A Critical Investigation of Knowledge Management as a Determinant of New Product Development Success

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Abstract

This thesis investigates the relationship between Knowledge Management Activities (KMAs), New Product Development drivers (NPDd), and New Product Development (NPD) process success in organisations that rely on new products for competitive survival. The literature review highlights that while KMA is in 2008, a common part of the practice of NPD, it is not included in any of the lists of well-known success factors. Given that research in the KM field claims KMAs are a significant driver of success, this omission in the NPD literature seems worthy of further investigation.

This thesis details the method and results of an empirical investigation examining the claim that KMAs are an independent influence on NPD process success. Data was collected in 2006 using survey methods and a classic positivistic research philosophy. The sample was taken from 124 UK-based projects, chosen from private organisations in the Department of trade and Industry's Research Development Index. The data was analysed using multivariate techniques, notably comparing NPD drivers, KMAs and their individual contribution to success based on stepwise regression analysis. Statistics indicate that while well-known NPDd account for much of the variance in NPD process success, KMAs are also significant.

The unique contribution of this thesis is two fold: first empirical evidence that some KMAs can act as independent drivers of success in the NPD environment; and second a model detailing the relationship between the test elements, updating the existing high-level research in the field with a more detailed analysis of the relationships implied. The conclusions highlight for private sector managers that some KMAs make a distinct and measurable addition to NPD process success. Public sector managers may also find the results of interest as they add a finer level of detail to understanding the "systems" view of NPD, information worth sharing within the burgeoning UK knowledge economy.

List of diagrams and tables

Abbreviations

KM:	Knowledge Management
KMA(s):	Knowledge Management Activity
NPD:	New Product Development
NPD process success:	New Product Development process success (as measured by conformance to the projects budgeted time, cost and specification)
NPDd:	New Product Development drivers
H1:	Hypothesis one
H2:	Hypothesis two
H3:	Hypothesis three
IT/ICT:	Information Technology/Information Communication Technology
MNCs:	Multi-national Companies
Comm.:	Communication
Snr.:	Senior
Sig.:	Significance
T+D:	Training and Development
RandD:	Research and Development
SC:	Supply Chain
Pres.:	Present

Statement of original authorship

PHD IN MANAGEMENT
Jason Alexander MacVaugh
A Critical Investigation of Knowledge Management as a Determinant of New Product Development Success

Individual work	Thesis
I certify that this is my own work except where otherwise indicated as collaborative work within the school/department and that use of material from other sources has been properly and fully acknowledged in the text. I have read the University's definition of plagiarism and the department's advice on good academic practice. I understand that the consequence of committing plagiarism, if proven and in the absence of mitigating circumstances may include failure in the degree.	
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1 Introduction

1.1 Background

Knowledge Management (KM) can be defined as 'An entity's systematic and deliberate efforts to expand, cultivate, and apply available knowledge in ways that add value' (Holsapple and Joshi, 2004). This name conjures the idea that knowledge is somehow part of an organisation's assets, that it is something to gather, something to keep, something to control. At the same time there is little agreement about how to achieve *Knowledge Management.*

There are two schools of thought. The first school consists mainly of consultants, who seem more than willing to sell KM systems, practices, or tools that (they would argue) have proven to be successful in leading MNCs all over the world. The difficulty here is that this success is more often measured by how many people they have sold a system to, rather then how well that system works.

The second school consists of academics, who stress the importance of knowledge to organisations, and even some that have provided empirical evidence-linking KM to bottom line success. But, while it is undeniable that KM is the focus of increasing research interest (Prusak, 2001), the academic community is still short on evidence as to *how* KM affects bottom line business success. Of course it is beyond the scope of one thesis to investigate this question in its entirety, but the notion highlights a relatively new branch of KM worthy of further investigation.

As of the year 2000 much of the research on KM had been conducted from a very theoretical perspective. An account detailing what actual behaviours or tools were incorporated in KM was rarely seen (Sveiby, 2000). This being said, one increasingly common argument (on a more micro level) was the applicability of KM to certain business processes. Of these processes New Product Development (NPD) is one of the more frequent mentioned. For example: Ambrecht, et al. (2001) argue: 'RandD organizations have derived significant value from embracing knowledge management (KM) principles in order to promote the flow of both resident knowledge and external information.' Herder et al. (2003) examine the case of Motorola (famed for being one of the first to achieve six-sigma process quality) and uncover KM practices that support sharing of various types of knowledge in the NPD process. Hoegl, and Schulze (2005) argue that Knowledge Management makes a significant contribution

to knowledge creation, commonly seen as the key to effective NPD (Madhavan and Grover, 1998). In their 2005 paper Liu et al. provide some of the first empirical evidence to this end; identifying KM as both a significant contributor to the development of an NPD strategy and to bottom line product success.

Preceding the recent interest in KM by some 30 years at least, New Product Development research investigates many similar issues to KM research. Since the 1970s a common starting point for this has been the question: What factors determine the effectiveness of the NPD process? This question seems a close cousin of the as yet unanswered KM question. A large body of research has developed around attempts to answer this question (e.g. Myers and Marquis, 1969; Booz, Allen, and Hamilton, 1982; Cooper and Kleinschmidt, 1987; Zahra, 1993; Cooper, Edgett, and Kleinschmidt, 2004). Though the literature to date suggests a plausible, if not wholly convergent list of significant success factors, it is striking that only quite recently has the concept of knowledge management been integrated into systematic NPD studies. One relatively new proposition in the field is that: proactive knowledge management, which results from an organisations deliberate use of KM tools and techniques, is a significant element in the effective conduct of the NPD process (Hoegl and Shulze, 2005 Darroch, 2005; and Liu, Chen and Tsai 2005; Tranfield et al. 2003).

Once academic papers began to be published claiming to measure the impact of KM on some business processes, it then became more possible to develop a framework that would allow detailed analysis of day-to-day KM activity (KMA). For example it is understood that there are specific contexts in which the general application of KM has been linked with performance (Hoegl and Shulze, 2005 Darroch, 2005; and Liu, Chen and Tsai 2005), at least from the perspective of those working in organisations using such techniques. Given this background it is now a more direct task to explore the "black box" of KMA.

So, to date it is possible to postulate a theoretical framework, possibly in the form of a diagram: on one side KM, on the other NPD success, and a large arrow linking the two. But, while generating this framework may be a useful exercise for academic understanding, it tells the reader relatively little about practical application. Many questions remain unanswered, and it is this gap in the knowledge that inspired the research that follows.

1.2 Research problem

This thesis will investigate the hypothesis that there is a relationship between deliberate Knowledge Management Activities and the successful conduct of the New Product Development process. It would seem likely, given the long-standing research on drivers of NPD success (NPDd) that the value of KM is already accounted for. Thus research in favour of KMAs as a driver of NPD may simply be a re-branding of long standing NPD practices, resulting from the inception of new processes or information technology tools (IT). On the other hand it is possible that KM techniques have been used to improve existing NPD practices, and as such are value-adding. A more remote possibility is that some KM practices and tools have, fairly recently, become independent drivers of NPD process success. These may have stemmed from innovations in the fields of operations research, IT, or possibly human resource management (Earl, 2001). The challenge for this study is to develop robust support for one or more of these propositions.

1.3 Definitions and key terminology from the literature review

For the sake of brevity, several terms used throughout this study have been reduced to an abbreviated form. While the theoretical value of each term will be debated further in the literature review, they are presented here to make the following chapters clearer for the reader:

KM: 'An entity's systematic and deliberate efforts to expand, cultivate, and apply available knowledge in ways that add value' (Holsapple and Joshi, 2004).

KMA: The deliberate use of KM tools, practices, and behaviours in an effort to facilitate knowledge creation, capture, storage, transfer, sale, or application. In this study 28 KMAs are used. These 28 come from the results of the Pilot, where the respondents had the opportunity to identify KMAs from a list of 50 KMAs gleaned from the indicative literature.

KM mechanisms: The variety of possible KMAs likely to be encountered in any organisation is beyond the scope of one study to capture. This problem is highlighted

in many other studies in the field. Thus this study has proposed 9 general mechanisms as categories. These categories are helpful in identifying the general purpose of one or more context specific KMA(s), and thus form the basis of the hypothesised relationships in the study.

NPD: The new product development process transforms product concepts into commercially viable products (Hertenstein and Platt, 2000).

NPDd: Cooper and Klienschmidt (1995) argue that the presence of NPD drivers has the greatest correlation with process success. In this study 9 NPDd are used.

NPD process success measures: Several options exist for measuring NPD process success. In this study conformance to budgeted project time, cost and specification are used.

1.4 Justification for the research

First, it is posited that previous research on the topic of KM is split over the relative importance/impact of KMA as supportive/driving mechanisms in organisations (Grover and Davenport, 2001). Furthermore, this thesis argues that many of the current theoretical models of KMA are of little use when evaluating the deterministic factors of NPD process success. So, if deterministic value is to be attributed to KM's claims, a more specific and testable model of KMA (in the NPD setting) is needed. *This thesis will develop such a model of KMA.*

Second, it is posited that KM research to date has yet to provide empirical support for the value added by its prescribed techniques on anything like the scale now available in the NPD literature. This weakness serves to underscore broader uncertainties about the soundness of KM's theoretical base, echoed in recent editorials and journals (Grover and Davenport, 2001). Given that NPD has a well-known list of deterministic influences (independent variables) and process measures (dependant variables), it would seem to serve as a suitable setting for a realistic evaluation of the possible effects of KMA, thus addressing current weaknesses. *This thesis will carry out such a quantitative analysis of KMA and NPD success.*

Third, it is posited that studying process output in a population of NPD projects, minus the "known" effects of other elements of the development mix (see Cooper and Kleinschmidt, 1995), will give a more realistic idea of KM's contribution to the product development process. One very interesting possible outcome of such an investigation would be the identification of KMAs that contribute to NPD process success independently of known NPDd. *This thesis will attempt to better explain the contribution of KMA to NPD process success.*

Finally, the results of such a study will not just show the extent of the relationship between KM and NPD (as discussed in the second proposition), but would also serve to develop a revised KMA, NPD, and NPDd model. This will guide discussion of why KM affects NPD in much finer detail; also serving as a more substantial basis for further qualitative research. *This thesis will explore some of the reasons why KMA may affect the NPD process.*

1.5 Delimitations of scope and key assumptions

Framework: Model of deliberate KM generated from the literature and Cooper and Kleinschmidt's Stage-Gate model of NPD

Hypothesis: Hypothesis 1: There is a positive relationship between "known" NPD factors and NPD success.

Hypothesis 2: There is a positive relationship between the use of KMAs and NPD Success.

Hypothesis 3: There is a relationship between the presence of KMAs and "known" NPD factors.

Hypothesis 4: (Some of) The contributions that KMAs make to success variance are independent of NPDd

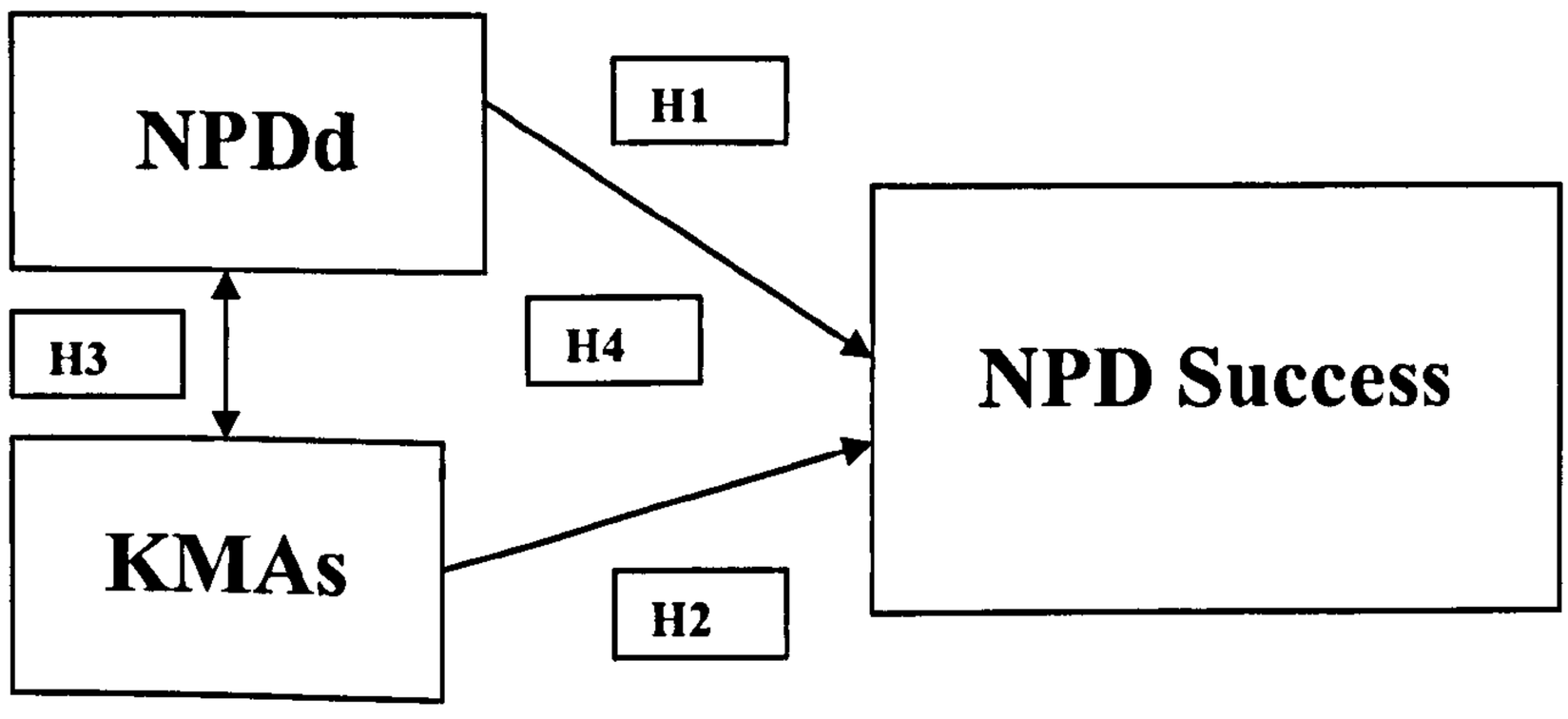
Boundaries:

Variables: Listed and/or "known" KMAs, NPDd, and NPD metrics

Time: As currently used, not as done in the past, not planned for implementation in the future; a measure of current achievement.

Space: Bound to the sample population and the unit of analysis (NPD Projects)

Diagram 1. Research Model:



1.6 Method

The research was carried out using a survey as the method, a questionnaire as the research tool, and classic positivism as the grounding philosophy. Drawing on the indicative literature, the study first presented a research model based on the work to date. This model comprises what is known in the field about the relationships between KMA, NPD processes, and NPD success. The model highlights two "known" components (the empirically founded relationship between nine common NPD factors and NPD success; and the one generally believed to be between KMA and NPD success) and two unknown components (the relationship between a firm's ability in the nine common NPD factors and the kinds of KMA present/used; and to what extent either NPD factors or KMA variables are independent influences on NPD success when considered in tandem).

This model provided a basis for the survey questions, which later were incorporated into a research tool. The research tool was put through a pilot, which asked NPD team members to develop the tool for better clarity and content. The pilot aimed to ensure validity initially through buy-in from those familiar with the activities under investigation. This tool was distributed to a population of managers, engineers, scientists, and support staff in firms whose economic survival is dependent on NPD success. The firms ranged from information technology (IT) start ups to major

national defence and aerospace contractors. The respondents were members of NPD groups within each firm, and both the firm and individual staff pre-agreed to participate. Information on 123 different NPD projects was returned, and it is argued that the sample projects are in many ways similar to the "known" NPD intensive population.

1.7 Outline of findings

The literature review defines an interesting problem in the fields of NPD and KM theory. Both fields consider that competence in their activities will explain a significant proportions of the variance in NPD process success; but neither explicitly recognises the elements of the other as of equal significance (bar Liu et al., 2005, who identifies the value of three NPD drivers along with four KM competencies). This seems partially unlikely in the NPD field, where the popularity and use of KM techniques has grown over the last 15 years; and highly unlikely in the KM field, where much practice arises from the routinisation of long-standing information management and personal learning behaviours (normally associated with the NPD process).

In the method section these variables are operationalised to allow the kinds of comparison normally seen in the empirical literature on NPD to be carried out on the highly conceptual KM field. The analysis of data from generated in from the sample shows, there is statistically significant evidence with which to answer the research questions. In the sample, the NPDd and KMAs are shown to be context specific; their presence and use varies depending on the industry, size of company, and stage in the development process the project is in. The sample also shows variance in project success (the dependant measure) and covariance between many of the KMAs and NPDd (the independent variables).

In response to Hypothesis One: In the sample there is broad support for the relationship between NPDd and NPD success. In response to Hypothesis Two: In the sample there is broad support for the relationship between KMAs and NPD success. In response to Hypothesis Three: In the sample there is limited support for the relationship between KMAs and NPDd. In response to Hypothesis Four it can be said that some KMAs are related independent drivers of NPD success, but not all.

1.8 Conclusions

This thesis will provide empirical evidence to support a detailed theoretical model of the relationship between NPDd, KMAs, and NPD process success. It will also present a perspective on the value of each of these variables in context. To the best of the author's knowledge, it is one of the first to attempt inclusion of both NPDd and KMAs when examining drivers of NPD success.

The chapters that follow outline the theoretical framework for the research model; propose a method of empirical investigation; present the results of the statistical analysis of the data, and draw conclusions based on both the sample and the existing knowledge base.

2 Literature review

2.1 Introduction

In chapter one Knowledge Management and New Product Development are presented as topics whose convergence in application exposes a new and interesting set of problems in the field of management studies. Following this background, an initial set of arguments was presented pointing to a potential gap in academic understanding of this overlap. In light of the dispersed nature of the research in this field to date, it is necessary to review the literature and research first principles in both fields before conducting any new research on the phenomena.

This literature review begins with a statement of the author's initial understanding of the posited overlapping fields. Next, the two parent disciplines of KM and NPD are discussed. These form the basis for the study's theoretical framework, key assumptions, and "known" answers in each field. After the parent disciplines are discussed, the immediate discipline of KM applied to NPD is investigated. This section re-evaluates the literature mentioned in the introduction, further exposes the gaps in knowledge of the field, and draws out the research questions to be tested in the empirical study. Section three presents the completed research model combining the assumptions of section one with the questions of section two. Finally the conclusion summarises the findings of the literature review and sets the stage for the development of the method in Chapter three.

2.1.1 Author's initial understanding

At the outset it is recognised that knowledge work is at the heart of NPD processes. The ability of an organisation to know what it knows, add to this, and recombine it in useful and innovative ways is its route to competitive survival and growth (Kogut and Zander, 1992). Therefore to develop, manage, and exploit organisational knowledge is fundamental to NPD and always has been.

Recently, some researchers (Pitt and MacVaugh, 2008, also appended to this thesis) have categorised these behaviours generically as knowledge management mechanisms, and claim that they act as significant enablers of innovation processes and systems. Of these systems, NPD happens to be a singularly important objective for many organisations, involving the combination and re-combination of tacit and explicit knowledge, personal and collective cognition, and social interaction (e.g.

Madhavan and Grover, 1998). However those familiar with the field are probably aware both anecdotally and from the burgeoning literature that knowledge management activities in many organisations have become a widespread, conscious and increasingly formalised aspect of business processes, including NPD. It is possible to argue that knowledge management has become Knowledge Management; senior managers are increasingly allocating organisational resources to formal KM, often supported by the appointment of senior staff with job titles such chief knowledge officer, to orchestrate these activities effectively.

This overlap highlights a problem in the existing body of knowledge on product development. NPD is a process-predating KM that is inherently about the application and imbedding of knowledge and information into goods, but in 2008 KMAs are used by those engaged in NPD in addition to longer standing practices. Both are claimed to improve the success of the NPD process. Thus appears difficult to separate the chicken and the egg in this instance, without some insight into the two as (possibly) separate phenomena.

A new study of KMA in the NPD process should begin, therefore, with an overview of perspectives on NPD processes predating KM, and consider criteria whereby the overall effectiveness of NPD projects may be assessed. Only then can the literature that considers knowledge management in broad conceptual terms be usefully examined. The absence to date of a universally accepted typology/taxonomy of KMAs suggests that a focus on the development of a number of pertinent and operationalised knowledge management mechanisms and routines would be useful. If this can be done effectively then it would be possible to develop research hypotheses that link KM mechanisms to NPD effectiveness. These hypotheses could then be developed into a conceptual model of the posited relationships. Finally it would be useful to consider how (based on knowledge to date) best to test this conceptual model, possibly providing evidence to evaluate the veracity of the currently posited relationship between KM and NPD (see Darroch, 2005; Hoegl and Schulze, 2005; Liu, Chen and Tsai, 2005).

2.2 Parent disciplines

2.2.1 New Product Development

First, it is important to narrow the broad scope of "innovation literature" into the material relevant to the proposed study. Adler (1989) provides a useful starting point to this task, and his taxonomy seems to be widely accepted, as evidenced by its use in several other major reviews of the field (e.g., Brown and Eisenhardt 1995; Cooper and Kleinschmidt, 1995). He writes that innovation research can be split into two broad areas of interest. The first is macro-level research into industry, national, and international growth as driven by innovation. This field explores major influences on the propensity to innovate and the net effect of such innovation over time (Nelson and Winter, 1977; Dosi, 1988). The work is primarily driven by economists and political scientists, and is for the most part, a descriptive theoretical base. The second is a tradition based on the study of NPD, which transforms concepts into commercially viable products (Hertenstein and Platt, 2000).

While NPD stands alone as a management discipline, it is important to highlight the importance of researching NPD. Why is successful NPD so desirable? Zahra (1993), in an investigation of NPD in established companies provides a salient synopsis on why innovating companies value NPD:

> Achieve growth and profitability (Cooper and Klienschmidt, 1987; Kanter and Richardson, 1991; Zahra, 1993) by seizing opportunities in its industry, attracting new customers and venturing into new markets (Porter, 1980). Products introduced first to the market can also help a company to acquire a significant market share, sometimes 50% of the market (Duffy and Kelly, 1989). This allows the company to charge higher prices than later entrants (Neven, Summe, and Uttal, 1990) and gives it an opportunity to establish industry standards (Stalk and Hout, 1990). By introducing new products to the market, companies can simultaneously retain their entrepreneurial spirit and protect their market position.

This is not to say that innovation or NPD is uniformly desired by organisations. Many organisations generate their profit by more efficiently

producing an existing product, or providing the same service at a lower cost. For many organisations, NPD may seem a luxury that is not cost effective. But, for those organisations whose profit is based on a certain *technical* or *knowledge* advantage (Clark and Fujimoto, 1991), effective NPD reproduced at key stages in the product lifecycle is key to competitiveness in the long term.

NPD research explores the microenvironment of organisations that develop new products, often using the development project as the unit of analysis. Accepting that productive NPD capacity is important for many organisations the next logical step is to expose the common knowledge in the field. But as with many academic fields within the study of management, there are no universally accepted meta-methods for evaluating a NPD project, process, or the organisation within which these take place. For example Brown and Eisenhardt (1995) argue that NPD research can be variously characterised as exercises in 'rational planning', in 'disciplined problem solving', or even as the enactment of a 'communication web'. A full discussion of these three streams is included for completeness in the appendices (see appendix A).

A further element that adds complexity to the investigation of NPD is that the value that is embodied in the final product arises from inherently distributed, rather than centralised locals. For example much of the knowledge in NPD is tacit, residing in the minds of its expert employees who work within the NPD project team (Alavi and Tiwana, 2002; Kreiner, 2002; Tsoukas, 1996). Accordingly, there are obvious tensions between the desire of senior managers to implement standardised, best practice NPD processes that they believe are the way to achieve optimal outcomes and researchers who perceive NPD processes to be inherently unpredictable, ensuring that the progress of particular projects will be uneven and stubbornly resist attempts to generalise and standardise approaches. Indeed, NPD project team members may see formal processes as simply another, significant attempt to tighten managerial control over the creative process.

