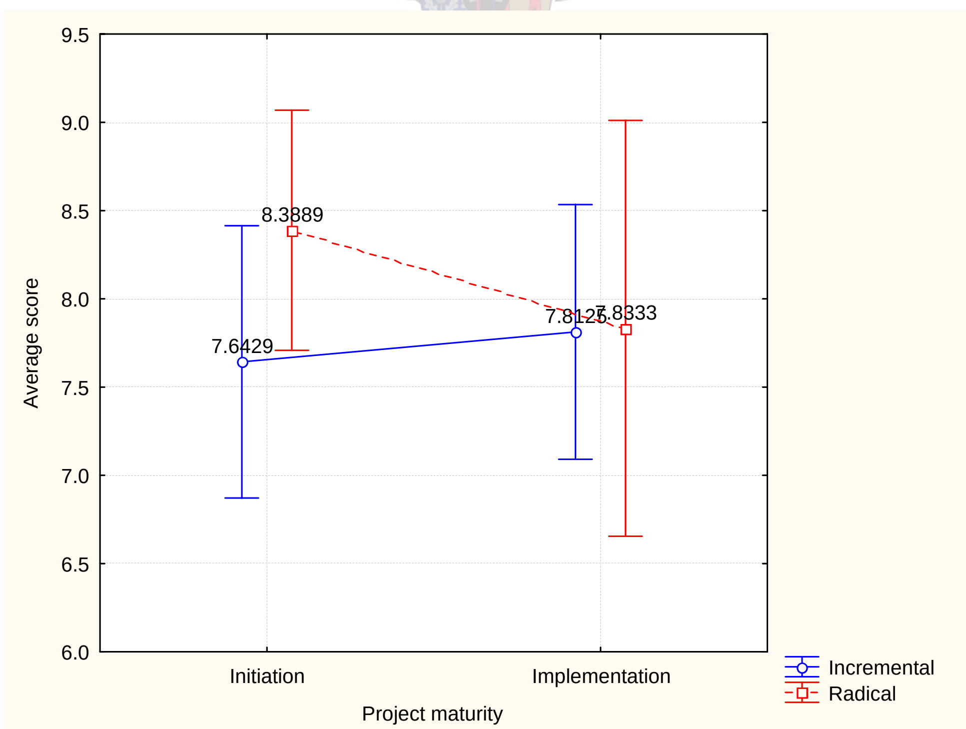

Figure C16 Informal Communication

APPENDIX C (continued): The Individual

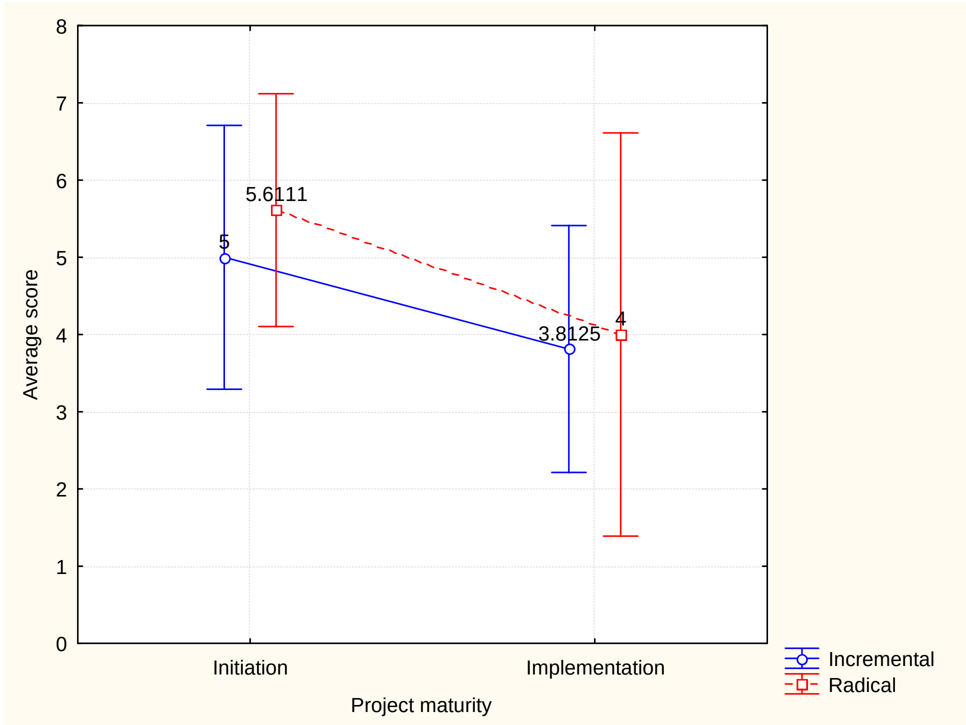

Figure C17 Championing

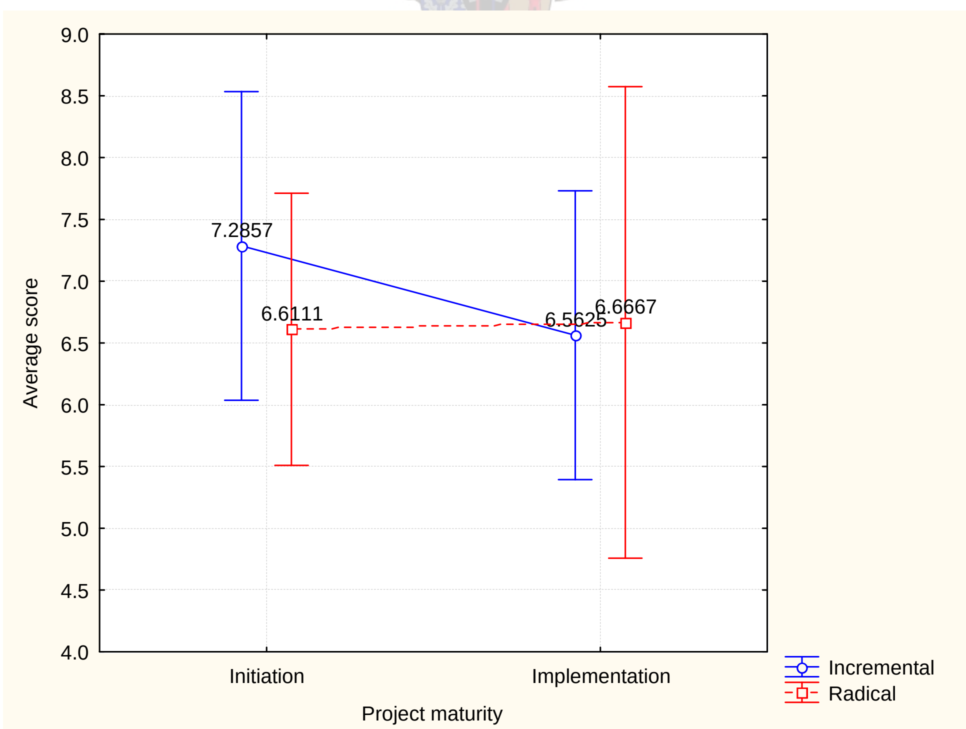

Figure C18 Team autonomy