Thus it can be surmised that NPD is, in the main, a rationally planned and controlled process; but one that also relies on the mobilisation and coalescence of knowledge and skill, which is not the explicit goal of the traditional formal mechanisms examined by Cooper and Klienschmidt (1995). The NPD literature to date suggests that it is often the tools, practices and social behaviours used by developers/employees during the NPD process that are most noticeable as input. It also would seem unlikely that any one existing list of NPD process elements would

account for 100% of the variation in value added of the NPD process, and none of the research to date claims to account for much more than 60%. This leads to an initial research question:

R1: Is the nature of the relationship between NPDd and NPD success in any given sample population similar to that seen in the literature?

It is worthy of note that a variety of tasks has been well argued, and continues to be empirically supported as (in a normative sense) necessary for effective NPD. Using a variety of sources (e.g. Booz, Allen and Hamilton, 1982), Cooper and Kleinschmidt (1986) present a nominal 13-step NPD process activity model; though they found few firms that completed every one distinctly and exhaustively. Similar prescriptive models abound in the project management literature (e.g. Clark and Fujimoto, 1991); where there is a general assumption of a time-based sequence to activities, giving rise to the concept of a multi-stage structure with stages punctuated by decision points or gates.

However, there is increasing support for managing activities concurrently (e.g. Takeuchi and Nonaka, 1986; Page, 1993; Cooper, Edgett and Klienschmidt, 2004) both to enhance project co-ordination and to reduce overall development times. The latter is of significance because the time available subsequently to appropriate the rewards of successful innovation appears to be ever decreasing (Teece, 1987). Self evidently, whether stages proceed sequentially or concurrently there is a need for competent intra-and inter-stage management.

In a recent paper on knowledge management routines applied to innovation processes Tranfield et al. (2003) posit a model of innovation activity in which there are three overarching phases. The first of these, discovery, encompasses various knowledge routines that relate especially to markets and technologies, notably environmental scanning, capture and the generation of awareness of possibilities in the firm. Their second phase, realisation, is where acknowledged possibilities are translated into tangible outcomes via the application of what is known and what is created. Phase three, nurture, can be characterised essentially as continuing organisational reflection, learning and development. One criticism is that this model tends to ignore the importance of strategic and tactical activities of prior interpretation and decision-making about project options that link discovery and realisation. This

being said the distinctness of the three stages provides a categorisation likely to be better understood by many NPD practitioners then the thirteen stages of Cooper and Kleinschmidt's (1986) model.

Few would argue that NPD processes are not challenging, complex, firm and industry specific. NPD stages, processes, and practices in a microchip firm must differ in form and pace from that in a pharmaceutical company, which differs again from NPD performed by a food processing organisation. Moreover, new innovation possibilities are widely believed to be a function of firm-specific developmental paths (Dosi, 1982; Pavitt, 1990) delineated partly by competencies and partly by ingrained organisational beliefs (Tripsas and Gavetti, 2000). Since typical NPD teams will be engaged in multiple, concurrent development projects, they are likely to accumulate bundles of technologies and related experiences over time. Taking this into account, if it can be shown that specific activities play a significant role in particular phases of NPD, and/or in the management of the progression between phases, there will be evidence of an influence on overall NPD effectiveness. Thus it can be surmised that NPD processes may overlap and be part of non-discrete activity, but when analysed from the perspective of a single end product, these processes form a stage/gate chain, each part of which will be subject to some form of management measurement and/or control. It is therefore possible to identify stages in NPD, be they in broad conceptual terms, or in company specific activities. These stages provide useful points at which to examine the success of the practices employed.

How might one assess the success of the NPD process at each stage-gate? Several options exist (Table 0). They include the timeliness and costs of development (including objectives related to unit cost of manufacture), product performance, longevity and generational upgradeability, as well as considerations of fit with corporate objectives and strategies. Thus, while it is impossible to know the reaction of the market until the product is on the shelf it is possible to measure how successful the process and mix of inputs to that process has been.

Table 1. Measures of NPD process success:

Form of measure	Examples
Input measures	Development costs of a new product, both absolute measures and comparisons with project budget and against prior "benchmark" development projects (Werner and Souder, 1997)
Output measures	Application/use of new knowledge, systems, processes. (Hoegl and Schulze, 2005)
Product performance	Ease of manufacture; cost of manufacture – prior investment; unit cost; Potential spin-off developments – other new products; development and/or production processes Sales and profit streams –absolute/versus predictions (Hertenstein and Platt, 2000)
	Market Recognition
	Acceptance by Senior Mgt (Werner and Souder, 1997)
	Product specification (absolute and relative to initial intentions and/or benchmark products (own or competing) Absolute performance; performance against existing and/or competing products (Chiesa and Masella, 1996)
	Potential for future upgrading
Timing measures	Against predictions of project duration; against history – development of current products; against other benchmarks including competing products; Actual market lifespan versus expected span (Hertenstein and Platt, 2000)
Competence measures	Existence of new skills/resources resulting from the project Personnel development Process improvements, Go/Kill rates (late decisions to stop or continue a project), Patents Cooper et al., 2004)
Strategic	Fit with corporate strategic objectives (Werner and Souder, 1997)

At this point it is important to point out one common shortcoming in studies of success measurement. In many studies this measurement takes place at the end of the NPD process, or even less precise still, when it has been released to market. This gives the formula: input X leads to output Y, which is measured at end point Z (Vittoriao and Masella 1996). There is little consideration that the wide variety of activities occurring between X and Y may themselves be relatively successful or unsuccessful. Also, sub-stages before Z may be unsuccessful, but may not be recognised as such because of the relatively larger success of the process as a whole. While post project review is a standard element of project management routines, the NPD literature rarely uses longitudinal techniques to evaluate success in retrospect.

The problem of considering NPD as a whole is that this endeavour contributes little new to operational knowledge and stifles the discovery of alternative success factors. One important feature of any analysis should therefore be inclusion of the wisdom that the NPD process includes at least three, but possibly as many as thirteen, substantially different technical phases (Panne et al, 2003). Others have argued for a larger number, including several overlapping (Nonaka and Takeuchi, 1995) managerial choice, input, and/or measurement phases (Cooper et al., 2004). Such inclusion allows for a finer-grained exploration of factors which are significant within each different NPD stage, what their impact might be, and why. For the purposes of this study, it seems worth considering the simplest list of these phases. The categories: research, discovery, and realisation, come from the work Tranfield et al., (2003) prove useful as they are intended for examining knowledge generation as well as physical product development in the NPD process. Furthermore, for the purposes of this study it is noted that three research amenable success measurements (applicable across projects, industries and countries) would be conformance to expected process:

1. Cost,
2. Time *and*
3. Specification.

Each of these measures, often termed "the Iron Triangle" in project management literature, can be considered of equal importance across industries, but also be measured with specific regard to an individual company's expectations. This three-

fold success categorisation is supported by the work of Cooper et al. (2004). Cooper et al. (2004) also recognises the importance of internal success measurement when previous studies had focused more on market-based evaluations of success. As this study intends to measure internal drivers such as KMA, then the use of an internal success measure seems more appropriate.

Beyond simply understanding how to measure NPD success, it is also important to highlight the corresponding literature on known influences or rather "success factors" within the NPD literature. Reading from any of Cooper and Kleinschmidt's "NewProd" studies (in this case, 1995), a list of 9 NPD success factors appear to account for a very large percentage of the variance in NPD success across projects. An example of such a factor is 'quality of the new product process.' How do Cooper et al. (1995) determine the quality of a project's process? In actuality the success factor listed as 'process quality' is composed of several individual questions asked at different points in the survey. Each question indicates the respondent's opinion of the process, and these responses are aggregated to determine over all ability.

Cooper and Klienschmidt (also see Cooper, 1979; Cooper and Klienschmidt 1987; 1993; and 1995, and Cooper, Klienschmidt and Edgett, 2004) are the recognised field leaders in tracking the success and failure of the NPD process (and also of product success in the market). In their research (in this case Cooper and Klienschmidt, 1995) they have used detailed questionnaires and statistics to develop the position that the presence of the following nine NPD constructs has the greatest correlation with process success:

1. a high quality new-product process
2. a clear, well-communicated new product strategy
3. adequate resources for new products
4. senior management commitment to new products
5. an entrepreneurial climate for product innovation
6. senior management accountability
7. strategic focus and synergy
8. high-quality development teams
9. cross-functional teams

This study acknowledges that a very large percentage of variance in NPD success can be accounted for by known success factors such as resource availability, managerial commitment, and process quality. This can be simplified as a first hypothesis:

H1: There is a positive relationship between "known" NPD factors and NPD success.

It is also important to point out that while this type of empirical measuring of success factors has become very popular in the major NPD journals, it has also drawn its fair share of criticism, some of that from the authors themselves. To paraphrase Cooper and Klienschmidt (1995); while large sample sizes yield a convergent list of factors that have both correlation and causation with NPD success, it is also known that on a case by case basis many other factors influence success and some of the major influences listed in this research may be shown to have no impact at all. In the recent 13th International Product Development Management Conference published proceedings Ledwith et al. (2006), argue that such findings should be used as the *starting point* for closer inspection via qualitative research methodologies such as case studies, rather than the traditional research route which sees question development through case research and verification via large survey investigations. This being said, Ledwith et al. (2006), also highlight the value of empirical measurement to reduce speculation and identify variables worth investigating. With access to 30 years of surveys it seems reasonable for Ledwith et al. (2006) to assume that most NPD factors are known.

Examining "success factor" research articles has influenced this study in three significant ways. First, this study accepts that *as much as* 84% (Henard and Szymanski, 2001) of the total variance in NPD success can be accounted for by "known" internal and external success factors; for example market orientation (6%), managerial commitment (2%), and predevelopment task proficiency (2%). Never the less, it is clear that none of the major factor studies explicitly include KMA (which is later argued to impact NPD). Second, the importance of examining over-all success is understood, but it is important to recognise that uncommon and therefore competitive process improvement can only be based on understanding the sub-stages that lead to success, rather than through replication of industrial best practice. Third, while

contextual factors are more difficult to report, they are important for developing a better understanding of NPD success, as such an understanding will likely have a significant influence on variation in success.

To summarise the NPD literature findings: one of the most commonly recognised and well respected list of NPD success factor's comes from the "NewProd" surveys of Cooper and Kleinschmidt and the American Productivity and Quality Centre (which supports their research). While the list changes from year to year, its core propositions have strong statistically supported significance, and this is not limited to the USA, but to major NPD focused organisations across the developed world. Measuring a project's process capability along the lines of NPDd will normally predict much (50-80%) of the variance in NPD success in terms of process time, cost, and product specification for that project (the Iron Triangle). These success factors represent the common wisdom into explanations of variance in NPD success, but do not as yet explicitly include any KM/KMA phraseology. It is worthy of note that even though this study accepts the notion that 60-80% of variance is already accounted for, then there must still be at least 40-20% unaccounted for. So while it is clear that NPD must embed knowledge into end products, it is unclear as to whether the processes and practices necessary to achieve this are being accounted for in the common success factors (NPDd) empirically measured to date.

2.2.2 Knowledge Management

Science has ever strived to place human experience and existence into neat categories, with watersheds in the form of discoveries, personalities, organisations, or event-dates being the significant time determinant for an outline of the box. The significant dates applicable to the study of knowledge management are oft quoted: Nonaka's 1994 article, Drucker's book in 1993, the establishment of the KM function or Chief Knowledge Officer (CKO) position in some of America's larger technology firms. Each of these might be counted when evaluating when the recent interest in KM started.

However, the importance of knowledge as an input into the value of a good or service has been understood implicitly, and mentioned explicitly, long before management was even considered an academic research discipline. Polanyi's (1962) work in the 1950s and 1960s is often quoted based on his sociological interest in the nature of knowledge. Today many authors consider KM as worthy of research, and some, such as Prahaled and Hamel (1992), as possibly the only sustainable source of competitive advantage.

Unfortunately the term KM itself is an ontologically embattled one, which currently refers to an amazingly wide range of academic theory and practitioner activity. This includes, but is not limited to such topics as: Knowledge management practice (Holsapple and Joshi 2004; Earl, 2001; Hansen, Nohria and Tierney, 1999; Rowley, 1999), the nature of knowledge (Nonaka, 1990/1994; Nonaka and Takeuchi, 1995; Boisot, 1995; Nonaka, Toyama and Konno 2000; Smith, 2001, Snowdon 2003), Organisational learning (Senge, 1990; Brown and Duguid, 1991; Coopey, 1995), Information technology management (Prusak, 2001; Marshal, 1997), Knowledge as a resource (Weiss, 2001, Leonard-Barton, 1992), Human/intellectual capital theory (Edvinsson and Malone, 1997).

The term KM is usually used as a catch all for the many research areas revolving around this fuzzy concept of Knowledge, rather than any specific management technique. This conceptualisation is both a simplification and an underestimation of the breadth and depth to which the study of KM has contributed to understanding how knowledge has/can be used to create value within organisations.

Of course another way to consider KM is as "something we have always done." Given an NPD context it has been argued that KM simply underscores the importance

of knowledge and information resident in diverse organisational systems, processes and people (see Blackler, 1995, among others). If this were the case then rather than underestimating KM, as many take it to do, this role would seem of vital importance. If the subject is disparate because it represents hundreds of existing idiosyncratic business practices, then by the very nature of the process of organising knowledge around a central notion, i.e.: in ways that add value to the organisation, then by formalising such efforts some organisations would be able to develop competitive advantage (Hansen et al., 1999).

Rather than struggling with the same issues of definition that are likely to plague KM researchers for years to come; it is more useful to build this investigation on some of the better attempts to formalise KM theory to date. For example, in 2004 Holsapple and Joshi published a paper in the American Society for Information Science and Technology containing what can be considered a seminal knowledge management ontology. This work is an accumulation of several previous papers that aim to evaluate "ground-rules" for examination of practices within the KM discipline. While often broad in scope, this work has the benefit of drawing on the KM ideas and experiences of a large number of well-known practitioners and academics. The published opinion of: Larry Prusak, Karl Sveiby, Michael Zack or any of the 27 other notables from the Delphi list, are considered valuable to this study. the result of Holsapple and Joshi's (2004) work is a series of Definitions, Axioms (see appendix B), and Models, forming one of the most consistent and complete taxonomies for understanding existing KM theory to date. The core elements of this work provide this study's definition of KM, the bases for the chosen KM terminology, and for examining the phenomena of KMA. Thus this study defines KM as: 'An entity's systematic and deliberate efforts to expand, cultivate, and apply available knowledge in ways that add value' (Holsapple and Joshi, 2004).

Kreiner (2002) notes that by virtue of the tacit nature of much specialist knowledge, KM comprises two conceptually distinct domains: knowledge control and sharing on one hand, and knowledge mobilization on the other. Newell et al. (2002) make a similar distinction between a cognitive, information processing view of KM and a socially constructed view of it. Given the availability of high-performance/low-cost IS and IT; there is increasing temptation for organisations to focus energy and expense here, to the possible detriment of human capability, in pursuit of more effective processes (Hansen et al., 1999). Thus there is a need to explore the

theoretical and practical utility of knowledge management as a series of activities from a wide ontological base (Holsapple and Joshi, 2004).

It is also worth of note that the Knowledge pertinent to organisational needs may reside in any number of locations: within the firm, without the firm, in the right part of the firm...or not (Drew, 1999). It is also possible to infer from Marchand (1998) that this knowledge may not be in the right state; in that tacit skill must be converted into explicit action in the making of a product, or in that explicit knowledge must be rendered tacit for an individual to use in a differing context from the one it was learnt in. As yet there is little to distinguish literature that deals with KM as knowledge creation rather than as knowledge *management*. This also seems worthy of investigation given previous discussion of the role of internal communication to NPD success.

Such difficulties form a significant justification for why *systematic* KM is needed within and across organisations, where knowledge requirements may differ depending on the context. Holsapple and Joshi (2004), Mylonopoulos and Tsoukas (2003), Earl (2001) and Tranfield et al. (2003) all offer wide-ranging summaries of KMA, though differing in scope and purpose. While there is less than universal agreement in the current literature about taxonomic specification of knowledge activity, a number of generic KM routines can be identified. So at this point it is useful to highlight a split between "Knowledge Management Practice" issues and the broader "Study of Knowledge and Organisations." In the sections that follow Knowledge Management Activity (KMA) is the chosen name for KM as practice. This ontology gives a framework for suggesting how activity could work, but has little grounding in how this is done *in practice*. Several significant papers have been written based on the following three KMA typologies: KM as a Project, KM as Process, and KM as a Strategy. Each has a bearing on how best to identify KM practice.

KM as a Project: Davenport and Prusak (1998) write that one simple way to study KMA is to examine the various *projects* companies undertake in pursuit of KM. In their analysis KMA projects can be categorised in the four following ways: knowledge repository creation, attempts to improve knowledge access, enhancement of the knowledge environment, and the management of knowledge as an asset. This typology categorises KMA primarily by goal, and tends to ignore the details of how the work is done. This is useful when analysing company motives, and gives broad scope when applied in other contexts because it allows researchers to focus on perception and

results rather than pedantic categorisation of the KM mix. This typology also causes problems for the researcher as it becomes hard to separate out specific elements of success and/or apply them in a different context.

KM as a System: Montano et al. (2001) posit that KM should be categorised along the lines of its framework, phases, procedures, and outputs. They give a list of KMAs that are designed to emphasise the flow of knowledge around the organisation and account for some of the many theories of knowledge creation. This includes: Generating new knowledge; Accessing knowledge from external sources; representing knowledge; embedding knowledge in processes/products/services; transferring existing knowledge; using knowledge in decision making; facilitating knowledge growth through culture and incentives; measuring the value of knowledge assets, and the impact of knowledge management. The model ties in well with Holsapple and Joshi's theoretical understanding of KMA and begins to point researchers in the direction of what to look for when examining KM in *practice*. The work also acknowledges the value of assessing KM's contribution, the explicit goal of this study.

KM as a Strategy: Thinking of KMA as strategy is initially alluring, given that the goal of this study is to evaluate how chosen KMAs (and thus strategy) have actually impacted the well-understood territory of NPD. In the body of literature on KM strategy, two articles seem to provide significant insight into current understanding.

The first: 'What's your strategy for managing knowledge?' (Hansen et al. 1999) is often quoted, because it simplifies the issue of strategic choice in KM down to 1. Codification 2. Personalisation. Hansen et al. (1999) explain Codification:

> The strategy centres on the computer. Knowledge is carefully codified and stored in databases, where it can be accessed and used easily by anyone in the company...' Economics: 'Reuse...Invest once in a knowledge asset; reuse it many times' KM: 'Develop an electronic document system that codifies, stores, disseminates, and allows reuse of knowledge' HR: Hire new college graduates who are well suited to the reuse of knowledge...Reward people for using and contributing to document databases.

And Personalisation: In other companies, knowledge is closely tied to the person who developed it and is shared mainly through direct person-to-person contacts. Economics: Expert...Charge high fees for highly customized solutions to unique problems. KM: Develop networks for linking people so that tacit

knowledge can be shared. HR: Hire M.B.A.s who like problem solving…Reward people for directly sharing knowledge with others.

And so they posit that: A company's knowledge management strategy should reflect (as they do in the given examples) its competitive strategy: how it creates value for customers, how that value supports an economic model, and how the company's people deliver on the value and the economics.

Thus, activities that involve the collation, storage, and dissemination of data and information can have a significant impact on processes, but the ways in which knowledge is accessed, mobilised and exploited is not and arguably cannot always be confined to formal mechanisms. Given this logic other authors have argued that research into the "mix" of practices used in pursuit of KM is more appropriate. Many of these have highlighted that the subject of *what* is done is more complicated than document storage vs. networking (Earl, 2001). Since 2001 this picture of activities in pursuit of KM has increased in both size and complexity. So to render these ideas more explicitly: Knowledge Management Activity (KMA) is this study's terminology for the practical actions taken to mobilise and utilise knowledge in a firm specific context. This activity is a practical reality and may or may not resemble the theoretical ideal of KM. None the less KMA seems significant enough to warrant a second research question:

R2: Is there a relationship between use of measurable KMAs and NPD success in any given sample population as inferred by the literature?

This begs the question: what constitutes the best *current* understanding of KMA and its importance to organisational performance. Earl's (2001) efforts not withstanding, a more complete picture of the strategies, tools, and practices used in KM should include the following (see Table 2):

Table 2. KM Mechanisms and Exemplar Sources:

Knowledge management mechanism	Exemplar sources
External (relevant) knowledge search and acquisition	Brockman and Morgan (2003) Darroch (2005) Holsapple and Joshi (2004) Kreiner (2002) Liu, Chen and Tsai (2005) Montano et al. (2001) Tranfield et al., 2003
Capture, codification and storage	Alavi and Tiwana, (2002) Blackler (1995) Herder et al. (2002) Hoegl and Schulze (2005) Kreiner (2003) Liu, Chen and Tsai (2005) Montano et al. (2001) Tranfield et al. (2003)
Tracking, access and retrieval	Herder et al. (2003) Holsapple and Joshi (2004) Earl (2001) Montano et al. (2001)
Diffusion/dissemination	Brockman and Morgan (2003) Darroch (2005) Herder et al. (2003) Hoegl and Schulze (2005) Holsapple and Joshi (2004) Kreiner (2002) Liu, Chen and Tsai (2005) Montano et al. (2001) Tranfield et al. (2003)
Assimilation/interpretation/ signification	Blackler (1995) Brockman and Morgan (2003) Herder et al. (2003) Hoegl and Schulze (2005) Holsapple and Joshi (2004) Madhavan and Grover (1998) Mylonopoulos and Tsoukas (2003) Nohria and Gulati (1996) Montano et al. (2001) Tranfield et al. (2003)
Generation, recombination, mobilization	Alavi and Tiwana (2002) Brockman and Morgan (2003) Darroch (2005) Herder et al. (2003) Hoegl and Schulze (2005) Holsapple and Joshi (2004) Kreiner (2003) Liu, Chen and Tsai (2005) Montano et al. (2001) Madhavan and Grover (1998) Park and Kim (2005) Tranfield et al. (2003)
Reflection and learning from outcomes	Davenport and Prusak (1998) Tranfield et al. (2003) Orr (1990)

The difficulty with this existing research into KM is that it is composed on the basis that: 1. KM mechanisms are clear and distinct from other project operations; 2. that these types of KM are mutually exclusive, and 3. that it is possible to measure the affect that the associated activities have on knowledge (such as that a database is a tool for knowledge storage, and so it *does* store knowledge, does not for instance create knowledge, and the relationship is direct). Those that have effectively argued this case have tried to address this concern by careful choice of unit of analysis: the more specific, the better. So, it is possible to use the elements of table 2 and identify *nine knowledge management mechanisms* with respect to the NPD project team:

In the literature the KM mechanism *Scanning and collecting information* is said to aid in the transfer of explicit knowledge from outside to inside a project team. This should increase a team's ability to develop a clear strategy (Hansen et al., 1999; Liu et al., 2005) and provide adequate information resources (Brockman and Morgan 2003; Darroch, 2005) for new products while also providing the external information necessary to reduce replication of development already available from the marketplace.

In the literature the KM mechanism *Enhancing staff (external) knowledge* is said to contribute to the explicit knowledge base of individuals inside the project. Using this mechanism should increase the chance that individuals have access to key information resources (Darroch, 2005) needed to develop new products, while having access to and/or control over the selection and capture of that information (Alavi and Tiwana, 2002).

In the literature the KM mechanism *Networking* is argued to give project team members the ability to access tacit knowledge known by others outside of the organisation. Having this deeper knowledge of outside information Tranfield et al. (2003), and in turn discussing and internalising this knowledge within a work related context (Kreiner, 2002), it can be argued that these team members would be more likely to develop into effective development teams.

In the literature the KM mechanism *External (facing) communications* is said to be significant as key users often shape development trajectories (Hippel, 2001). External facing communications are also important in accessing resources (Allen, 1971; Darroch, 2005). Hansen (2002) argues that this KMA is key to knowledge sharing across multiple projects in a single company. So it is possible that external communications aid the project communicating its purpose to external stakeholders,

users, and those involved in strategy, attracting user support, and receiving appropriate feedback from interested stakeholders.

In the literature the KM mechanism *Enhancing the extent of staff information from internal sources* is said to positively affect the ability of the project team to respond to changes in knowledge (Darroch, 2005). Effective internal communication is the key driver of project success for many innovation field authors (Allen, 1971). So it is reasonable to argue that enhancing the extent of staff information from internal sources will increase effective communication across departments and functions, simplifying this very important task for any individual project team.

In the literature the KM mechanism *Personal learning and development* is said to 'be at the very core of organisation theory' (Nohria and Gulati, 1996). So it can be asserted that in an environment where much of the value of a product can come from the unique and discretionary contribution of a few key developers, it is important to have mechanisms that increase the skill of those developers. When effective, personal learning and development should reduce project development time and save wasted expense.

Senge (1992) argues that the KMA *Organisational learning* will render all people and processes more informed and effective. Orr (1990) highlights that only through learning and teaching on the job can solutions to new technical problems be both effectively developed and tacitly shared. Hoegl and Schulze's (2005) study rates informal events and experience reports (both forms of organisational learning) as among the top three best known and deployed of KM methods in innovative organisations; arguing that they create new insights, increase technical ability, and increase the knowledge resource base.

In the literature the KM mechanism *Engineered work processes for codification of knowledge* is said to be the backbone of the technocratic school (Earl, 2001). As such they formalise the knowledge creation process, and ensure retention of this knowledge embedded in the system (Blacker, 1995). Hansen and Nohria (1999) refer to this as a 'codification' strategy. Furthermore, Blumentritt and Johnson (1999) argue that explicitly addressing development of mechanisms at the knowledge-information interface is the most important goal of formal KM.

In the literature the KM mechanism *Sharing of expert knowledge* is said to underpin a 'personalisation' strategy (Hansen and Nohria, 1999) and the behavioural

KM school (Earl, 2001). Sharing knowledge is key to innovation in the well-respected learning model of Nonaka (1994).

Thus, at the using the project as the unit of analysis, this study posits nine KM mechanism:

1. Scanning and collecting information
2. Enhancing staff (external) knowledge
3. Networking
4. Externally facing communication
5. Enhancing staff (internal) knowledge
6. Personal learning and teaching
7. Organisational learning
8. Engineered work processes for codification
9. Sharing expert knowledge

More recently, Darroch (2005) has argued that KM mechanism have a measurable relationship with firms who have a strong ability to deliver incremental product innovation. Darroch (2005) surmises: 'Within firms decisions are made as to what activities the firm will be involved in, how those activities will be performed, what resources are required, which resources are allocated to different activities and, ultimately which resources are used...having access to knowledge supports any decision making about resources...a capability in knowledge management enables a firm to leverage the most service from knowledge and other resources.'

The measurement of KM mechanisms in the NPD process is further explored by Liu, Chen and Tsai (2005) who state that: 'Knowledge has become the main manufacturing resource and a prerequisite for success in the production environment...[their statistics support the claim that] the stronger the knowledge management method, the more complete the new product development.' Thus there is a growing body of academic support for the (second) hypothesis that:

H2: There is a positive relationship between the use of KMAs and NPD Success.

To summarise: knowledge management is 'An entity's systematic and deliberate efforts to expand, cultivate, and apply available knowledge in ways that add value'

(Holsapple and Joshi, 2004). The academic understanding of KM is fragmented, but for the purpose of this investigation it is useful to focus on Knowledge Management mechanisms as variables. These mechanisms are no doubt delivered by an immense variety of Knowledge Management activities, which are them selves project and possibly even user specific. These often take the form of a tool, practice, or social behaviour that is recognisable as contributing to knowledge acquisition, movement, or application. A group of such KMAs might fall under a more general KM mechanism, which is easier to discuss in an academic sense. Such mechanisms are measurable, and more importantly to practitioners, KMAs are to a degree controllable.

2.3 Immediate discipline: Knowledge Management in the New Product Development Process

Reviewing the literature it is clear to see that KM, KM mechanisms and KMAs have a fairly strong association with organisations in the business of innovation. The concept of KM as the facilitation of Organisational Knowing and Learning through Strategy and Process includes investigation of methods for handling Innovation Processes (Tranfield et al., 2003; Takaya et al., 2003), Knowledge Coordination (Faraj and Sproull, 2000; Silva and Agusti-Cullel, 2003), focusing on innovation (Ribie`re and Sitar, 2003) and Open Vs Closed Sharing Strategies (von Hippel, 2001; Munsch, 2004). KMA can be viewed as the implementation of institutional mechanisms, tools, and technology for information management, includes research into: Leadership, Management, and Line Roles (Bontis, 2001; Lang, 2001; Ribie`re and Sitar, 2003), ICT Tools such as KM Software, Databases, Shareware, Networks, and Telecommunications, Internal Sharing mechanisms (Hansen, 2002) and Alignment of HR etc to KM (Robertson and Hammersley, 2000; Hafeez and Abdelmeguid, 2003). KM theory is also related to classic financial management activities applied to Knowledge Assets (KA); Accounting, protecting, measuring, valuing; Choice of KM Method based on a protectionist innovation strategy, KA Accounting for measurement's sake and Linking KM/Innovation to measures of performance (Edvinsson and Malone, 1997).

But KM and KMAs are not only a positive influence in organisations. The literature also suggests that there are several *potential drawbacks* of KM for innovation in organisations. KM may have a negative affect on the innovation process, and has been known to do the same in other areas of the organisation. Such difficulties have specific ramifications for employees, so are not limited to some oblique evaluation of the bottom line. Drawbacks to KM implementation include: best practice posing a barrier to radical ideas (Leonard-Barton, 1992; Horibe, 2001); that KM may loose good ideas in a mass of data; that KM can slow uptake or approval of innovation (Leonard-Barton, 1992); that employees may focus only on activities related to KM processes as this is the measure of performance; KM often focuses on efficiency when quality or the need for slack is more important (Nohria and Gulati, 1996), that knowledge only constitutes capacity not motivation (Waters, 2000; Horibe, 2001); that KM does not lead to cultural changes needed for success (Chandler et al., 2000; Horibe, 2001); that employees may not wish to share (Scarbrough, 2003) KM does not lead to commitment and may reduce this as it is seen as a burden or interference (Waters, 2000; Horibe, 2001).

These drawbacks not withstanding, if as is suggested KMA moderates the flow of information, enhances communication, aids knowledge creation through recombination, and a host of other processes that are arguably at the core of NPD, then it seems reasonable to suppose that their presence will generally have a positive impact on the effectiveness of the NPD process (as per Hypothesis 2). But it is worth noting is that this presence is not always deliberate. Many KM practices and behaviours may happen as the result of a myriad of other social exchanges and existing NPD processes. So it is important for organisations that wish to affect change with regard to KM that these KMA become better understood and deliberate.

However, there are multiple contextual influences on NPD in practice, so understanding the implied relationship between KMAs and NPD is complex. Tranfield et al. (2003) support the proposition that KMAs may be used differently in various types and stages of innovation. Also KMAs probably form project-specific patterns of application, on the basis of their take-up, and the perceptions of senior management and/or the NPD group regarding the appropriate form of NPD strategy and its anticipated effectiveness (Liu, Chen and Tsai, 2005). Modern, IT-based KMAs may significantly level the playing field among industry competitors who pursue similar notions of current best NPD practice; however, even best practice can be amended, favourably or otherwise, by idiosyncrasies regarding the specifics of use within each group or organisation. Other forms of KMA based on human resource practices, policies, and routines (i.e. not IT-based) are probably less convergent across projects, organisations, and industries. These behaviours would include personal networking, knowledge brokering, ad-hoc meetings and more formal workshops, boundary spanning behaviours etc. (e.g. Hoegl and Shulze, 2005).

The question still remains: is it practical to envision defensible propositions linking KMA mechanisms with NPD process success; given that existing factors make up much of the variance in NPD success and that KM may simply be a re-branding of the knowledge embedding that is implicit in the NPD process?

One response to this question has come from the examination of the relationship between KMA and NPD from a more abstract perspective and ignoring the usual organisational moderating factors. Darroch (2005) and Liu, Chen and Tsai (2005), argue that KMA is positively correlated with NPD success. Their papers follow the logic that idiosyncratic KMAs may be significant in and of themselves, but their real power lays in a broader contribution to an organisations capacity to acquire, store, share, and apply knowledge, themes also suggested in the Holsapple and Joshi (2004) Delphi study (See appendix B for a summary). This argument in favour of KM

categorisation mirrors that of many others (Brockman and Morgan, 2003; Herder et al., 2003, Hoegl and Schulze, 2005, Park and Kim 2005, and Tranfield et al. 2003), all of whom argue that the utility of individual Tools and Practices stem from contributions to an overarching KM strategy. It is argued, therefore, that such a strategy renders knowledge a usable resource of the organisation and this use; be it through new knowledge creation; informed application; or as a contribution to strategy, will increase organisational performance (see Diagrams 2 and 3 below).

Diagram 2. KM, Innovation and Firm Performance (Darroch, 2005):

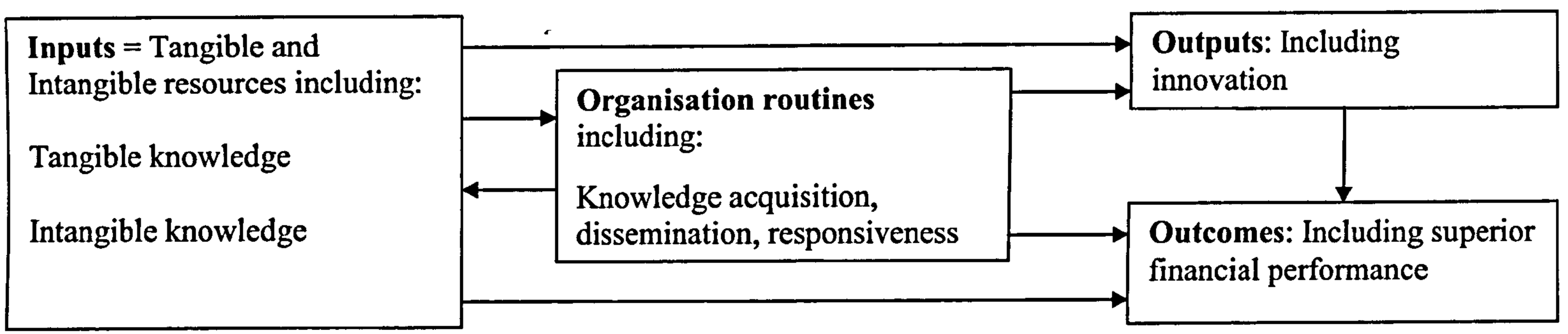
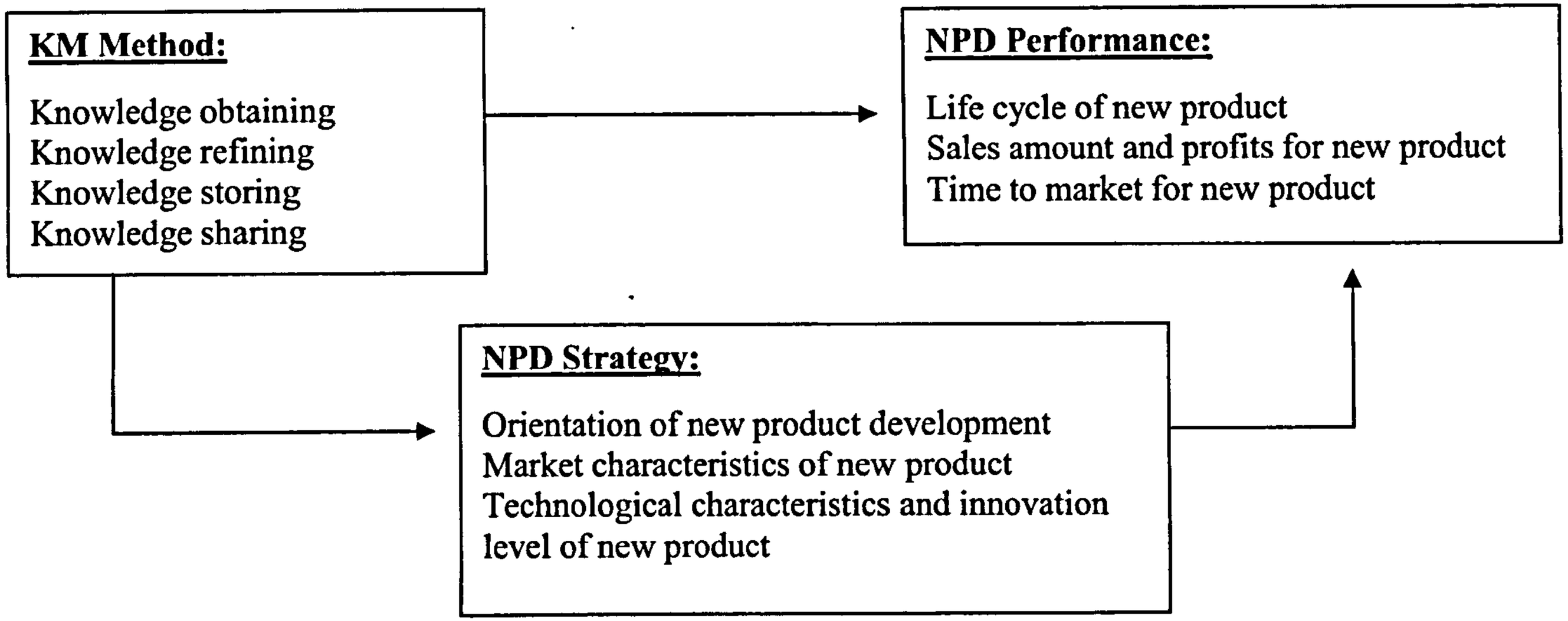


Diagram 3. KM, NPD Strategy and NPD Performance (Liu, Chen and Tsai, 2005):



This argument has certainly advanced knowledge since the early arguments of Hansen, Nohria, and Tierney (1999) for whom proactive knowledge management was simply a choice somewhere along a continuum from codification (IT enabled capture and storage) to personalisation (linking those with questions to people with answers). One problem that is never fully resolved in these works is the fuzziness of both the KM categories, and of which tools and practices fit within them. Re-examining Darroch (2005) and Liu, Chen and Tsai (2005) the question: "does the presence of a proactive KM strategy lead to a perceived increased performance?" seems to ignore the specifics of the questions: "which practices and by how much?" How many CEOs or senior managers in 2006 are likely to admit to having no strategy for managing knowledge or would not presume that the strategy they use includes deliberate efforts to capture, store, and share knowledge etc. As is common in many studies, senior managers (as in the case of Darroch, 2005) who were asked about *over all* firm performance were predictably bullish; and would self report any instances of weakness only as proof that they were on the case. Measuring success for the process as a whole seems suspect, and further more, so does combining any and all KM related efforts into one of four or five categories.

The problem is that these arguments end up in a logic cul-de-sac, where similar studies might only be able to reinforce or falsify findings based on some previously untested context. What seems necessary is some logical next step, an opening of each black box (acquiring, sharing, storing, applying) to see if a specific KMA element may contribute to success on its own; if combinations of elements are significant in uncommon success, and if there is not some broader pattern of KM activity which links ephemeral tacit knowledge to the explicit knowledge which is necessarily part of any finished end product.

While it may be unrealistic to consider the effect of KMA on NPD as solely positive and uncomplicated; it must also be said that the literature to date does provide ample evidence to suggest that those working in NPD consider KM a significant factor in the day-to-day practice of NPD. The literature also gives ample information on the nature of NPD; how success can be measured, and some other factors to consider that help fill out the picture. Thus this study must ask:

R3: Is there a relationship between any given project's ability in terms of their NPDd, and the presence/use of KM tools and practices, as is suggested in the literature?

So, it is argued that a synthesis of current understanding across the disciplines of NPD and KM can provide a logically reasonable model of the possible forms of knowledge manipulation, and what practices might enable this endeavour. Considering the context of NPD, it seems practical to advance the debate through the consideration of propositions which build on the subjects current assumptions (Brockman and Morgan, 2003; Herder et al., 2003; Hoegl and Schulze, 2005; Holsapple and Joshi 2004, Park and Kim 2005, and Tranfield et al. 2003; Darroch, 2005, and Liu, Chen and Tsai, 2005) but which also can expose the component parts of KM's effect in a way that is more functionally practical.

It is easier to argue that there is a link between KM, the 9 NPDd, and NPD success, if the specific KMAs would influence an individual NPDd, and thus in turn, are already drivers themselves. While it will be necessary to ask individual project teams which specific KMAs they use (to measure their effect), it is possible to pull some of the likely generic mechanisms from the KM literature on knowledge state and location transfers. So, to summarise this section on links between KM and NPD, the following lists the 9 general knowledge mechanisms (transfers between locations and states) identified in the literature and shows their possible associations with existing NPDd:

KMAs that aid in the *scanning and collecting of information* from the external environment: transfer explicit knowledge from outside of the organisation to inside the organisation. This should increase an organisation's ability to develop a clear *new product strategy* (Liu et al., 2005) and provide adequate information *resources* (Darroch, 2005) for new products while also providing the external market information necessary to develop a *strategic focus* (consider Porter, 1980 and others on market based views of competition).

Organisations that can *enhance staff knowledge from external sources:* transfer explicit external knowledge from outside of the organisation to the explicit knowledge base of individuals inside the organisation. This should increase the chance that they may participate constructively in developing *a clear new product strategy* (Liu et al., 2005). The staff would be provided with the information *resources* (Darroch, 2005) needed to develop new products, while also being provided the external market information necessary to understand the organisation's *strategic focus*.

An organisation that can *enhance staff opportunities to network:* gives internal candidates the ability to learn tacit knowledge known by others outside of the organisation. This should increase the chance that they may participate constructively in developing *a clear new product strategy* (Liu et al., 2005). The staff would be

provided with the current and context specific information *resources* (Darroch, 2005) needed to develop new products, while also being given the external market perspective necessary to understand the organisation's *strategic focus*. Having this shared knowledge of outside information, and in turn discussing and internalising this knowledge within a work related context, it can be argued that these staff would be more likely to develop into *high-quality NPD teams* (Keller, 1986).

Effective *externally facing communication:* gives explicit internal information to relevant outside parties. This would arguably increase *senior management commitment* to new products and *senior management accountability* for new product success through exposure of NPD to relevant external stakeholders (Hardy et al., 2003; Ribie`re and Sitar, 2003).

An organisation that has an effective system for *enhancing their staff's knowledge of internal information:* transfers explicit internal information to the individual knowledge base of an employee. This increases the likelihood that individuals know what 'everyone is supposed to know' (Faraj, S, and Sproull, l 2000). This would likely: increase the *quality of the new-product process*; give individuals access to shared knowledge *resources* necessary for the development of new products; 'evangelise' (Bontis, 2001) any message that NPD matters thus supporting an *entrepreneurial climate*; ensure that development teams have a 'shared-ness' and 'intensity,' while providing a communication channel to facilitate the development of *cross-functional teams* (Hansen, 2002).

Personal learning and teaching: gives employees the opportunity to render their available explicit knowledge tacit. This seems intuitively part of any innovative business and has fairly obvious links with NPD (Madhavan and Grover, 1998). Staff who learn on the job, and in turn who take the time to teach others would: assist in the development of adequate human *resources* for NPD; their actions would foster a collegiate and *entrepreneurial climate* where (depending on culture) innovation becomes "the norm," and in turn would increase the *quality of NPD teams* to which they belong.

Senge (1990) argued that *group learning and teaching* would change and organisations trajectory and location on a traditional life cycle by rendering all people and processes more informed and effective. This mechanism allows tacit knowledge to be transferred from individuals to groups within the organisation. Organisational learning as a conscious KM practice has an immediate relationship with: the development of a *high quality new-product process*, and the provision of adequate knowledge *resources* (and knowledge about resources) for NPD (Darroch, 2005).

The principle behind why *engineered work processes for knowledge codification* (as a form of KM) are likely to already be part of NPD follows the same argument for organisational learning, but reflects the importance and value generated by organisations in the continuous development of codified *best practice* (Hansen et al. 1999). This mechanism helps to render group or individual tacit knowledge more explicit and transfer the part that is explicit to the organisation as a whole.

Sharing expert knowledge: renders an individual's tacit knowledge explicit and transfers it to another individual. This has also likely always been a significant part of effective NPD, but when the process is encouraged and considered a KM practice then it could: increase the *quality of the new-product process* by ensuring adequate knowledge and knowledge about knowledge) resources were accessible to *cross-functional teams*, even when those with the knowledge might not be in the team themselves. Again, with a shared-ness and intensity developed through 'open-door' access to the highly knowledgeable it seems likely that *entrepreneurial climate* would result (Chandler, Keller, and Lyon, 2000).

So with a healthy sense of scepticism on the independence of KM mechanisms from NPDd it is possible to hypothesis that:

H3: There is a relationship between the presence of KMAs and "known" NPD factors.

In conclusion to the discussion of theoretical determinants of NPD success: it is possible to propose three fairly well supported ideas from the literature. First that ability in the nine NPDd will lead to increased NPD process success. Second that knowledge management needs to function at the level of the project to be of use to the development process. The literature predicts that these KM mechanisms should also lead to increased NPD success. Finally, the terminology used to identify KM mechanisms has a conceptual and logical overlap with many of the NPDd. Thus it is possible to predict that the affect of KM on NPD may actually be because the KM mechanisms are interrelated with NPDd.

2.3.1 A theoretical framework for the study of KMA in the NPD process

There are many existing theoretical frameworks that posit *where* and *how* Knowledge Management might affect operations in an organisation. This study chooses Systems Theory to explain *why* we would value any empirical/causal link between the KM theory and the Stage-Gate theory of NPD. As Blackler (1995) states 'Applied to the study of knowledge work, the approach developed here suggests that...attention should focus on the systems through which knowing and doing are achieved.' This view is supported by Montano et al., (2001) who argue that the previous shortcomings in the field of KM result from the inability of perspectives other than a Systems view to explain and integrate the disparate elements required to effectively manage knowledge. Of course Systems Theory is not without flaws, but is the choice of many well-respected academic's researching KM (see table 4 below), and is the organising premise (see diagram 4. below) of the broad ontology espoused by Holsapple and Joshi (2004). Thus, this study argues that Systems Theory is the most appropriate research framework given both the unit and level of analysis.