APPENDIX C (continued): Other enablers

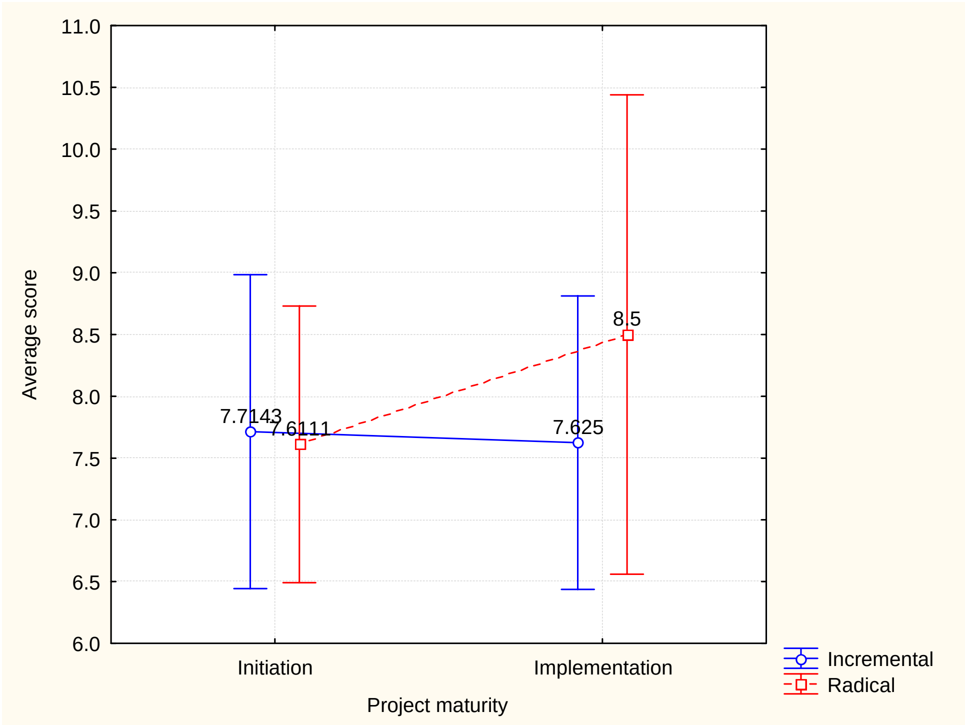

Figure C19 Specialisation

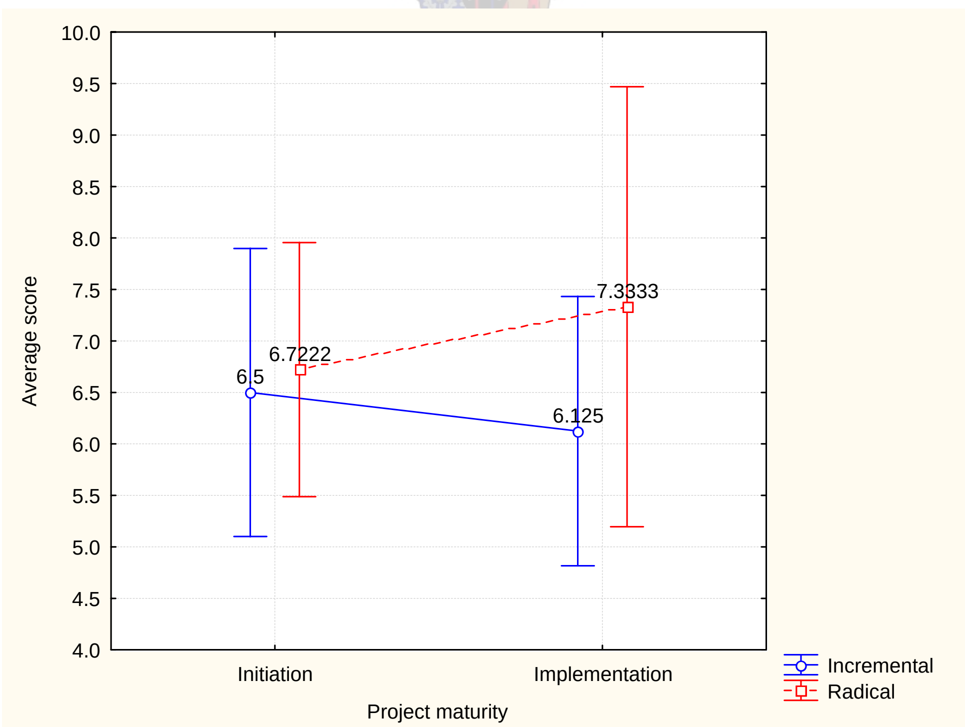

Figure C20 Information and Communication Systems

APPENDIX D

List of Publications from this Research

Kleingeld, A.W., Ross, V.E. and Lorenzen, L. (2001). Aligning Innovation Strategy with Organisational Structure and Value Propositions. *Proceedings of the 6th World Congress of Chemical Engineering,* Melbourne – Australia.