Diagram 4. Systems Theory applied to KM in the NPD process: (Adapted from Holsapple and Joshi, 2004)

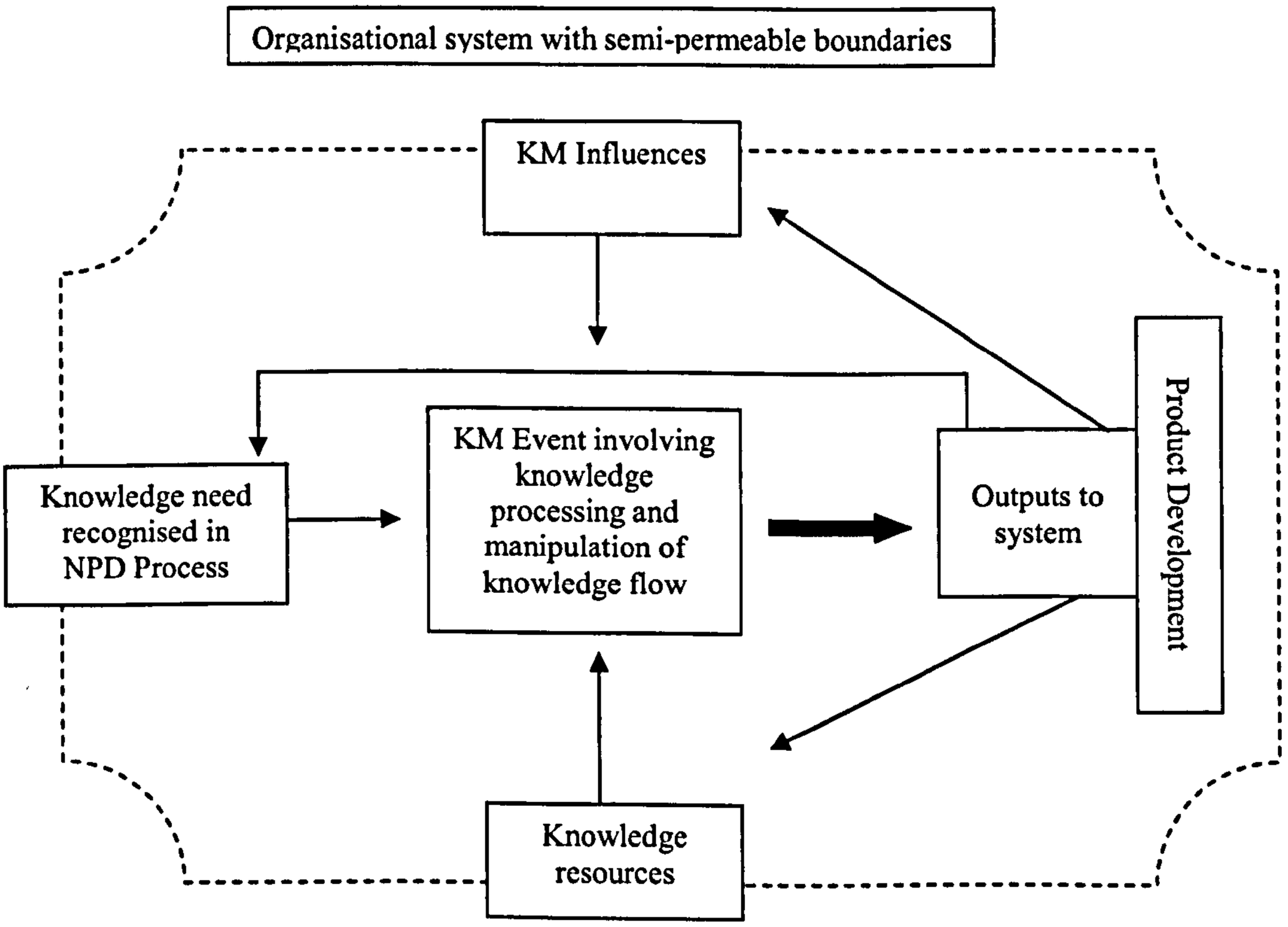


Table 3. Theoretical Frameworks for KM and NPD:

Table 3:	Classic Scientific Perspectives:	Resource and Market Based Views:	Systems View:	Emergence Based Theories:
Proposes that KM can be understood as:	A rational/scientific process where all knowledge can be managed. Strong ties to classical management theory and positivism. Usually is carried out via ICT.	A managerial activity where control of knowledge assets combined with human capital and other resources/processes contribute to the specific competitive advantage of the firm.	An organisation specific system, which can be modelled. Its management is control over many elements, but these and the environment have a non linear but measurable effect. This KM system can be observed operating at a variety of levels, is holistic, and operates within a feedback loop.	A scientific task that can only be half completed as knowledge will emerge in uncontrollable ways during the KM process… Doing it well means keeping a close eye on the outcomes of this emergence.
Assumptions:	All knowledge is knowable/definable. It is straightforward to access/use this Knowledge.	Knowledge is made up of information and human capital. This resource is controlled by the company and is ~ easy to access.	Knowledge exists within systems of people and structures. Systems can be affected by managerial, technological, and social action.	The end result emerges from undefined contexts andpeople…3 Knowledge types tacit/explicit/emergent.
Posited Advantages:	Allows for very specific measures and testing of KM techniques.	Has literature support from RBV of the firm. Will probably lead to results of empirical importance if tested.	Allows for KM to be seen part of a larger org system which has more validity if positivistic view is posited.	Is closest to reality of complex and messy nature of KM Focuses on observation etc.

Posited Disadvantages:	Over-simplistic view that can only capture a small % of Knowledge…	Focus on knowledge as an asset carries human problems as has been discussed in HRM lit for years.	Is problematic because it is hard to account for *all* elements of a system…Can we separate KM effect?	Hard to compare results/methods with most other management research.
Researchers using this lens to study KM:		• Maier and Remus: Knowledge and Process Management 2002 • Barney: Journal of Management 1991 • Grant, Contemporary Strategy Analysis text 1991 • Leonard-Barton: Strategic Management Journal 1992 • Gold, Mahlhotra, Segars: Journal of Management Information Systems 2001	• Blackler: Journal of Management Studies, 1995 • Holsapple and Joshi: JASIST 2004 • Darroch, 2005 • Liu, Chen and Tsai, 2005 • Nonaka and Toyama: Knowledge Management Research and Practice 2003 • Prahaled and Hamel: Harvard Business Review 1990 • Rubenstein-Montano et al., Decision Support Systems 2001 • Rubenstein-Montano et al., Journal of KM 2001	• Snowden: Knowledge Management Research and Practice 2004 + Journal of KM 2002

Given this understanding, the questions would now seem better posed as: is it possible to conceptualise KMA in the setting of the NPD process in such a way that we would see a clear link between the high level conceptualisation of KM (Hoegl and Schulze, 2005; Tranfield et al. 2003; Darroch, 2005, and Liu, Chen and Tsai, 2005) and a list of measurable KMAs present in NPD projects?

Using systems theory as an over arching framework it is possible to argue that the significant contribution of KMA must come from each KM tool or practice's ability to form the machinery necessary to render knowledge more useful to the project, and ultimately to embed knowledge into new products. Thus projects who have more complete and more complementary sets of KMAs (and of course, who use them) will be able to action the needed KM mechanisms, and thus will achieve greater success in NPD than those who do not.

Moreover, though it is possible that the various phases of NPD activity require a unique set of KM tools and work practices (routines), it is more likely that any such activities could be identified as in context. So to develop a sound, practical understanding of KM activity likely to influence NPD, it is arguable that the focus should be on KM activities already being used in the population.

2.3.2 Discussion of the need for further investigation

Reading the New Product Development literature two things become readily apparent. First, while NPD has a relatively well-defined and common set of success factors, what is important to any one project can vary widely based on contextual factors and industry changes over time. This is highlighted over and over by looking at how success factors, as discussed by a small but influential group of authors, changes in the 1970s, 1980s and continue to do so now. This implies that in even fairly stable industries it is possible to find a new influence on NPD success, building both new theory and contributing to practice where circumstances allow. Second, as was mentioned above, NPD theorists and practitioners alike seem to value factors that can be shown to have a measurable affect on the outcome of the process or on market success. Given that the NPD literature implies that certain activities may now involve KMAs, then any attempt to measure or correlate "effects" would prove popular and interesting even with a negative or null result.

From the perspective of Knowledge Management literature, several important authors and many have voiced the opinion that Knowledge Management lacks both; an understanding of what principles are important in a given context, and a measure

of the impact of such practices on the bottom line. While it is beyond the scope of this study to fully answer such questions, this study will provide some of the first empirical evidence for KM's theoretical claims; as well as a more practical contribution to NPD management in the chosen population.

While the volume of literature to date in the fields of New Product Development and Knowledge Management Practice is large, there is as yet no single framework that would allow answers developed in this study to support both KM and Innovation referent questions (although Holsapple and Joshi, 2008, Pitt and MacVaugh. 2008, Snowden, 2003, and Tranfield et al., 2003 each provide insight into this dilemma). Developing such cross-disciplinary groundwork is a common challenge in academia, and one that has no simple rules.

In the course of this review three significant themes have emerged that inform the chosen research topic: A) KM as conscious effort to collect and apply knowledge to add value. B) The Stage-Gate and 9 significant inputs approach to NPD. C) Systems Theory.

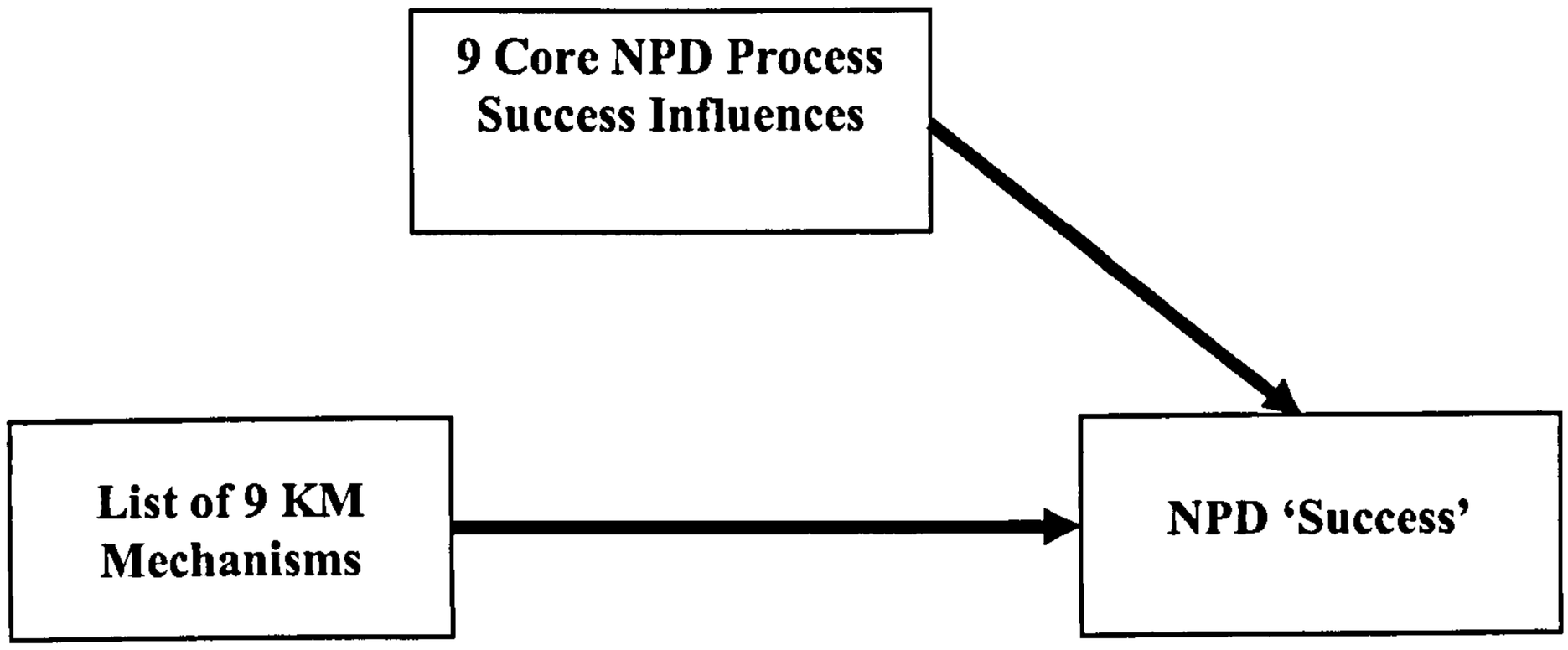
To advance the state of knowledge in this field this dissertation posits that the conscious practice of KM has a measurable relationship with NPD success. While this statement is broadly supported by the research as mentioned, it has been argued that there is more to understanding this relationship than is currently known. At present, both the KM literature and the NPD literature posit non-commensurate lists of factors determining NPD success, with an implicit but as yet unstudied process for embedding knowledge in an end product. While it is beyond the scope of this study to investigate all reasons why any given KM/NPD practice aids in the embedding process, it is possible to use statistics to examine both sets of factors in context, and in doing so find out more about the effect that their presence and use has on NPD success.

2.4 Research agenda

2.4.1 Existing theoretical model:

Excepting that a small number of recent studies have moved beyond the (following) notion, it is argued that much of the older KM literature and all of the current NPD specific literature treats core NPD processes and KM mechanisms as independent influences on NPD success (see diagram 4).

Diagram 5. Existing Theoretical Model:



Questions arising from the literature about this model:

1. *What is the affect of KMA on NPD success?*
2. *Do "known" NPD factors mediate the relationship?*
3. *Why does current research/literature indicate two separate lists of influences on NPD success?*

2.4.2 Beyond the Research to date:

From the review thus far it can be surmised that any further research into the relationship between KM and NPD process success must seek to integrate/include the following:

1. The significant impact of "known" NPD factors, whether from the Cooper and Kleinschmidt research or similar meta-studies
2. That KM activities, mechanism, or processes are complex and indistinct, but if it is necessary to examine their relationship with business success, that they are better understood as tools, practices, or social behaviours for the transfer and conversion of knowledge into increasingly usable forms
3. That, given recent work in this field (Darroch, 2005 and Lie et al., 2005), KM may not be an independent driver of success, but is likely an inherent or enhancing feature of an existing process or mechanism.

Given this understanding, this study proposes an empirical evaluation of the relationship between knowledge management activities (KMAs) NPD drivers (NPDd) (using the Cooper and Kleinschmidt model) and NPD process success (using three of the most common success measures). But it is also nessesary to discuss the likely

outcomes of such an investigation, as the unique contribution of H2 and H3 comes from their ability to answer a fourth question in the field:

R4: Given knowledge of the data generated in answer to questions 1-3, to what extent is any KMA an independent contributor to NPD process success?

In the literature the KMA *Scanning and collecting information* is said to aid in the transfer of explicit knowledge from outside to inside a NPD project team. This should increase a team's ability to develop a clear NPD strategy (Liu et al., 2005) and provide adequate information resources (Darroch, 2005) for new products while also providing the external information necessary to reduce replication (and thus time spent) of development already available from the marketplace. *So, the ability of a project team to scan and collect information should make an independent contribution to project time success.*

In the literature the KMA *enhancing staff (external) knowledge* is said to contribute to the explicit knowledge base of individuals inside the project, but notably this takes more time then internal knowledge transfers. The team would have access to the key information resources (Darroch, 2005) needed to develop new products, while also being provided the external market information necessary to understand how to develop a high specification end product. *So, the extent to which staff are aware of (external) knowledge should make an independent contribution to project specification success, but will reduce projected time success.*

In the literature the KMA *networking* is argued to give project team members the ability to learn tacit knowledge known by others outside of the organisation. This should increase the chance that they may participate constructively in developing a clear NPD strategy (Liu et al., 2005). The team could have access to current and context specific information resources (Darroch, 2005) needed to develop new products, while also being given the external market perspective necessary to understand the organisation's strategic focus. Having this shared knowledge of outside information, and in turn discussing and internalising this knowledge within a work related context, it can be argued that these team members would be more likely to develop into effective NPD teams. *So, the relative ability of a project team to network should make an independent contribution to project specification success.*

In the literature the KMA *external communications* is said to be significant as key users often shape development trajectories (Hippel, 2001). External communications

are also important in accessing resources (Allen, 1971; Darroch, 2005). Hansen (2002) argues that this KMA is key to knowledge sharing across multiple units in a single company. So it is possible that *external communications* aid the project communicating its purpose to externally stakeholders, users, and those involved in company strategy. This should reduce the time taken to develop the product through reduction of barriers, gaining access to resources, attracting user support, and receiving appropriate feedback from interested stakeholders. *So, the use of appropriate mechanisms for external communication should make an independent contribution to project time success.*

In the literature the KMA *enhancing the extent of staff information from internal sources* is said to positively affect the ability of the project team to respond to changes in knowledge (Darroch, 2005). Effective internal communication is *the* key driver of project success for many innovation field authors (Allen, 1971). Therefore it is reasonable to argue that *enhancing the extent of staff information from internal sources* will reduce the cost of duplicated effort, as a result of effective communication across departments and functions. *So, the extent to which project members are informed of information from internal sources should make an independent contribution to project cost success.*

In the literature the KMA *personal learning and development* is said to 'be at the very core of organisation theory' (Nohria and Gulati, 1996). Rewarding development is a key part of developing an innovative culture, especially in the western tradition of personal rewards and professionalism. So it can be asserted that in an environment where much of the value of a product can come from the unique and discretionary contribution of a few key developers, it is important to have mechanisms that increase the skill of those developers. When effective, *personal learning and development* should reduce project development time and save wasted expense. So, *the opportunities that project team members have for personal learning and development should make an independent contribution to project time and cost success.*

Senge (1992) argues that the KMA *organisational learning* will render all people and processes more informed and effective. Orr (1990) highlights that only through learning and teaching on the job can solutions to new technical problems be both effectively developed and tacitly shared. Hoegl and Schulze's (2005) study rates informal events and experience reports (both forms of *organisational learning*) as among the top three best known and deployed of KM methods in innovative organisations; arguing that they create new insights, increase technical ability, and increase the knowledge resource base. So it seams clear that a project that has

mechanisms that aid *organisational learning* may develop projects with higher specification. *So, a project team member's involvement in organisational learning and development should make an independent contribution to project specification success.*

In the literature the KMA *engineered work processes for codification of knowledge* is said to be the backbone of the technocratic school (Earl, 2001). As such they formalise the knowledge creation process, and ensure retention of this knowledge embedded in the system (Blacker, 1995). Hansen and Nohria (1999) refer to this as a 'codification' strategy and note this has clear cost saving advantages. Furthermore, Blumentritt and Johnson (1999) argue that explicitly addressing development of mechanisms at the knowledge-information interface is the most important goal of formal KM. So, there is reasonable support to suggest *engineered work processes for codification of knowledge* will reduce the cost of lost information and increase the resource base from which contributions to specification are made. *So, the use of engineered work processes for codification of knowledge should make an independent contribution to project cost and specification success.*

In the literature the KMA *sharing of expert knowledge* is said to underpin a 'personalisation' strategy (Hansen and Nohria, 1999) and the behavioural KM school (Earl, 2001). Sharing knowledge is key to innovation in the well-respected learning model of Nonaka (1994). On the other hand the use of knowledge sharing will increase the time taken to develop a product; something practitioners might argue is a "necessary expense." *So, the sharing of expert knowledge should make an independent contribution to project specification success but may also reduce projected time success.*

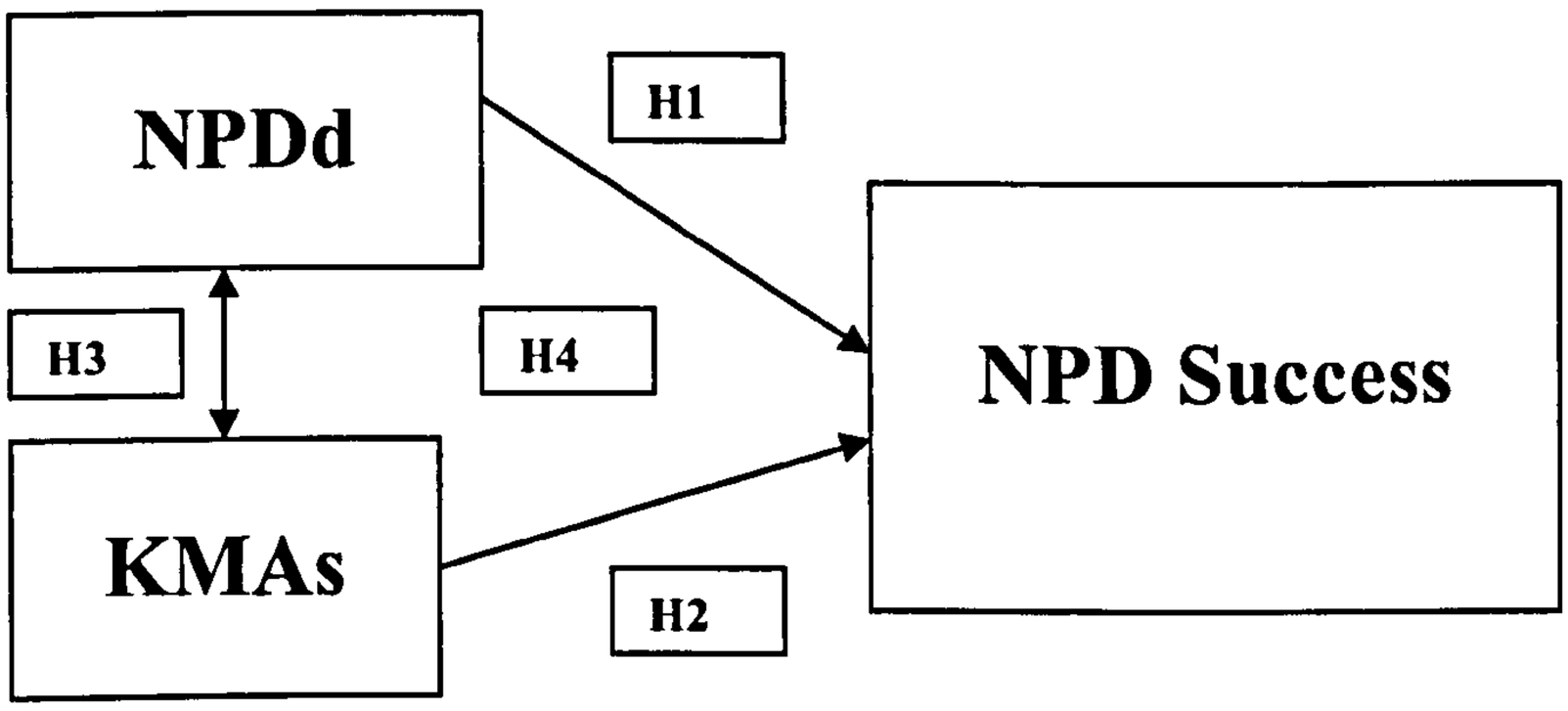
If, as is argued above, specific KMAs play a significant, and often unique, role in the embedding of knowledge into new products it seems reasonable to argue that:

H4: (Some of) The contributions that KMAs make to success variance are independent of NPDd

2.5 Research model:

Given the test elements, the supported relationships in the literature, and the possible combinations of KM and NPD drivers as antecedents of NPD success, the study posits the following research model

Diagram 6. Research Model:



2.6 Conclusions from the literature review

New Product Development success is a key element of the business strategy of many organisations. For these organisations, it is of critical importance to understand how they may exert influence and control over the NPD process. While NPD is understandably unpredictable, several major influences on the process have been identified, and over the last 20 years many organisations have taken advantage of this knowledge to change their business practices (for the better?). These "known" influences have never explicitly recognised the role of KMAs as a conscious method for the management of knowledge transfer. This gives pause for thought given an unwritten axiom of NPD: NPD is an organisation driven project that embeds knowledge into a saleable end product.

Over the last 10 to 15 years there has been a growing interest, in both academic and practitioner circles, in the ability of a firm to manage knowledge and information. Regardless of which management philosophy KM is perceived as being part of (see table 4); there is widespread agreement that the ability to capture, create, and apply knowledge is critical to continuing business success. While one might argue that this has always been the case to a varying degree, over the last few years many firms have devoted time and money to acquire and/or develop practices and tools that

specifically aid in this "knowledge management." For the purposes of this study these efforts are named (conscious) knowledge management activities (KMAs). KMAs have become commonplace in organisations, including those who are engaged in NPD. In recent years researchers have gathered evidence that KM can positively influence the success of the NPD process, but such studies have ignored the influences of "known" NPD factors. This also gives pause for thought given that we know much of the variance in NPD success can be accounted for by measuring a firm's ability in the common NPD influencing practices, or in this study, NPD drivers (NPDd).

Arguably then: NPD is the process by which knowledge is embedded into an end product; many "known" of the factors influence the success of the NPD process, and KMAs (which have become part of the NPD process) may be one of them. Unfortunately this understanding is based on research that has ignored the obvious overlapping explanations of the knowledge-embedding phenomenon. It is possible to pose research questions to explore this overlap in a number of ways, but crucial to furthering understanding in the field at this stage is statistically untangle the affect of KMA from "known" NPD factors, and from NPD success. Once such a study has taken place it would be easier to explore the nature of the effects of KMA and NPD, as the overlap suggests that the current factors are unlikely to be wholly independent of one another.

3 Method

3.1 Introduction

3.1.1 Aim:

The aim of this research is to explore the veracity of the proposition that *Knowledge Management Activity* has a *significant*, *independent*, and *measurable* effect on *New Product Development process success*. For the purposes of this study: *Knowledge Management Activity* is understood as those tools, practices, and behaviours that organisations deliberately select and encourage in an effort to: move knowledge between states, locations or both; render it more useable, and ultimately embed it into end products. These mechanisms are in the first instance recognised by the list of nine generic mechanisms of transfer gleaned from the Knowledge Management literature review. In the second instance a pilot will enable the researcher to identify a specific list of KMAs recognised by NPD practitioners in the sample as being present in their NPD project teams. *New Product Development* is defined as discussed in the review of Innovation literature, a process by which marketable ideas are developed into saleable goods. *Independent* is defined as those activities that contribute to variance in measured success, but not yet accounted for in measures of Cooper and Kleinschmidt's (1995) nine NPDd. *Success* results are measured by comparison with three industry standard metrics, conformance to planned time, cost and specification, as discussed in the NPD measurement review (see Table 1).

3.1.2 Objectives:

To achieve the stated Aim the following set of Objectives are posited. First, research questions will be operationalised in line with this study's theoretical framework. Next, sub-questions will be developed that deconstruct the core questions into smaller, more actionable, elements. This is followed by a brief discussion of the research philosophy. Given the question and philosophy, the study will apply a suitable methodology. It is then important to develop practical guidelines for the empirical investigation (i.e. the research activity) within the framework set by the choice of methodology. This chapter will also identify and discuss a research population/sample. Accepting the methodology and population, there is a concurrent need to develop means to evaluate the data generated from the sample. These should be *answerable*, and this chapter will posit what would represent answers to the stated questions. Finally, the timeline of this investigation process will be presented.

3.1.3 Research Questions:

Principal Question: Is KMA an independent influence on NPD process success in organisations that rely on NPD to generate economic returns?

Research questions:

1. Is the nature of the relationship between NPDd and NPD success in the study's sample population the same as shown in the literature?
2. Is there a relationship between use of measurable KMAs and NPD success in the sample population, as was inferred by the literature?
3. Is there a relationship between a project's ability in the NPDd, and the presence/use of KM tools and practices, as was discussed in the literature review?
4. Given knowledge of the statistical data generated in answer to questions 1-3, to what extent is any KMA an independent contributor to NPD process success?

3.2 Justification for the proposed methodology

3.2.1 Philosophical Tradition:

This study will support its broader claims to knowledge creation through the social science philosophical tradition of Positivism. Positivism has a significant impact on how this study conceives the world of management, and this can be simplified through an understanding of an espoused Ontology, Epistemology, Methodology, and the justification for their choice:

Ontology: *Internal Realism*. This ontology concentrates on the process of observation. It notes that while it is never completely possible (as in traditional science's view of positivism) to obtain a full and objective account of a phenomenon, it is possible to discover scientific laws independent of further observation. This leads to the understanding that facts are concrete, but never directly accessible; and that truth therefore, can only be determined through verification of predictions (Easterby-Smith et al., 2002).

Epistemology: Positivism. This epistemology highlights research questions, propositions, deduction, and hypotheses as the key to inquiring about the nature of the world. It posits that questions should be answered by exposing causality, generalised through statistical probability, from a relatively large sample population. In this epistemology the observer is independent from the phenomena under investigation (Easterby-Smith et al., 2002).

Methodology: Survey Research. Survey research refers to a variety of data collection activities, but is primarily an exercise in gaining data from a relatively large population in an independent manner. Survey research involves design and applying a survey tool, analysing the survey data, and interpreting the results (Hussey and Hussey, 1997).

Justification: The focus of this research is an investigation of specific KMAs applied to the "known" model of NPD. Positivism helps to explain such relationships with statistical probability and the examination of influence.

In this document the research question aims to uncover the impact of a relatively new construct on a well-known set of existing constructs. Given this focus, the best possible methodology is one that allows verification of the proposed relationship (proposition). At the end of this study the desired *result* is some statement of the effect of KM in the NPD process. While many issues in KM exist that a positivistic research program may not be able to investigate, it is unreasonable to deny the value of finding evidence to support or disproof the relationship under examination. For these reasons a positivistic methodology provides a sound philosophical grounding for the method that follows and this study's broader claims to knowledge.

Face and Content validity: A test is said to have face validity if a non-expert can see the logic behind the posited relationship between the independent and dependant variables. Content validity is achieved by carefully choosing these variables based on what is already known about the test population. Thus, a test has content validity built into it by careful selection of which items to include (Anastasi and Urbina, 1997). Face validity will be gained through the use of a pilot, which will ask the informants to highlight which concepts and terms (i.e. KMAs) actually apply in their organisation from a broader, pre-identified list that conform to the test constructs generated in the literature. In this way the test will report on a theoretical phenomenon by generating data embedded in the social

phenomenon from which it had been originally identified. Content validity will be achieved by the use of a list of KMAs, NPDd, and success measures derived and justified from both the academic and practitioner literature in chapter two. Thus the KMAs and NPDd have content validity as they represent the best current understanding in the field.

Internal Validity: An experiment is said to possess internal validity if it properly demonstrates a causal relation between two variables (Brewer, 2000). To achieve this the study will show whether or not KMAs and NPDd precede project success in time, if there is co-variation between the test variables as predicted by the hypotheses, and that the study will attempt to account for all currently known alternative explanations for the variance in success. Even accounting for this variation, the study will not necessarily achieve strong internal validity as the tests (later) used support correlation, and regressions of correlation, but not causation.

External validity: External validity refers to the extent which results from the sample are generalisable to the field (Brewer, 2000). Initially this research will attempt to generate external validity from the sample of NPD firms to the population as a whole by: including diverse mix of possible respondents: by targeting a wide range of industrial sectors; by evaluating both hard and soft KM practices; and by collecting data on respondent characteristics. This being said; with the small total number of NPD projects measured compared to the likely millions in the international population, this study will not be able to claim strong external validity.

3.2.2 Survey Research:

This study aims to examine the relationship between KMAs and NPD. The method exercise will follow the positivistic assumption that KMAs are identifiable, and exist, in project teams that aim to develop new products. Furthermore it is assumed that KM has some affect on, or relationship with, this NPD process.

KMA, seen in the context of a project team, can best be described as a mixed bag of; technology solutions, workplace social behaviours, and harder-edged management controls. This broad mix of activities seems to suggest some form of *qualitative* study to build a clearer picture of the impact of elements discussed by case study research in the past. In contrast NPD is usually well documented (even if only in hindsight),

follows well defined development paths (some of which are incremental, while others are radical), and its' output is generally easy to measure. This more specific type of subject clearly lends itself to *quantitative* methods, although some case based research informs the literature base. To evaluate the between link these two subjects *survey method* will be applied. This quantitative method is appropriate for several reasons: First, it gives a framework to evaluate which KMAs exist in the organisations studied and are actually used. Second, it can expose a useful summary of the output of the development stage. Third, it can provide data for the statistical evaluation of the relative importance of NPDd inputs. Fourth, it allows for verification or falsification of the oft-debated contribution of KMAs. Finally statistics can show to what extent the NPD process is actually being influenced/improved.

Data Collection Method: Within survey method there is a choice between interviews and questionnaires. This study will use questionnaires. Questionnaires have several advantages in this research situation. First they will allow data collection from a geographically dispersed sample population. Second, they allow for the collection of specific responses to the large number of test variables. Finally it allows for the possibility that the population and/or sample size may need to be scaled up for a more generalisable set of conclusions.

There are some well-known limitations to questionnaires and to survey method as a whole. The most significant of these, in this instance, is the question over whether the KM phenomenon is a sufficiently strong and identifiable social construct. To be amenable to a data collection method that will use aggregation the construct must be similarly understood by each respondent, and so when x percent of them say that it helps NPD, then it arguably does. If the construct were understood differently in different locations then interviews would be more suitable, as the research could then discuss the application in context, and possibly create a deeper understanding of its use.

Another limitation of note is that the study will only collect the responses to the questions asked. Given an anonymous questionnaire as the data collection tool there is no way to evaluate the truth of the responses chosen, nor observe whether espoused KM behaviours actually take place in practice.

In this study KM mechanisms are the phenomena identified as significant to the NPD process, but are themselves abstractions from the literature review. These nine mechanisms would likely not be recognised by all staff within an NPD team, and are thus not usable as questionnaire test elements. On the other hand Cooper and

Kleinschmidt's nine NPDd, and the three measures of success, are likely to be recognised. So to facilitate the construction of a questionnaire this study made use of a pilot. The pilot asked the sample population to identify the specific KMAs they were familiar with, had present in their company, and/or used. These were chosen from a list of 50, each relating to one of the 9 categories identified in the literature review. This list was also added to on occasions where practitioners identified new KMAs not yet represented in the list. From this exercise, 28 KMAs across all 9 categories were identified. As these 28 represented strong constructs used similarly by at least some people in the sample, and with the knowledge that any duplications or omissions were accounted for, the list KMAs became useable for a questionnaire as "known" social phenomena.

Research Ethics: The notion of research ethics is important for several reasons. First, the respondents must accept the reason for the research, and would likely be unwilling to participate if they thought that their views would be misrepresented. Second, the organisations who have agreed to take part on condition of anonymity expect this to be upheld, or would not participate. Finally, the research must keep faith with the scientific/management research community, its principles, and conventions or the research, once complete, will not be trusted/accepted.

The author notes that he is bound by, and follows, the research ethics principles of the University of which he is employed at the time of writing this thesis (see Appendix I).

To this end the following steps were taken to ensure this study conforms to ethical conventions. First, the questionnaire was designed in such a way as so the individual respondents and organisations could be made anonymous in the data file. Second, a statement on ethics and participation was included with each questionnaire. Third, only the researcher will have access to the physical copies of the questionnaires. Four, this data will not be used for any commercial purpose, but the results will be aggregated and published as part of a doctoral thesis. Finally, the accuracy of the statistical analysis of the data will be checked by both the second supervisor, and by independent statistical analyst from outside of the university system.

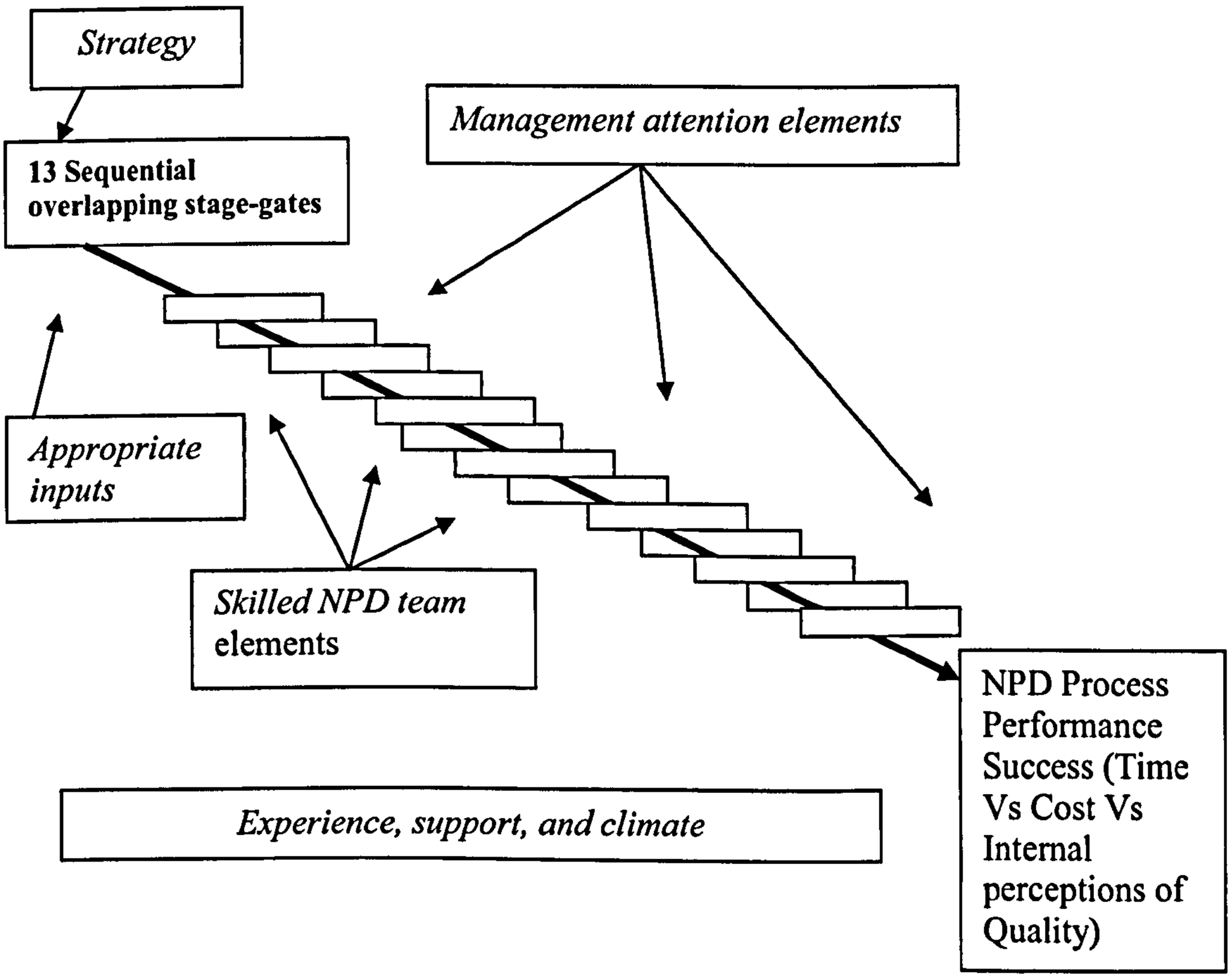
3.2.3 Theory Building:

Social scientists often argue that instruction given to new academics on the topic of theory/thesis building is constantly shadowed by a normative/regulatory influence. This influence could be the reason why Functionalism/Positivism is still very popular amongst those developing a research thesis. While this may be the case, one paper that has attempted to give a broader, multi-paradigm, perspective on methodology, contributes the following Functionalist format (and Paradigm) for a program of empirical research (Gioia and Pitre, 1990). For a model of this see appendix D. Given a deterministic research outline it becomes critical to establish some criteria for evaluating theory before, during and after the research process. Bacharach (1989) proposes several specific methods for evaluating theory (see appendix D).

With this understanding of how theory should be built and a clear methodology in place; the following is a presentation of this study's posited theory as represented by its framework, constructs, propositions, variables, and indicators.

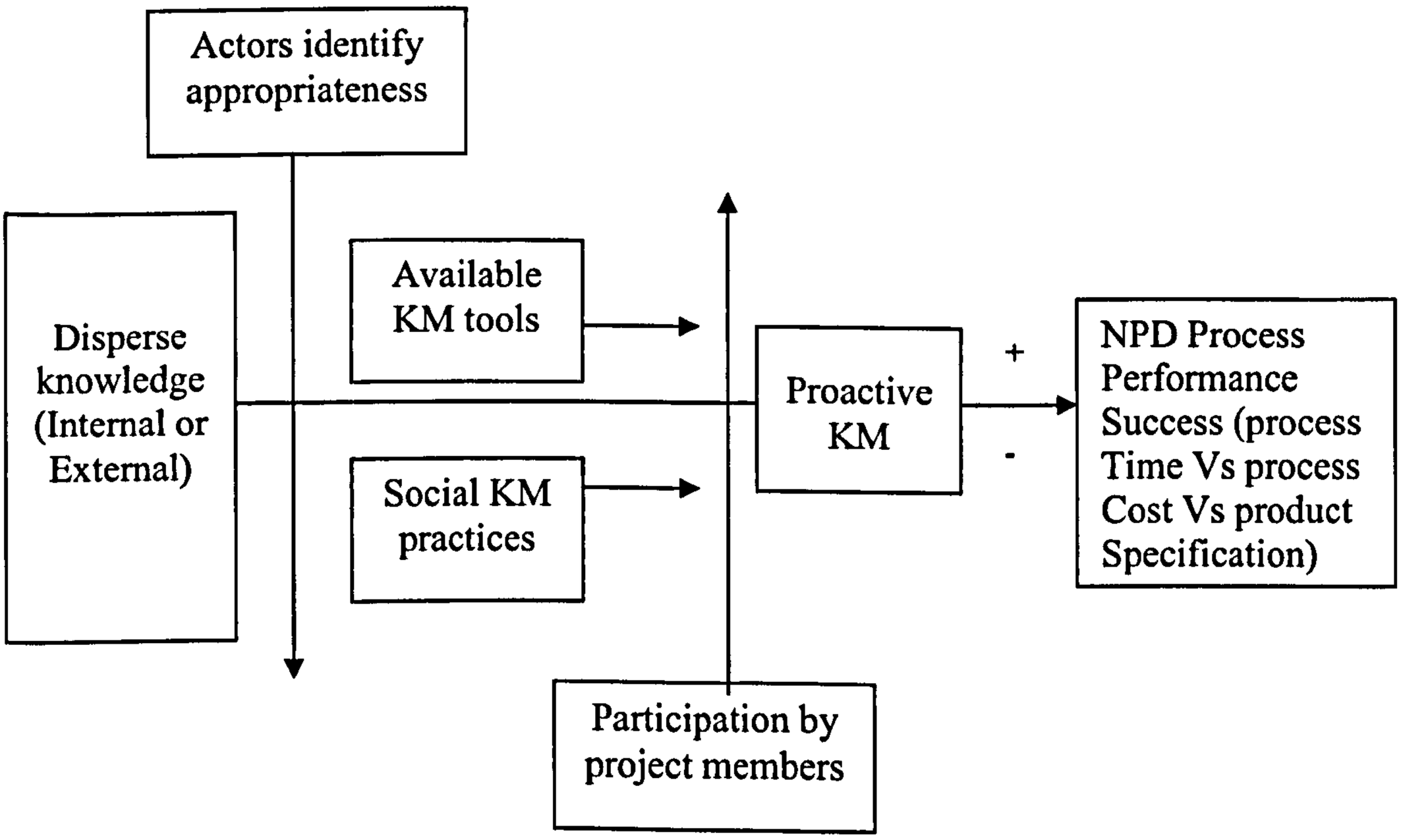
Diagram 7. Modelling the NPD Process (H1):

(Adapted from Cooper and Klienschmidt, 1995)



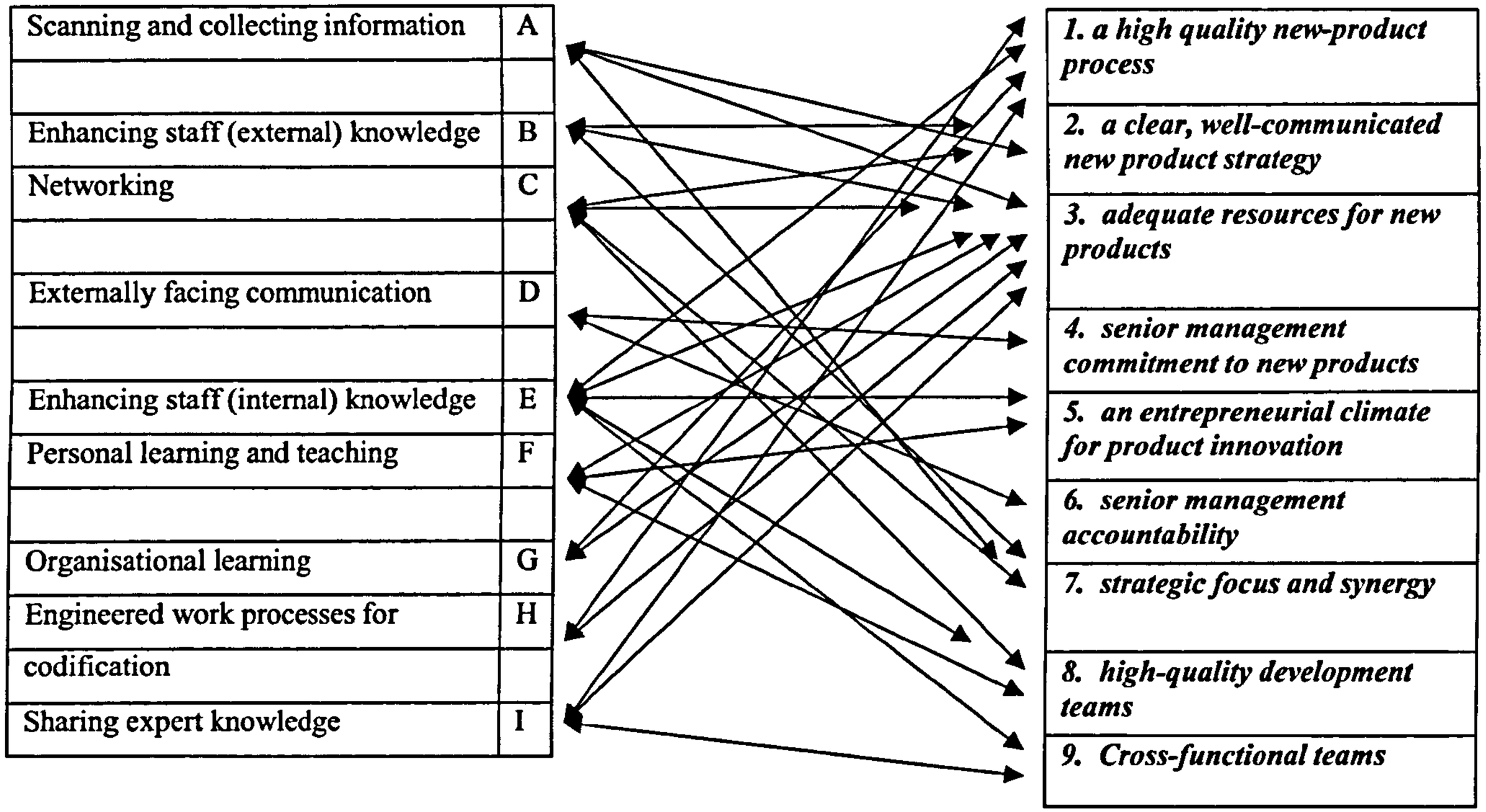
New product Development, as characterised by Cooper and Kleinschmidt, is a multi stage process that begins with a product strategy, support from senior management, and a dedicated development team. Over the course of time the project moves through 'stage-gates' (Cooper and Kleinschmidt, 1995) at which the decision to invest further time, money, and management attention is taken. Product development is influenced by a number of factors before reaching the market, and these are listed in the table of theoretical elements (below) and in the literature review. There are many ways to measure the success of this process, but amongst those most often used are conformance to the organisations budgeted time, cost, and perception of quality as might be measured by project specification. This survey will capture data on multiple organisations skill in these nine NPDd, and the success outcomes of recent projects, as reported by those working within the stages.

Diagram 8. Modelling a deliberate KM Process (H2) (Adapted from Darroch, 2005 and Liu et al., 2005):



Proactive KM is the process in which an organisation, or its NPD team members move disperse knowledge via KM tools or social practices to useable locations or states. As noted by Darroch (2005) and Liu et al. (2005) this participation aids in the formation of strategy, provides a knowledgeable base to inform decision-making, develops the skills of those working in the process, and provides direct knowledge inputs as need to be embedded in the final product. This study will measure this participation by the presence and frequency of use of the 28 KMAs by those working in the process, each of which loosely fall into the nine categories of knowledge management mechanisms generated in the literature review.

Diagram 9. Modelling possible relationships between general KM mechanisms and NPDd (H3):



As was discussed at the end of the literature review; it is very unlikely that KM, a relatively new set of practices, is the only way to embed knowledge in products. More likely is that while a KM tool or practice may be a newer solution to the business problem of capturing, sharing, or applying knowledge. The down stream effect of such practice is likely accounted for in Cooper and Kleinschmidt's (1995) nine new product development drivers. So while this study aims to uncover possibly new, independent, KM based influences on NPD success, it has proved valuable to first consider some of the theoretically implied overlaps between KM and NPDd, which an empirical investigation would uncover.