Ross, V.E. and Kleingeld, A.W. Organisational Brain Dominance, and the Implications for Strategy and Innovation (2001). *Proceedings of the TTI 2001 Conference,* Brisbane – Australia.

Ross, V.E. and Kleingeld, A.W. (2002). A Topographical Map of the Innovation Landscape. *The Innovation Journal*, **7**(1) [online].

Ross, V.E. and Kleingeld, A.W. (2002). Radical vs. Incremental Innovation: A Study of Key Enablers. *Paper presented at the International Conference on Management of Innovation and Technology (ICMIT'02)*, Hangzhou City – China.

Kleingeld, A.W., Ross, V.E. and Lorenzen, L. (2003). A Topographical Map of the Innovation Landscape. *Paper to be presented at the IMPC 2003 Conference*, Cape Town – South Africa.

APPENDIX B5

Correlation Matrix of enablers

Enabler	te	rr	sk	cf	cy	lp	em	rt	ch	ex	pp	hr	il	ic	au	qy	bm	cm	cn	su
te	–																			
rr	0.07	–																		
sk	0.24	-0.11	–																	
cf	0.64**	0.03	0.40**	–																
cy	0.39**	-0.07	0.28	0.31	–															
lp	0.24	-0.19	0.53**	0.33*	0.60**	–														
em	-0.15	0.30	-0.52**	-0.14	0.04	-0.16	–													
rt	-0.16	0.10	0.05	-0.24	0.57**	0.41**	0.16	–												
ch	-0.23	0.30	-0.29	-0.15	0.14	0.07	0.31	0.26	–											
ex	-0.23	0.26	0.04	-0.11	0.33*	0.32*	0.22	0.49**	0.55**	–										
pp	0.57**	-0.04	0.12	0.53**	0.01	0.12	-0.43**	-0.32*	-0.11	-0.32*	–									
hr	0.21	-0.25	0.29	0.48**	0.20	0.18	-0.18	-0.16	-0.30	-0.30	0.36*	–								
il	0.32*	0.34*	-0.19	0.11	0.06	0.00	0.23	0.14	0.17	0.40**	0.15	-0.06	–							
ic	-0.12	0.14	0.01	-0.13	0.00	-0.16	-0.10	-0.08	0.20	0.39**	0.04	-0.46**	0.00	–						
au	-0.26	-0.21	-0.30	-0.39**	0.05	-0.18	-0.08	0.05	0.07	0.05	0.07	0.04	0.21	0.13	–					
qy	0.09	-0.33*	-0.13	0.17	-0.17	-0.08	-0.16	-0.21	-0.27	-0.41**	0.50**	0.37*	0.07	-0.09	0.30	–				
bm	0.03	-0.23	-0.07	0.03	0.41**	0.16	-0.03	0.39**	-0.06	0.31	-0.06	0.17	0.14	0.03	0.15	0.16	–			
cm	-0.12	0.04	0.23	-0.17	0.51**	0.40**	0.03	0.48**	0.16	0.45**	-0.24	-0.11	-0.09	0.29	0.26	-0.22	0.49**	–		
cn	0.10	-0.03	-0.28	-0.01	0.00	-0.30	-0.08	0.09	-0.16	-0.10	0.13	0.32	0.22	-0.12	0.23	0.49**	0.60**	0.02	–	
su	0.43**	-0.17	0.21	0.52**	0.24	0.16	0.02	-0.11	-0.35*	-0.32*	0.29	0.42**	-0.19	-0.14	-0.27	0.32*	0.19	-0.06	0.22	–

Significance levels: *p < 0.10, **p < 0.05.