Table 4. Table of test elements:

Table 4.	Model of Systematic KM	"Known" model of NPD	
Constructs	A. Systematic scanning of / interaction with the external environment and collection of information B. Enhance extent of staff information from outside sources C. External networking D. External communications E. Enhance extent of staff information from internal sources F. Personal learning and development G. Group learning and teaching "on the job" H. Engineered work processes for codification of Knowledge I. Sharing of "expert knowledge" within the firm (9)	1. The quality of your New Product Process 2. The quality of your New Product Strategy 3. The resources available for NPD are 4. Senior Management's commitment to NPD 5. An entrepreneurial climate 6. Holding top people accountable for NPD success 7. A strategic focus and takes advantage of synergy 8. NPD teams are of a high quality 9. Teams are cross-functional (9)	• Cost • Time • Specification (3)
Hypothesise	Hypothesis 2: There is a positive relationship between the presence/use of KMAs and NPD Success.	Hypothesis 3: There is a relationship between the presence of KMAs and "known" NPD factors.	Hypothesis 1: There is a positive relationship between "known" NPD factors and NPD success.
Variables (As recognised/generated by practitioners during the pilot)	1. Use External Research Services 2. Survey/Collect External Information 3. Use External NPD Support 4. Explore External Opinions 5. Use Information Searches 6. Attend External Training and Development 7. Consult Specific Outside Experts 8. Participate in Communities of Practice 9. Empower Knowledge Brokers (supply chain) 10. Empower Knowledge Brokers (sales) 11. Brief Interested Stakeholders	The quality of your New Product Process The quality of your New Product Strategy The resources available for NPD are Senior Management's commitment to NPD An entrepreneurial climate Holding top people accountable for NPD success A strategic focus and takes advantage of synergy NPD teams are of a high quality Teams are cross-functional	% over/under targeted cost (Known as Budget) % over/under targeted time (Known as Plan) % over/under targeted features (Known as specification)

	12. Publish Findings 13. Demonstrate Products 14. Discuss NPD Strategically 15. Internal Communications 16. Document Management Practices 17. Reporting and Communication Structures 18. Reward Systems 19. Slack Time 20. Rewarding development 21. Learning and teaching "on-the-job" 22. Informal Learning and Interaction 23. Formal Project Management 24. Prototyping 25. Decision Support Systems 26. Knowledge Mapping Activities 27. Directory of Internal Expertise 28. Electronic Forums for Debate		
Indicator	Questions/responses on survey tool (questionnaire)	Questions/responses on survey tool (questionnaire)	Questions/responses on survey tool (questionnaire)

Hypothesis 4: (Some of) The contributions that KMAs make to success variance are independent of NPDd

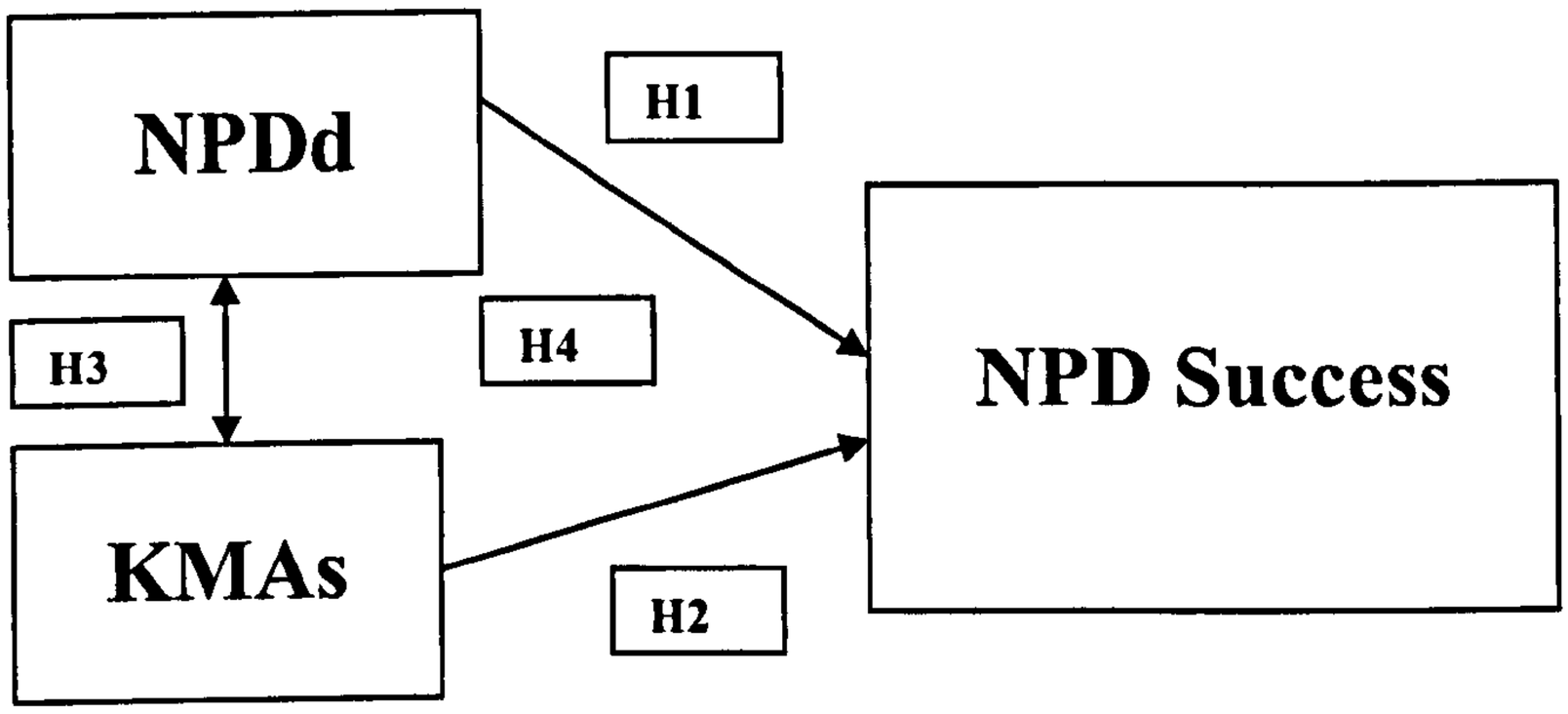
Boundaries:

Value: Listed and/or "known" KMAs and NPD metrics

Time: Currently used, not as done in the past, not planned for implementation in the future. A measure of current achievement

Space: Bound to population and the sample (NPD Projects)

Diagram 10. Proposed research model:



3.3 Research Activity

3.3.1 Procedures

It was identified early on by the author that the lengthiest part of the data collection process would be identification/contact/follow up with project teams involved in NPD and the concurrent development of specific questions that would operationalise the research questions. Once these questions were in place, a data collection tool could be developed that met the needs of the research and potential sample population.

The first step taken in this process was the identification of the population. In the PhD proposal document the general population had been any project that developed an identifiable part of a new product, discounting those that developed a new service. Examining the empirical NPD research literature there were several variables available that could segment this broad population: by region/nation, by industry, by company size, by involvement in NPD, and by use or non-use of KMAs. It was also important to define where the sample population would be drawn from. The decision was made to use the UK as the region. The UK is both the home location of the researcher but also has the following advantages: a broad range of industries and company sizes; is an advanced nation in terms of ICT; is often included in the more major studies of NPD; has well developed trade and professional organisations; is home to many multinational NPD organisations who are more likely to have and use "modern" techniques such as KM, and has major research universities around which

NPD firms cluster. This suggests that: UK firms have every opportunity to recognise, access, afford, and utilize available NPDd and KMAs; that firms within the UK represent most major industrial sectors, that the researcher could reasonably estimate the nature and size of the total population, and that any differences in response rate would be more likely due to the wiliness of the specific respondent than to difficulty in international communication or trust.

Once the UK was chosen the second issue was the choice of projects within the UK. Arguably one of the more independent ways to categorise project/company groupings is to use a governmental or independent research commission's report. The choice was made to maximise the population's involvement in NPD. This could be broadly measured in six ways: total value of new products sold, percentage of total revenue dependent on new products, by their total spend on NPD, on their spend on NPD as a percentage of total spend, on the number of employees working in NPD, or on the percentage of employees involved in NPD.

An investigation of national rating systems identified that in 2004 the Department of Trade and Industry (DTI) had conducted a study into UK firms (companies with operations in the UK) to investigate just these issues. The DTI called it the research and development (RandD) scoreboard (DTI, 2004). The scoreboard exposes a company's involvement in RandD through 10 factors: RandD investment in pounds in the prior fiscal year, change in the investment value since the previous year, increase in RandD that year over the average of prior 4 years, RandD as % of operating profit, RandD as % of sales (intensity), RandD sales + percentage of capex (a derived measure of intensity), operating profit, change in operating profit from prior year, 4 year growth, operating profit as percentage of sales. Given these 10 measures the DTI developed several rankings (although more could be simply derived) of UK firms who are involved in RandD. RandD ranking was thus usefully chosen as an indicator of NPD intensity for the purposes of this study, excluding service firms from the sample. Given a national scope the DTI then focuses on RandD spend across and within sectors as the prime indicator of involvement in RandD. This provided a well-researched list of UK firms who (if producing a physical product) it could be reasonable assumed, have NPD projects as a significant part of their raison d'être.

From this list it was clear that an exponentially large number of NPD projects could be identified. Within each industrial group there are several very large firms involved in RandD, then many more medium size firms, and an even greater number

of small firms. It must be assumed that the RandD index (2004) is not and exhaustive of all UK projects, but does indicate most firms heavily involved in RandD. Thus the researcher also made an effort to look for projects in as many of these firms as was possible in the timeframe.

With a target population identified, the process of contacting the potential respondents began. Without knowing how many employees were directly involved in NPD projects in each firm, the issue became making a contact that could link the researcher to as many as possible, and with that link made the more specific sample could be identified. The first step was to find basic contact details of the identified firms (HQ phone numbers, media/external contact officers, general question email addresses). This was done via company websites, national phone directories, and specific industry directories. The vast majority of firms in the index had easily available general contact information, but few published contact details for the individuals involved in NPD projects directly. Given the broad net approach being used (through several initial trail contacts) a form letter, which could be emailed, faxed, or posted to potential company's was developed (see appendix F). This form letter was modified on a case-by-case basis and by the middle of October had been sent to 250 of the firms identified.

The process of looking up contact details, sending out initial contact letters and checking for responses took place over twelve weeks. During this time responses from both large and small firms varied, but notably, not by size. Some organisations dismissed the request off hand. Some of the more well known reported that they did not have the time to answer all of the requests they received. Setting aside those organisations whom had a blanket "no" policy, those who did not have realistically contactable people, those who had no UK NPD locations, and those who were already involved in investigations of KM practice with other universities; the pool of 250 was reduced to 50 within which distinct projects had started to be identified. Of these, there were no distinct pattern, and firms from most of the DTI's 24 industrial sectors (barring service organisations) and of varying sizes had accepted the initial letter and promised to review the request. Between this stage and final agreement to participate, there were up to five more conversations, letters and emails. Some organisations were very enthusiastic and saw the study as a way to "pulse check" their KM policies etc. Other organisations gave internal contacts only after assurance that their details would

be kept confidential (a latter addition to the form letter) and that the time needed to data collect would be kept to a minimum and would be flexible/on their schedule.

It was mentioned in conversations with potential respondents, and is noted here, that the type of information the research was asking for was very close to the core competencies of these organisations, and that this was likely to cause many to refuse participation. Others still asked that the projects and success to be reported be made anonymous, which would reduce the studies ability to do project comparisons intra-organisation. One of the most important elements during contact seemed to be the promise that someone senior in the organisation would be allowed to read a draft of the survey tool, and suggest changes, prior to sending individual employees in NPD the actual questionnaires, an interesting research decision! On the one hand, if the right to review was granted, then the study was no longer purely the derivative of prior literature and the Research Question posited by the upgrade. On the other hand if this request were denied about half of those companies who were considering the request would refuse straight away. At this time two questions seemed pertinent: First, how strong was the theoretical base that was being argued from; Second, would allowing members of the organisation to *see* and *edit* the document in some way give an opportunity for management to influence the opinions of the potential respondents? There were at least three potential solutions to this dilemma: 1) Not allow any organisational members to see the survey tool in advance (which would reduce the number of respondents and still not guarantee that management would not influence the answers given) 2) Allow all companies to edit the document in a way that would ensure their participation (which would change the research direction and possibly impact the pilot study) or 3) Drop the planned statistical pilot study and use a formal request for responses from senior NPD staff commenting on the document as a pilot itself (which gives the same number of respondents, changes the research direction, and achieves the goal of a pilot: evaluating question validity in a given context). Consulting both the first and second supervisor the researcher came to the conclusion that using a draft survey as a pilot sent to all participants was an innovative solution that maximised my sample population while getting a true to life understanding of KM and NPD from the perspective of those working with it every day. Considering the fact that the literature argument evaluates current NPD and KM theory at very high level and is not yet empirically robust, this seems a reasonable defensible decision.

The process of contact, wait, reply, re-contact, had further reduced the list of potentials respondents who were interested in taking part and who had appropriately significant involvement in distinct NPD projects. In the context of a national search it is unlikely that this sample constitutes a representative sample of projects and organisations. Each organisation had agreed to read the pilot version, and fully comment on them. Specifically they were requested to include some employees from the development phase, as this was the focus of the original research question. An estimate of numbers was taken, and at this stage the study had identified about 180 projects as the total sample.

The draft questionnaire was developed with this sample in mind. The goal of the process was to convert the four identified research questions into manageable and discreet items on the survey tool. This required consideration of: the constituent parts of the questions, what language could be understood by the sample population, the investigation's ability to adequately distinguish between levels of NPDd/KMAs/NPD success, and the ability to code/enter the data generated into SPSS in a way that facilitates analysis. In addition the questionnaire would also need questions that would allow the researcher to note if the variables were varying depending on context, as was posited by the literature review.

While most of the variables in the pilot were carried forward into the final survey tool, the pilot also included 50 KMAs (see appendix C). In the literature review KMA is shown to be highly context specific. Thus it was likely that using general knowledge management mechanisms such as share or store (as used by Liu et al., 2005) or even the 9 transfer specific mechanisms generated in this study, such as scanning and collecting or learning and teaching on the job, in the survey tool would likely result in universally positive associations (as see in both Darroch, 2005, and Liu et al., 2005). The decision was taken, therefore, to use the pilot to identify which KMAs were known to those in the sample and use this as the basis for the independent KMA variables. This was done so that the survey would generate a context specific list of KM tools, practices and behaviours, not simply allude to "information management" or "learning," which would likely always be present in the NPD process. When the pilot was returned 28 KMAs were identified by at least one of the pilot respondents. These 28 were grouped in accordance with the mechanisms generated in the literature review, and are included in table of test elements (above).

3.3.2 Research questions conversion

The following section details how the four research questions and two further identifying attribute areas (below in bold font) were made operational for the pilot survey:

1) **Is the nature of the relationship between NPDd and NPD success in the study's sample population the same as shown in the literature?**

and

3) **Is there a relationship between a project's ability in the NPDd, and the presence/use of KM tools and practices, as was discussed in the literature review?**

Q. Rate your workgroup and/or organisation on the following 9 key NPD inputs

(Each sub-question asks you to rank your organisations key inputs/practices regarding NPD. Consider the last 6-12 months as a timeframe. Please circle one number only.)

A. The quality of your New Product Process is:

(Think of the steps you use: are they explicit or implicit? How well coordinated are they? What is the quality of execution like? Is the system flexible? Is it planned in advance? Are poor projects 'killed' early enough? Is the process 'known to all?'):

Of high quality, with well defined steps, careful planning, and a focus on solid execution	5	4	3	2	1	Hasty and haphazard, with confusion over stages in the process, little planning, and late decision making

B. The quality of your company's New Product Strategy is:

(Think of your company's goals and objectives. Are they clear? Are they well communicated? Do they focus on specific markets/customers? Has this been the case for at least the last three years?)

Clear, easily understood, and well communicated. We've always had this strategy	5	4	3	2	1	Poorly understood; with many changes in focus, market, and objectives. Seems to change every year

C. The resources available for NPD are:

(Has senior management devoted the resources to achieve its own goals? NPD project budgets are adequate? Are the necessary people and other resources are also in place?)

More than enough to get the job done. We have people, equipment, and a solid budget	5	4	3	2	1	Less than we need to get the job done. Too many expectations; not enough time, money, or people

D. Senior Management's commitment to NPD is:

(Is your senior management strongly committed to NPD? Do they get involved when necessary? Do they have input on 'go/kill' decisions? Do they slow you down or help you finish?)

Strongly committed to NPD and my workgroup. They are involved, but not invasive	5	4	3	2	1	Distant and/or not committed …they are rarely involved, and if involved waste valuable time

E. Do you work in an entrepreneurial climate:

(Are lots of new ideas solicited/floating around? Do you have the free time to work on them? Are resources available for 'blue sky' ideas? Are there any 'unofficial projects'?)

Yes. We have lots of ideas floating around, free time to work on them… and some resources too	5	4	3	2	1	No. It's hard to develop any real 'new ideas' in our work environment. We never do 'blue sky'

ds top people accountable for NP

(Are NPD metrics an explicit part of senior managements annual objectives? Is performance and pay linked at this level? Are the people at the top 'keeping score'?)

Yes. NPD success measurement is a serious management activity, and they are rated on it	5	4	3	2	1	No. Senior management are rated on scales that don't include NPD metrics. Nobody 'keeps score'

G. You organisation has a strategic focus and takes advantage of synergy:

(Are new products in line with current market and technical knowledge? Is the firm 'sticking to the knitting'?)

Our new products are in line with our abilities. Our strategy is focused and existing market-oriented	5	4	3	2	1	Our products, technical skills, marketing, and objectives have never really had 'synergy'

H. Your NPD teams are of a high quality:

(Do you have dedicated team leaders? Does the team communicate well as a matter of course? Are decisions made efficiently and effectively?)

Yes, we have team leaders, frequent communication, and the teams make high quality decisions	5	4	3	2	1	No, not all teams have leaders, communication is haphazard, and decisions are poor

I. Your Teams are 'cross-functional':

(Do they include a leader, some of the 'old guard', people with new ideas, people from other business functions?)

Yes, we have everyone you would expect plus a few extra who extent into other functional areas	5	4	3	2	1	No, our teams are made up of highly specialised members and don't include 'outsiders'

This question, containing nine sub-sections, was developed to measure the respondent's opinion of the NPD process capability of their project; using the NPDd Cooper and Kleinschmidt (1995) identify as accounting for much of the variance in process success. In the first instance the researcher contacted R. Cooper and E. Klienschmidt via email, and then again via their research associate S. Edgett, whom the researcher later met at the 13th IPDM conference in Milan. In both instances

Cooper and Klienschmidt stated they would not release the transcripts of their data collection due to confidentiality agreements but on the second occasion sent a brief description of their terminology via email. This email and their 1995 paper were used to construct the language (above) of the questions and their explanations. The five point Likert scale is the same used by Cooper and Klienschmidt (1995), and the language made non-industry or education level specific.

Q. Complete the multi-project assessment based on your workgroup's relative performance along the dimension of Time. (First, please give a name to the most recent project you worked on, and enter it on line 1. Then do the same for less recent projects extending out until 12 months ago, using lines 2-6. List no more than 6 projects. After each, give your own opinion of success in terms of TIME on the scale provided.)

	The project was completed far ahead of the original schedule. **Or** At least 30% earlier than the original schedule			"On Time"			The project was completed far behind the original schedule. **Or** At least 30% later than the original scheduled
Most Recent Project							
1:_____:	7	6	5	4	3	2	1
2:_____:	7	6	5	4	3	2	1
3:_____:	7	6	5	4	3	2	1
4:_____:	7	6	5	4	3	2	1
5:_____:	7	6	5	4	3	2	1
6:_____:	7	6	5	4	3	2	1

Project nearest 12 months ago

Q. Complete the multi-project assessment based on your workgroup's relative performance along the dimension of Cost. (Using the same six projects as in Q7)

The project was completed far UNDER the original budget **Or** At least 30% UNDER budget	The project was completed far OVER the original budget **Or** At least 30% OVER budget

"On Budget'

1:_____: 7 6 5 4 3 2 1

2:_____: 7 6 5 4 3 2 1

3:_____: 7 6 5 4 3 2 1

4:_____: 7 6 5 4 3 2 1

5:_____: 7 6 5 4 3 2 1

6:_____: 7 6 5 4 3 2 1

Q. Complete the multi-project assessment based on your workgroup's relative performance along the dimension of Specification. (Using the same six projects as in Q7 and Q8)

The project EXCEEDED the original specification **Or** Delivered several valuable features not included in the original specification

'Met Specification'

The project was completed, but lacked several features included in the original specification

1:_____: 7 6 5 4 3 2 1

2:_____: 7 6 5 4 3 2 1

3:_____: 7 6 5 4 3 2 1

4:_____: 7 6 5 4 3 2 1

5:_____: 7 6 5 4 3 2 1

6:_____: 7 6 5 4 3 2 1

These three questions were developed to measure the respondent's opinion of the success of recent NPD projects they had been involved with. The measures of conformance to budgeted Time, Cost, and Specification were identified in the literature as useful cross- sector measures of success, and aims to avoid giving organisations of a specific size or type the advantage they would exhibit if the market

success of the product was measured. As these success measures are the dependant variable of the investigation a seven point scale was chosen; giving the opportunity to the respondents to clearly distinguish between success, failure, and average performance. This range also allows for a broader range of statistical tests to be performed on the resulting data.

Q. To what do you attribute the relative success (or failure) of the (1-6) projects you have mentioned in the above Questions? (Please comment on anything - other than the hard work of you and your colleagues of course - that contributed directly to project outcomes along the dimensions of Time, Cost, and Specification.)

Project:_____ What contributed to success or failure: _____

_____

_____

This question was designed to identify potential project anomalies that might account for variance in success not influenced by the independent variables of NPDd and KMAs. An example would be if the project in question had been tied to a specific customers order, and that order was either changed resulting in poor time conformance or cancelled resulting in the loss of the project's budget.

2) Is there a relationship between use of measurable KMAs and NPD success in the sample population, as was inferred by the literature?

Q. Rate *presence and frequency of use* in regards to KM activities in your organisation. (Please circle the letter P *if the KM tool or practice is present* in your workplace. Next circle a number between 5 and 1 once per line to the KMA in terms of *your frequency of use, or its significance to you.* Please only rate the frequency of

use for KM *tools and practices you actually use.* The list starts on the next page, below is an example answer.)

Frequency of use:

I use the tool/ practice every day Or This kind of KM is important in my company/job		I haven't used the tool/ practice in the past year Or This kind of KM is not usual in my company/job

Example:

Name of Tools or Practice [P] 5 [4] 3 2 1

(Examples or definition of this Tool /Practice)

1) Circle the letter P if the line item is Present and Available to your Workgroup. This doesn't mean you use it.

2) Rate any of the 'Present Items' YOU use. The higher the number, the more important the item is to you/your firm.

Blank KMA (Description of KMA)	P	5	4	3	2	1
Blank KMA (Description of KMA)	P	5	4	3	2	1

>List of KMAs as agreed by organisations will follow here<

In addition, please list and rate any KM tools and/or practices not mentioned above, but present in your workplace. (First, please name and describe the KM tool or Practice, and then rate it using same usage scale as previously.)

Item A: _____

5 4 3 2 1

Item B: _____

5 4 3 2 1

Item C: _____

5 4 3 2 1

Item D: _____

5 4 3 2 1

This question was developed to capture data on both the presence and use of KM tools and practices in the NPD project environment as perceived by the respondent. In the pilot as sent to the sample population the question was as above and a list of KM tools and practices was sent as a separate sheet. This helped determine whether the question would be understood without the confusing issue of whether or not the KMAs were recognised. This question asks the respondent to identify whether or not they have access to a given KM tool (such as a database), or are enabled to display a certain kind of social behaviour (such as project debriefing sessions) in the course of their work on the projects they had worked on in the previous 12 months. The question then goes on to ask them to rate how often they use it or how important it is in their work on the same five point Likert scale used for the NPDd.

Q. List any recent additions to the KM tools or practices YOU have used in the last 12 months. (Line by line, please list the names of any *KM tools or practices you have begun to use in the past 12 months*, followed by how long ago you started using them i.e. 1 month ago, 2, 3, through 12 months ago. Please feel free to use the names from Q4 or Q5. I will assume that you have used *all other KMAs not listed below longer than 12 months*.)

Item 1:_____:___ Item 4:_____:___

Item 2:_____:___ Item 5:_____:___

Item 3:_____:___ Item 6:_____:___

If you wish to make any additional comments concerning the KM tools you use, please do so below.

This question was developed to pick up on any KMA related changes or anomalies that would account for variance in NPD success not accounted for by NPDd or the use of KMAs.

4) Given knowledge of the statistical data generated in answer to questions 1-3, to what extent is any KMA or NPD factor an independent contributor to NPD process success?

Requires no further questions as can be derived from questions on NPDd, KMAs, and project success.

Individual identifiers:

Q. How would you categorise your Job Role? (You have the option to list a primary *and* a secondary *Role.* Please place a number 1 to the right of a letter if you only have one role or it's your primary role; place a number 2 to the right of a letter if it's your secondary role)

A. ____ An Engineer, Scientist, Technical Developer
B. ____ A Manager, Team Leader
C. ____ An Administrator, Personal Assistant, or Similar
D. ____ A Technical Assistant, Research Assistant, or Similar
E. ____ None of those. I'm _____

Text: It is often observed in practice, and written about in academic literature, that NPD has many 'stages.' These stages can number from 2 to 20 and most certainly overlap, get 'fuzzy', and feed back into one another.

Q. How many 'stages' would characterise NPD in your firm, and what are they? (Please write down a name for each of the stages in your NPD process as you might refer to them in your organisation)

Text: Many believe that NPD can be split into 3 more general phases:

A. *Research, Discovery and Strategy: Where a business opportunity is identified and preliminary technical research is conducted.*
B. *Development and Realisation: Where technical possibilities are developed into real products.*
C. *Manufacturing and Commercialisation: Where products are manufactured and delivered to end-users.*

Q. In your opinion, do you think it is possible to identify these 3 phases in your organisation's NPD process?

A. Yes
B. No

Q. If you answered YES to Q3, which phase would you say you primarily work in?

A. Research and Discovery
B. Development and Realisation
C. Manufacturing and Commercialisation

Company Identifiers:

Q. Identify the primary industry your company works within. (Circle one only)

A. Aerospace and Defence B. Automobiles and Parts C. Banks

D. Beverages E. Chemicals F. Construction

G. Diversified Industrials H. Utilities I. Electronics

J. Engineering and Machinery K. Food Production and Processing

L. Forestry, Paper and Mining M. Oil, Gas and Processing N. Retailing

O. Health P. Household goods, Textiles and Personal care

Q. Insurance and Finance R. Transport S. Tobacco

T. Pharmaceutical and Biotechnology U. Telecommunication Services

V. Steel and Metals W. Media X. Support services

Y. Software and computer services Z. Mobile Technology Hardware and Software

Q. Estimate how many employees work within your company. (Please estimate how many employees your company has. Do not include any holding companies or broader networks of firms.)

Q. Estimate what percentage of employees in your company work specifically within the New Product Development Process. (Please write a percentage between 1 and 100%. This should include concept work, research, development, manufacture-design, and related customer contact roles)

It is also possible to use the existing statistics to analyse whether there is a relationship between a firm's ability in the NPDd, and the presence/use of KM tools and practices.

Questions groups five and six identify were developed in line with direction from the literature review, enabling the researcher to examine contextual influences on the data.

3.3.3 Finalising the questionnaire

With a draft questionnaire and an identified sample, the process of piloting the study began. An email was sent (December 2005) to the respondents (see appendix F). The responses to this email (the pilot) came in the first three weeks of January 2006. A short document was compiled to track the changes, clarifications, and questions raised by each respondent, and these were also considered as parts of larger groups, industries, and by firm size. After receiving responses, the questionnaires were changed to better fit the workplace linguistics of the sample of the population (see appendix G for final questions as mailed to sample population) and the final 28 KMAs to be used in the questionnaire were added to the document.

3.3.4 Administering the survey

With a data collection tool in hand that reflected both the theoretical position of the research and the needs of the test sample, the first phase of physical survey distribution began. First how many projects were active, and the most recent contact details for the project respondents were recorded. Then copies, labels, and envelopes were bought for the mail out. The format was as follows: each point of contact would receive one large Special Delivery package, and this package would contain one brief cover note (see appendix G). The package would also contain two further envelopes. After mail out, the Business School's Post Graduate office was contacted and asked to set up a special collection tray so that the returned envelopes would be kept separate from other mail and be stored until the data collection phase was complete. This introduced a measure of "arms length" behaviour (individual sealed envelopes with postmarks from various towns showed responses were coming from the office of the respondents).

April the 30th 2006 was the cut off date for receiving the questionnaires back from the organisations taking part in the survey. At this point the research collected the questionnaires from the administrative office and sorted them. All received responses were complete and included in the survey. The researcher notified the participants that the responses had been received and the survey was deemed complete.

3.4 Additions, Concerns, and Challenges:

Reviewing the proposed method, there are some potentially contentious issues that need to be reviewed and made explicit before the survey method can be considered open and complete. This is also important to the successful analysis of the test elements to follow.

Some weakness in link between individual KMAs and NPD Success: It could be argued that there is a theoretical weakness in the direct links between specific KMAs and NPD success as measured by the given metrics. The studies that inform the literature review perspective supporting the importance of KMA to NPD processes are based on the use of questionnaires that ask people to consider KM in the abstract. Thus while there is empirical and theoretical justification for hypothesis two, the measures used in this research are far more specific, and so beyond the level of what had been previously considered KM.

Gaining statistical significance: There is an ongoing debate over the number of data points needed to statistically support propositions such as those made in this study. Some argue that basic correlation can be highlighted with as few as 20 data points. For others less than 100 is considered inadequate. Often the required sample is a factor of the number of different attributes being measured and the expected interrelationship between them. In any case it could be argued that the sample of 180 data points (minus those who do not participate in the main survey) used is arguably less than might constitute "strong" statistical evidence in support or opposition of the posed hypothesise.

Inability to factorise 28 KMAs: During the literature review 9 general mechanisms of knowledge management transfer were identified. Examining the practitioner literature, 50 KMAs were also identified and grouped by their relationship to a general mechanism of knowledge transfer. These 50 were reduced to 28 by analysis of the pilot responses. Generally accepted empirical research practice would be to use the data collected in the main study to factorise the independent variables, leading to stronger correlations and clearer distinction between the variables. Unfortunately while the pilot provided enough qualitative data to reduce the 50 to 28, the identified project sample population (180) is too small to further factorise the KMAs.

Evaluating non-KM influences on NPD success: It is important to understand what percentage of the variance in NPD metric measures is explained by the influence of KMAs. The NPD literature yields some percentage of NPD success that is commonly attributed to known NPD variables. This leaves the remainder (be it 10, 20 or 30%) open to being described as determined by KMA. Either way this becomes a significant question when evaluating the contribution of this study if the primary concern is elucidating the key causal factors in a successful NPD process.

3.5 Data Analysis Methods

While waiting for the mailed questionnaires to be returned the researcher coded the possible response options into an SPSS file (available on request). This file would be the basis for statistical tests of the four research questions. To provide evidence to support the questions from the data the following statistical tests were proposed:

1. *ANOVA tests to see if use of KMAs and NPDd were different by industry, by stages and correlation to test for size.* In the data collection/analysis process one objective is to identify those factors that have a significant relationship with variations in process success; and another, to show that the sample conforms to what is already know about the population from prior research. For a hypothesis to achieve external validity (generalisability), ANOVA and correlation tests would need to show that the variation of KMAs and NPDd was not dependant only on the variation in industry, stage, or company size. If these tests did yield such results it would provide evidence to suggest that KMAs are industry, stage and size specific, as was suggested in the literature. This would reduce the external validity of the hypothesis (or rather render it industry, stage, or company size specific); but it would in turn increase the empirical support for existing explanations of the application of NPDd and KMAs in the NPD process.

2. *Correlations of KMAs with NPDd to see if any were strongly related to each other.* This set of tests will be used to examine Hypothesis 3. In the literature review KM is reported as an influence on NPD process success. Longer standing evidence from the NPD field informs that some (9 or more) NPD

practices account for most of the consistent variation in success. Thus, running correlations of KMAs with NPDd will yield two important new pieces of information in the field. First, if any of the KMAs and NPDd are correlated then there will be evidence to suggest that use/success of one would likely influence the use/success of the other. This would be an area worthy of further research. Second, if any of the KMAs was shown to be independent of the presence of NPDd, then those KMAs would be stronger candidates for later tests looking for "new" independent influences on process success.

3. *Correlations of NPDd with success to see strength and direction of the relationship*. Hypothesis one states that NPDd will have a relationship with variations in NPD process success. Correlations will evidence this, and also expose the extent to which the sample is similar to the population as evidenced by the work examined in the literature review. This should provide evidence to suggest that NPDd are significant influences, but also would provide the underpinning needed prior to performing stepwise regressions.

4. *Stepwise regression of NPDd with success to find those NPDd which best explain variations in success*. While each of the nine NPDd has been shown to independently affect variance in success in the general population, it is likely that in the sample population there may be some difference. If the research model set out in this chapter is to be supported with evidence from the sample then it is necessary to identify those factors that can independently be added to the model. A stepwise regression of the NPDd from the sample would generate a list (less than or equal to nine) of NPDd that best explain variance in success, and thus would support the research model.

5. *ANOVA to test the presence of KMAs in the company with success to see strength and direction of the relationship*. Evidence to support Hypothesis two can be generated in two ways. One way is to perform an ANOVA to test whether having certain KMAs present in an organisation (if deemed useful) contributes to variance in process success.

6. *Correlations of the use of KMAs with success to see strength and direction of the relationship.* Evidence to support Hypothesis two can be generated in two ways. A second way is two perform a correlation test to see whether variations in the use of certain KMAs result in a similar variation in the success of the NPD process.

7. *Stepwise regression of KMAs with success to find the KMAs which best explain the variation in success.* While KMA has been shown to affect variance in success in the general population, it is likely that in the sample population there may be some difference. If the research model set out in this chapter is to be supported with evidence from the sample then it is necessary to identify those factors that can independently be added to the model. A stepwise regression of the KMAs from the sample would generate a list (less than or equal to twenty eight) of KMAs that best explain variance in success, and thus would support the research model.

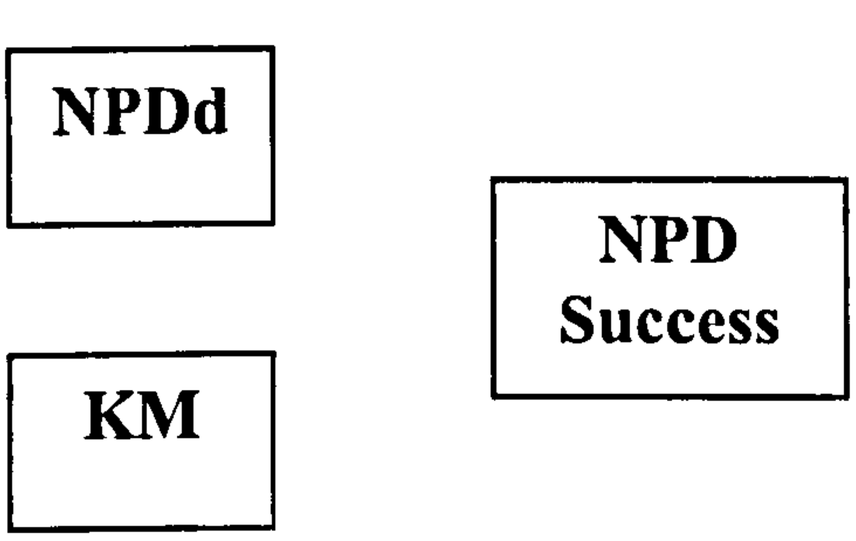
8. *Enter regression of NPDd found in stepwise with success, then stepwise method with KMAs to see if any KMAs explain any of variation in success not explained by NPDd.* Given adequate evidence to complete tests one through seven, it is then possible to carry out one further test, providing evidence that would complete the model. Tests one through seven inform as to: whether KMA is context specific, whether the KMAs are related to ability in NPDd, and to those factors from both the KMA and the NPDd list that significantly contribute to success. Given this information it is possible to run an enter regression of those remaining independent KMAs and NPDd so as to expose which contribute to success in the sample. This would yield results showing the specific support or disproof of each sub-element of the hypotheses (see appendix E) and allow the construction of a more accurate model in the conclusions chapter.

3.6 Possible test outcome models:

While the study seeks to test the relationships supported in the literature review, the data from the study may also expose other un-hypothesised relationships. These could in theory take any of the following nine forms:

Diagram 11. (Parts 1-9) Possible test outcome models:

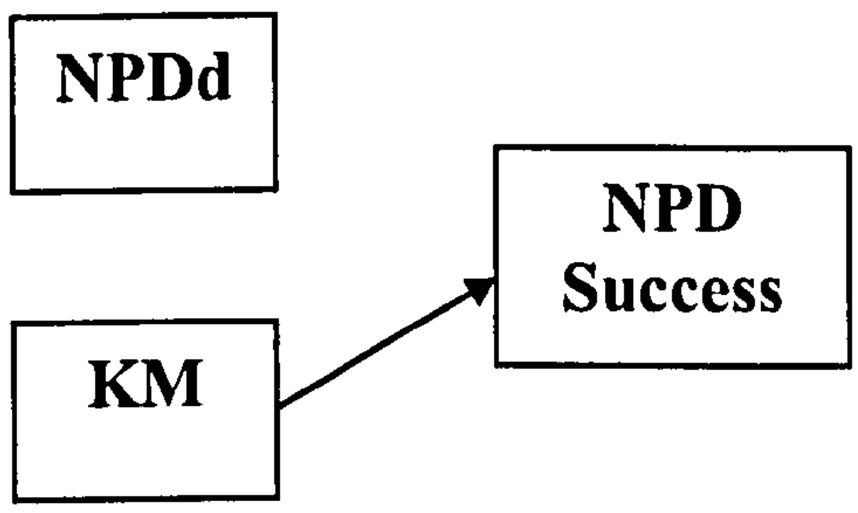
1.



The SPSS analysis reveals no relationships between the major factors in the test:

The sample is an abnormal sample of NPD firms or the test tool was poorly developed and/or administered

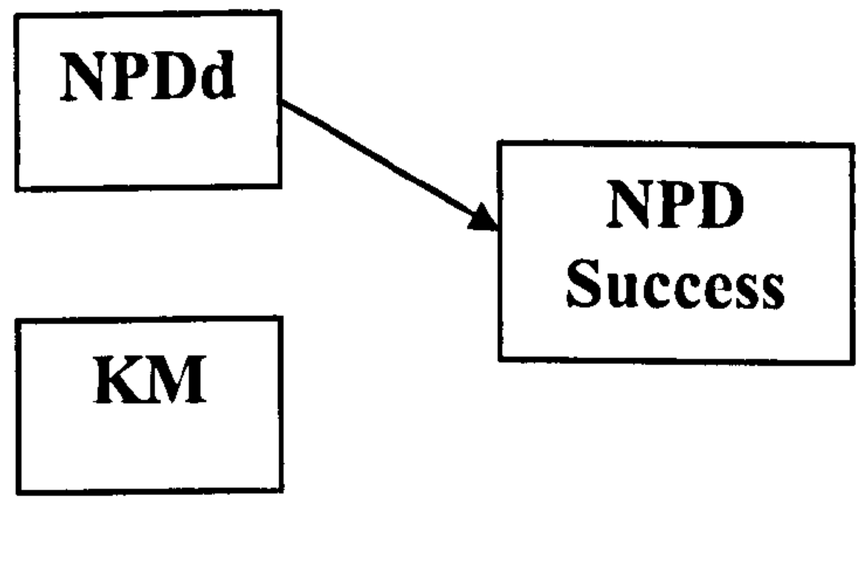
2.



The SPSS analysis reveals a relationship between KM factors and NPD success:

The sample is an abnormal sample of NPD firms or the test tool was poorly developed and/or administered

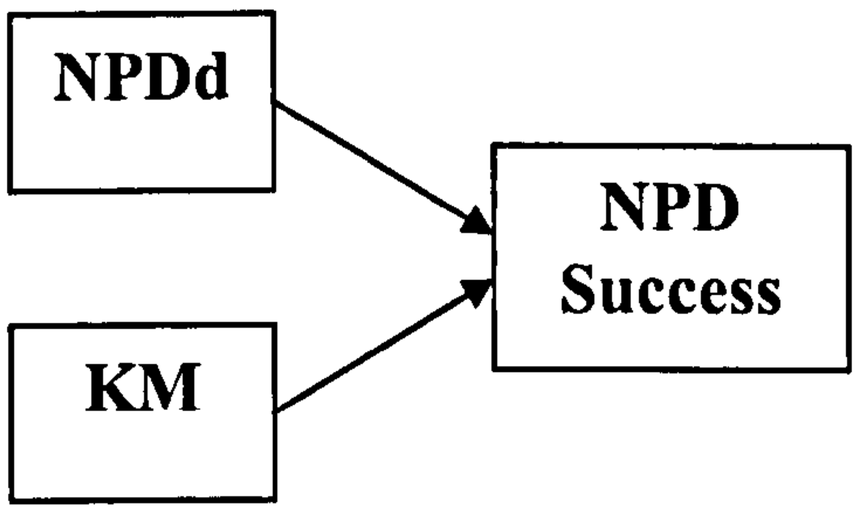
3.



The SPSS analysis reveals a relationship between NPD drivers and NPD success only:

KM factors have no affect on NPD success in the sample population and/or the KMAs listed are not representative of KM as used in the sample

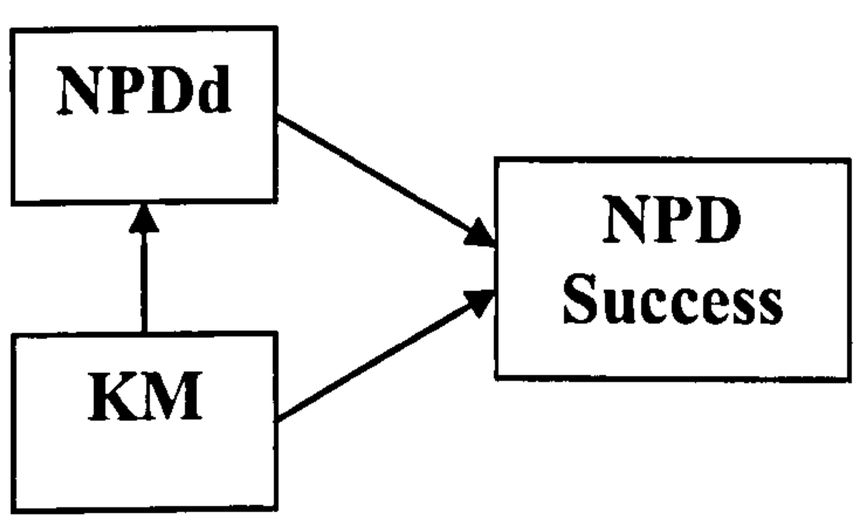
4.



The SPSS analysis reveals NPDd and KM are both related to NPD success but not to each other:

In the sample NPDd and KM are independent influences on NPD success. Also NPDd and KM have no relationship or one that this test does not reveal

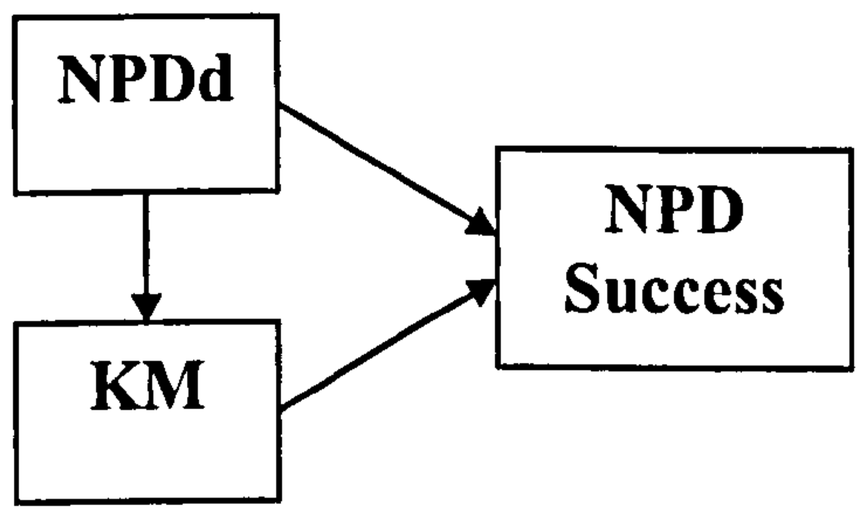
5.



The SPSS analysis reveals NPDd and KM are both related to NPD success and that KM is an antecedent of NPD drivers:

In the sample NPDd and KM are influences on NPD success. Also specific KMAs may be antecedents of certain NPD drivers

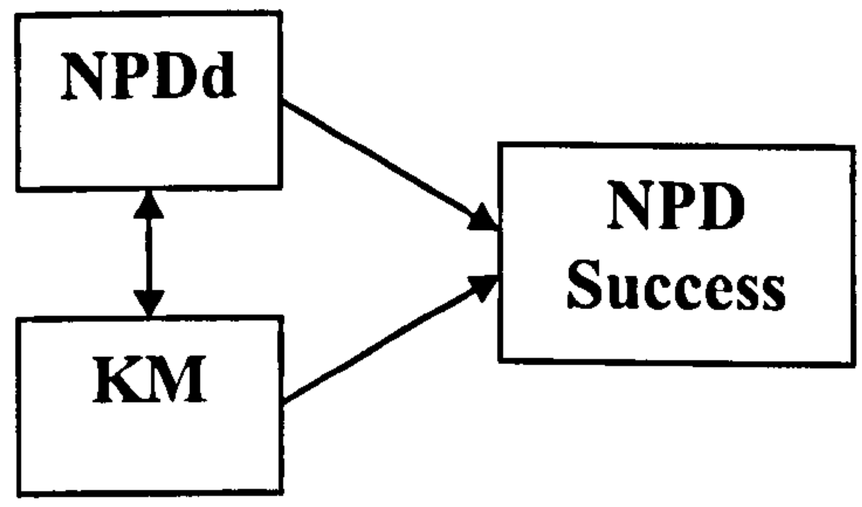
6.



The SPSS analysis reveals NPDd and KM are both related to NPD success and that NPD drivers are an antecedent of KM:

In the sample NPDd and KM are influences on NPD success. Also specific NPD drivers may be antecedents of certain KMAs

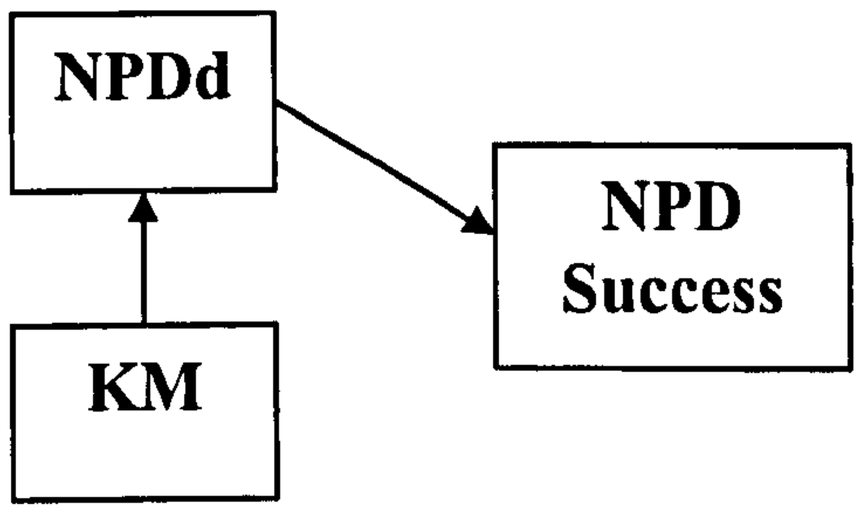
7.



The SPSS analysis reveals NPDd and KM are both related to NPD success but not independent of one another (partially correlated):

In the sample NPDd and KM are influences on NPD success. NPDd and KM are also related to one another. The nature of this relationship can be tested along the lines suggested by table 6.

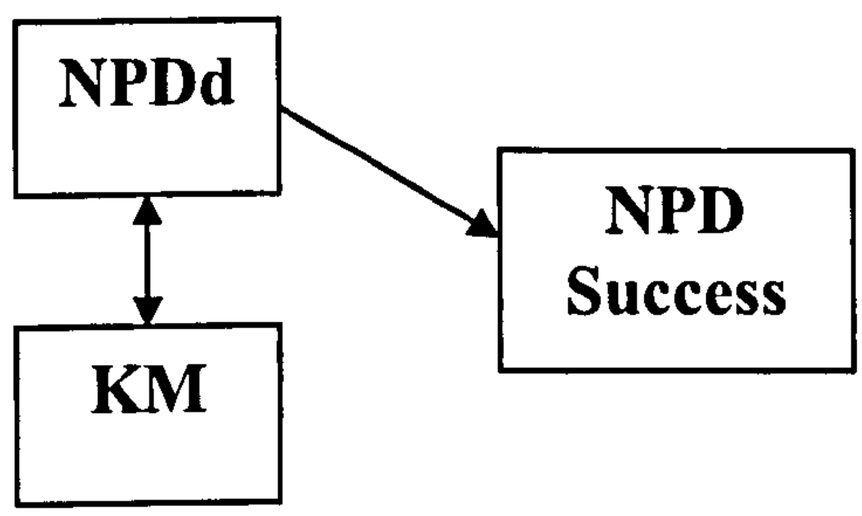
8.



The SPSS analysis reveals NPD drivers are related to NPD success and that KM is related to NPD drivers:

In the sample NPDd is the sole influence on NPD success. Also specific KMAs may be antecedents of certain NPD drivers enhancing their effect

9.



The SPSS analysis reveals NPD drivers are related to NPD success and that KM is related to NPD drivers:

In the sample NPDd is the sole influence on NPD success. Also specific KMAs and NPD drivers are interrelated, which may indicate that KMAs are an indiscrete attribute of NPD drivers

3.7 Conclusion

This section has outlined the premise, research method, justification, tools, procedures, and analysis methods for an investigation into the nature of the relationship between KMA, NPD processes, and NPD success. This investigation was carried out between September 2005 and April 2006. The survey collected 124 data points, each of which reflect the relationship between use of the nine NPDd, use of KMAs, and the relative success of the NPD process on a project-by-project basis. The results of this survey have been coded and entered into an SPSS database, and this provides the basis for the analysis (as discussed in section 3.5) to follow in the next chapter.

4 Findings

4.1 Introduction

This chapter details the results of the data collection and subsequent statistical analysis as outlined in the method section. Following this introduction the chapter is presented in four further sections. Section 4.2 discusses the make up of the test sample and the response rate within the identified population. Section 4.3 has five sub-sections. First, it presents findings to suggest whether KMA and NPDd use is development phase, company size, or industry specific. Second it presents findings on the hypothesised relationship between a firm's ability in the NPDd and the presence/use of KMAs. Third, it presents findings on the hypothesised relationship between NPDd and NPD success in the study's sample population. Fourth, it presents findings on the hypothesised relationship between use of measurable KMAs and NPD success in the study's sample population. Finally, it presents findings on the extent to which any KMA or NPD factor is an independent contributor to NPD process success. Section 4.4 examines the statistical limitations of the data set and the analysis performed in section 4.3. Section 4.5 makes concluding remarks considered prior to the discussion developed in chapter five. It is important to note that the tables presented here are reductions of the full statistical findings. The complete findings tables with corresponding reduced tables are located in appendix J.

4.2 Discussion of Sample

The test sample and corresponding data set used in this chapter is a sub-set of the sample identified in chapter three. Of most import is the change in the number of organisations, the number of respondents, and the number of projects. In January 2006 twelve organisations, 60 respondents, and a total of 180 projects had been identified. This sample population took part in a three month rolling pilot activity, which was used to develop the final survey tool; a multi-part questionnaire, as detailed in chapter three. Of this sample, useable responses to the questionnaire were received from six organisations, 39 respondents, accounting for 124 NPD projects. Questionnaires from two respondents giving three project reports were deemed unusable, as they were incomplete. This represents a response rate of 50% of

organisations, 65% of respondents, and 69% of identified projects.

While the projects and respondents were anonymous, phone conversations and post collection review confirmed that the majority of the projects reported were distinct. This can be demonstrated by the variation in project KMAs and project success reported between projects from the same company; and also by the distribution of questionnaires to different project leaders as is evidenced through the response to the "job function" question. This yields a statistically usable sample of ~124 projects, each of which has a distinct set of KMAs and NPDd that were applied, and three measures of project success recorded.

The sample gives data from five distinct industries and from both large and SME organisations. The table below provides a breakdown of the make up of the respondents and the projects they reported on. Examining this table, there are several features worthy of note:

First, the five industries reporting are Aerospace and Defence, Software, Food Production and Processing, Pharmaceutical and Biotechnology, IT, Media and Mobile Technology Hardware; 24 were possible. While these five certainly represent some of the more RandD intensive industries located in the UK, they are not a complete list of physical new product developing firms. It may be useful in the future to contact organisations from the oil and mining, automotive, and chemical production industries as they may employ different KMAs, and are of important value to the UK economy.

Second, some sectors had respondents who reported on more projects per person than others. A review of the DTI sector data and discussions with some of the firms during the pilot identified this variable as a likely outcome of the duration of the projects on which the respondents worked. In the Pharmaceuticals sector projects often took place over many years, and so in the previous twelve months a respondent was unlikely to have worked on more than one project. On the other hand in the food production and processing industry the development of incrementally new products was ongoing and project team members could have worked on more than the six projects in twelve months limit the researcher had placed on responses. While aerospace and defence, IT hardware, and Software projects had estimated lead times of six months to five years, it was common for project members to work on several different projects over any one year.

Third, the majority of respondents confirmed that they could identify three

aggregate stages (Tranfield et al., 2003) to the development of a new product. Further more most of the projects reported were in the Development and Realisation stage. This is useful as this stage was identified in the literature as being most amenable to influence by KMA and NPDd tools, practices, and management behaviours. On the other hand projects at the Research and Discovery stage are often influenced by chance discovery or unique knowledge creation; and projects at the Manufacturing and Commercialisation stage can be influenced by changes in the market.

Finally it must be noted that the project responses from the Pharmaceutical industry/organisation appear as somewhat of outliers given the make up of the other groupings on the table. There were only five projects reported from the sector, each person only reported on one project, and those who reported worked primarily within the research and discovery stage of NPD. These all would seem to be reasonable arguments for excluding them from the sample. On the other hand there are several reasons for including them in the findings for this study: first these respondents did take part in the pilot and so have shaped the questionnaire used in all 124-project reports; second, the Pharmaceutical industry is a nationally important NPD industry in the UK, and would add depth to the present understanding of KMAs used in this context; third, the five are a useful numerical addition given a drop in the final number of respondents; finally, much of what is done in the Pharmaceutical business is research, and thus the three way segmentation that pointed this study in the direction of Development stage as amenable to KMA influence may not apply.

Table 5. Reported projects and statistics:

Industry (5 from 24 choices)	Aerospace and Defence	Software	Food Production and Processing	Pharmaceutical and Biotechnology	IT, Media and Mobile Technology Hardware
Total number of projects reported	27	26	30	5	26
Respondents per sector	11	6	5	5	12
Can identify three main stages in NPD?	Yes 27 No 0	Yes 26 No 0	Yes 30 No 0	Yes 4 No 1	Yes 23 No 3
In which stage of project					
Research and Discovery	0	0	0	4	0
Development and Realisation	27	14	30	0	23
Manufacturing and Commercialisation	0	12	0	0	0

4.3 Patterns of data

4.3.1 Company/Individual identifiers:

As was discussed in the chapter three, the survey tool contained a series of questions that help identify contextual attributes of the projects reported. These included information on industry (from a list of 24) stage (from a list of 3) and size (a continuous variable). Testing the results of this contextualisation is considered important for several reasons (as detailed in chapters two and three), which can be summarised: do the responses from the sample conform to the expectations derived from the literature, thus confirming the theoretical framework/model prior to introducing new variables?

The following *six tests* determine if the presence of KMAs and use of NPDd are different by industry, by stage, and by size in the sample population. The assumption from the literature is that both NPDd and KMAs will vary by industry, by stage, and by size.

Test one: Table 6 below is an SPSS generated output of an ANOVA report. It provides evidence to support the relationship between the variance in the stage the project is in and the presence of NPDd. Where the significance of the variance is greater than the suggested confidence level for the test (in this case 0.05) then there is a positive relationship between the NPDd and the stage the project is in.

Table 6. ANOVA Variance in Stage Vs. NPD:

Green font indicates a positive relationship

ANOVA	
	Sig.
NPD Process Quality	0.00
NPD Strategy Quality	0.00
Resources available for NPD	0.00
Senior Management Commitment	0.00
Entrepreneurial Climate	0.00
Top People Accountable for NPD	0.00
NPD takes advantage of Synergy	0.00
NPD teams are high quality	0.00
Teams are cross-functional	0.00

Test one provides evidence to suggest that in the sample population all of the 9 NPDd at work vary by the stage the project is in.

Test two: Table 7 below is an SPSS generated output of an ANOVA report. It provides evidence to support the relationship between the variance in the industry the project is in and the presence of NPDd. Where the significance of the variance is greater than the suggested confidence level for the test (in this case 0.05) then there is a positive relationship between the NPDd and the industry the project is in.

Table 7. ANOVA Variance in Industry Vs. NPDd:

Green font indicates a positive relationship

ANOVA	
	Sig.
NPD Process Quality	0.00
NPD Strategy Quality	0.00
Resources available for NPD	0.00
Senior Management Commitment	0.00
Entrepreneurial Climate	0.00
Top People Accountable for NPD	0.00
NPD takes advantage of Synergy	0.00
NPD teams are high quality	0.00
Teams are cross-functional	0.00

Test two provides evidence to suggest that in the sample population all of the 9 NPDd at work vary by the industry the project is in.

Test three: Table 8 below is an SPSS generated output of a Correlation report. It provides evidence to support the relationship between the variance in size of the company the project is in and the presence of NPDd. Where the significance of the variance is greater than the suggested confidence level for the test (in this case 0.05) then there is a positive relationship between the NPDd and the size of the company the project is in.

Table 8. Correlation Variance in Size Vs. NPDd:

Green font indicates a positive relationship

Correlations	Direction of relationship	Sig.
NPD Process Quality	+	0.02
NPD Strategy Quality	+	0.00
Resources available for NPD	+	0.00
Senior Management Commitment	-	0.84
Entrepreneurial Climate	-	0.01
Top People Accountable for NPD	+	0.00
NPD takes advantage of Synergy	+	0.11
NPD teams are high quality	-	0.06
Teams are cross-functional	-	0.02

Test three provides evidence to suggest that in the sample population: NPD Process Quality, NPD Strategy Quality, Resources available for NPD, Entrepreneurial Climate, Top People Accountable for NPD, Team Cross-functionality all vary depending on the size of the company. Conversely: Senior Management Commitment, NPD teams take advantage of Synergy, and NPD team quality, do not vary by organisational size.

Test four: Table 9 below is an SPSS generated output of a Chi-square report. It provides evidence to support the relationship between the variance in the stage the project is in and the presence of KMAs. Where the significance of the variance is greater than the suggested confidence level for the test (in this case 0.05) then there is a positive relationship between the KMAs and the stage the project is in.

Table 9. Chi-square Variance in Stage Vs. Presence of KMAs:

Green font indicates a positive relationship

Pearson Chi-Square Tests	Sig.
Use External Research Services	0.00
Survey/Collect External Information	0.05
Use External NPD Support	0.00
Explore External Opinions	0.40
Use Information Searches	.
Attend External TandD	0.00
Consult Specific Outside Experts	0.00
Participate in Communities of Practice	0.00
Empower Knowledge Brokers in SC	0.00
Empower Knowledge Brokers Sales	0.00
Brief Interested Stakeholders	0.42
Publish Findings	0.00
Demonstrate Products	0.00
Discuss NPD Strategically	0.00
Internal Communications	0.02
Document Management Practices	.
Reporting and Comm. Structure	0.21
Reward Systems	0.13
Slack Time	0.07
Reward Development	0.01
Learning and Teaching on-the-job	0.00
Informal Learning and Interaction	0.00
Formal Project Management	0.03
Prototyping	0.00
Decision Support Systems	0.01
Knowledge Mapping Activities	0.00
Directory of Internal Expertise	0.12
Electronic Forums for Debate	0.06

Test four provides evidence to suggest that in the sample population the presence of KMAs that: Survey/Collect External Information, Explore External Opinions, Consult Specific Outside Experts, aid Participation in Communities of Practice, Empower Knowledge Brokers in the Supply Chain, Empower Knowledge Brokers in Sales, facilitate the Publication of Findings, aid Demonstration of Products, facilitate Discussing NPD Strategically, Promote Internal Communication, Reward Development, facilitate Learning and Teaching on-the-job, promote Informal Learning and Interaction, Formalise Project Management, encourage Prototyping, create Decision Support Systems, and support Knowledge Mapping, will vary by the stage the project is in. Conversely the presence of KMAs that: garner External NPD

Support, Explore External Opinions, help Brief Interested Stakeholders, strengthen the Reporting and Communication Structures, enshrine reward systems, provide slack time, create Directory of Internal Expertise, and give Electronic Forums for Debate, will not vary by the stage that the project is in. The test also shows that KMAs that: Use Information Searches and enshrine Document Management Practices are present in all projects in the sample.

Test five: Table 10 below is an SPSS generated output of a Chi-square report. It provides evidence to support the relationship between the variance in the industry the project is in and the presence of KMAs. Where the significance of the variance is greater than the suggested confidence level for the test (in this case 0.05) then there is a positive relationship between the KMAs and the industry the project is in.

Table 10. Chi-square Variance in Industry Vs. Presence of KMAs:

Green font indicates a positive relationship

Pearson Chi-Square Tests	Sig.
Use External Research Services	0.00
Survey/Collect External Information	0.01
Use External NPD Support	0.00
Explore External Opinions	0.00
Use Information Searches	.
Attend External TandD	0.00
Consult Specific Outside Experts	0.00
Participate in Communities of Practice	0.00
Empower Knowledge Brokers in SC	0.00
Empower Knowledge Brokers Sales	0.00
Brief Interested Stakeholders	0.00
Publish Findings	0.00
Demonstrate Products	0.00
Discuss NPD Strategically	0.00
Internal Communications	0.00
Document Management Practices	.
Reporting and Comm. Structure	0.00
Reward Systems	0.00
Slack Time	0.00
Reward Development	0.00
Learning and Teaching on-the-job	0.00
Informal Learning and Interaction	0.00
Formal Project Management	0.01
Prototyping	0.00
Decision Support Systems	0.00
Knowledge Mapping Activities	0.00
Directory of Internal Expertise	0.00
Electronic Forums for Debate	0.00

Test five provides evidence to suggest that in the sample population the presence of all KMAs, except Document Management Practices and Information Searches (which are present in all companies), vary depending on the industry the reported project is in.

Test six: Table 11 below is an SPSS generated output of an ANOVA report. It provides evidence to support the relationship between the variance in size of the company the project is in and the presence of KMAs. Where the significance of the variance is greater than the suggested confidence level for the test (in this case 0.05) then there is a positive relationship between the KMAs and the size of the company the project is in.

Table 11. ANOVA Variance in Size Vs. Presence of KMAs:

Green font indicates a positive relationship

ANOVA	Sig.
Use External Research Services	0.00
Survey/Collect External Information	0.10
Use External NPD Support	0.00
Explore External Opinions	0.01
Use Information Searches	.
Attend External TandD	0.54
Consult Specific Outside Experts	0.00
Participate in Communities of Practice	0.00
Empower Knowledge Brokers in SC	0.34
Empower Knowledge Brokers Sales	0.00
Brief Interested Stakeholders	0.02
Publish Findings	0.31
Demonstrate Products	0.00
Discuss NPD Strategically	0.00
Internal Communications	0.06
Document Management Practices	.
Reporting and Communication Structure	0.04
Reward Systems	0.84
Slack Time	0.54
Reward Development	0.00
Learning and Teaching on-the-job	0.00
Informal Learning and Interaction	0.01
Formal Project Management	0.12
Prototyping	0.00
Decision Support Systems	0.92
Knowledge Mapping Activities	0.21
Directory of Internal Expertise	0.89
Electronic Forums for Debate	0.64

Test six provides evidence to suggest that in the sample population the presence of KMAs that: Use External Research Services, Use External NPD Support, Explore External Opinions, Consult Specific Outside Experts, encourage Participation in Communities of Practice, Empower Knowledge Brokers working in Sales, aid in Briefing Interested Stakeholders, Demonstrate Products, facilitate Discussion of NPD Strategically, enshrine Reporting and Communication Structures, Reward Development, promote Learning and Teaching on-the-job, facilitate Informal Learning and Interaction, and support the process of Prototyping, will vary by company size. Conversely, the presence of KMAs that: Survey/Collect External Information, encourage Attendance at External Training and Development, Empower Knowledge Brokers in the Supply Chain, aid the Publication of Findings, facilitate Internal Communications, secure Reward Systems, provide for Slack Time, encourage Formal Project Management, act as Decision Support Systems, aid in Knowledge Mapping, that help create Directories of Internal Expertise, and that provide Electronic Forums for Debate, will not vary by company size. Test six also shows that the KMAs that facilitate Information Searches and Document Management practice were present in all projects in the sample.

Given the results from tests one through six it is possible to conclude that KMA and NPDd use vary by industry, firm size, and by the stage in which the project is being examined. This shows that in the sample KMA and NPDd use is context specific, as was reported in the literature. This gives some evidence to suggest that the sample is representative of the population in the sense that it affirms context-specificity (but not that it makes generalised conclusions possible).

4.3.2 Is there a relationship between a firm's ability in the NPDd, and the presence/use of KM tools and practices (H3)?

As discussed in Chapters two and three, a core objective of this study is to understand the posited relationship between KMAs and NPDd. This would either allow for KMAs to be regarded as some antecedent of NPDd, for KMA to be independent of known NPDd, or some combination of the two. Hypothesis three states that 'there is a relationship between the presence of KMAs and "known" NPD factors.' This is supported in the literature through a number of instances where KM mechanisms are reported as having one of the attributes of the 9 NPDd (simplified by the table on pg. 9 of chapter 3). From this table several sub-hypotheses are proposed (see appendix E). It is possible to assign indicators to support these sub-hypotheses by examining the KMAs identified in the pilot (see appendix) and assigning them to the KM mechanisms under which they were listed in the pilot.

Below is Table 12 showing *Correlations* of KMAs with NPDd in the sample population to see if any were strongly related to each other. Of note are the values in green, which show a statistically significant relationship between variation in the use of a given KMA and a corresponding variation in the NPDd.

Table 12. Correlations KMAs Vs. NPDd:

+ shows a positive significant correlation
- shows a negative significant correlation
A blank shows no significant correlation

KMA: / NPDd	NPD Process Quality	NPD Strategy Quality	Resources available for NPD	Snr. Mgt. Commitment	Entrepreneurial Climate	Top People Accn	NPD takes advantage Synergy	Teams are high quality	Teams are cross-functional
Use External Research Services			+	-	-			-	-
Survey/Collect External Information		-		-	-	-		-	
Use External NPD Support	+	+	+		-	+	+		
Explore External Opinions		-		-	-	-		-	-
Use Information Searches			-	+	+		-	+	+
Attend External TandD	+	+	+	+		+	-	+	
Consult Specific Outside Experts			+	-	-			-	-
Participate in Communities of Practice	+	+					+		+
Empower Knowledge Brokers in SC	+	+	+	-	-			-	
Empower Knowledge Brokers Sales	-	-	-	-		-	+	-	+
Brief Interested Stakeholders	-	-	-	-	-	-		-	-
Publish Findings	+	+	+	+	+	+		+	
Demonstrate Products		+		+		+	-	+	
Discuss NPD Strategically	+	+	+				+		
Internal Communications		-	-	-		-	+	-	
Document Management Practices			+	-	+	+	+		
Reporting and Comm. Structure	+	+	+	+	+	+	+	+	+
Reward Systems	+	+		+	+	+		+	+
Slack Time	+	+	+	+	+	+	+	+	+
Reward Development	+	+	+	-	-		+	-	
Learning and Teaching on-the-job	+	+	+				+		
Informal Learning and Interaction	+	+	+			+	+		
Formal Project Management	+	+			-		+		
Prototyping			+	-	-			-	-
Decision Support Systems	+	+		+	+	+	+	+	+
Knowledge Mapping Activities	+			+	+		+	+	+
Directory of Internal Expertise	+	+	+	+	+	+		+	+
Electronic Forums for Debate	-			+	+	+	-	+	

This table can be analysed in at least three different ways:

One way would be to discuss the simple results as shown on the table. For each NPDd, several specific KMAs are correlated. This data mining approach could be used to develop new hypotheses to underpin further research into how and why the practice of those KMAs may be significant in the successful use of the nine NPDd.

A second method would be to consider **H3** as a generalisation: "are KMAs related to NPDd?" Given that at least two thirds of the variables on the table show KMA significantly related to NPDd, the answer to the question would be "yes." Simplified, this renders KM's effect on success to some extent dependent on ability in NPDd, as might be derived from the literature.

For this study, it is more appropriate to look at the predictions made about **H3** by the sub-hypotheses **H3a-H3i**. These state:

H3a: In the sample population Scanning and Collecting KMAs (Use External Research Services and Survey/Collect External Information) will be positively associated with: a clear, well-communicated new product strategy, adequate resources for new products, and strategic focus and synergy

In the table there is limited support for **H3a**, with one of the two KMAs correlating with new product strategy, one with adequate resources and neither for strategic focus and synergy. This suggests that Scanning and Collecting KMAs could be candidates for "independent influences" on NPD success. Discussion of this would seem appropriate in chapter five.

H3b: In the sample population Enhancing Staff External Knowledge KMAs (Use External NPD Support, Explore External Opinions, Use Information Searches, and Attend External Training and Development) will be positively associated with: a clear, well-communicated new product strategy, adequate resources for new products, and strategic focus and synergy

In the table there is broad support for **H3b**, with three of the four KMAs correlating with each of the NPDd. This suggests that Enhancing Staff External Knowledge KMAs are unlikely candidates for "independent influences" on NPD success. One interesting outcome of this review is that the specific KMA Explore External Opinions is negatively correlated with NPDd. This suggests that organisations may Explore External Opinions when they are not as competent in the NPDd… a reasonable assertion, to be discussed further in chapter five.

H3c: In the sample population Networking KMAs (Consult Specific Outside Experts, Participate in Communities of Practice, Empower Knowledge Brokers in the supply chain, and Empower Knowledge Brokers in sales) will be positively associated with: a clear, well-communicated new product strategy, adequate resources for new products, strategic focus and synergy, and high-quality development teams

In the table there is some support for **H3c**, with three of the four KMAs correlating with each of the NPDd, except in the instance of strategic focus, where two of four are related. This suggests that most Networking KMAs are unlikely candidates for "independent influences" on NPD success. One possible exception to this is the KMA Empower Knowledge Brokers in Sales. This specific KMA is negatively correlated with most of the list of NPDd, meaning that when they are present the KMA is usually not. The KMA is, therefore, related to NPDd, but is not an antecedent of them. If this KMA is shown to be an influence on process success, then this could mean that some organisations Empower Knowledge Brokers in Sales to find value for the NPD process when they cannot adequately resource other NPDd. Discussion of this would seem appropriate in chapter five.

H3d: In the sample population Externally Facing Communication KMAs (Brief Interested Stakeholders, Publish Findings, Demonstrate Products, and Discuss NPD Strategically) will be positively associated with: senior management commitment to new products and senior management accountability

In the table there is broad support for **H3d**, with three of the four KMAs correlating with each of the NPDd. This suggests that Externally Facing Communication KMAs are unlikely candidates for "independent influences" on NPD success. One possible exception to this is the KMA Discuss NPD Strategically. This suggests that organisations, regardless of their NPDd capability, may rely on tight inter firm networks to add value during the NPD process, an idea worthy of further discussion in chapter five.

H3e: In the sample population Enhancing Staff Internal Knowledge KMAs (Internal Communications, Document Management Practices, Reporting and Communication Structures, and Systems) will be positively associated with: a high quality new-product process, adequate resources for new products, an entrepreneurial climate for product innovation, high-quality development teams, and cross-functional teams

In the table there is limited support for **H3e**, with about half of the KMAs correlating with NPDd. This suggests that Enhancing Staff Internal Knowledge KMAs could be candidates for "independent influences" on NPD success. Of these

Internal Communications seems to be the most interesting as the KMA is related to NPDd, but is not an antecedent of them. If this KMA is shown to be an influence on process success, then this could mean that some organisations use internal communications to add value in the NPD process when they cannot adequately resource other NPDd. This might be made more possible in firms with fewer employees or in those with NPD teams who have worked together over a long period of time. Discussion of this would seem appropriate in chapter five.

H3f: In the sample population Personal Learning and Development KMAs (Slack Time and Rewarding development) will be positively associated with: adequate resources for new products, an entrepreneurial climate for product innovation, and high-quality development teams

In the table there is strong support for **H3f**, with KMAs correlating with each of the NPDd in all but one case. This suggests that Personal Learning and Development KMAs are unlikely candidates for "independent influences" on NPD success. This could be argued as a known and important part of the nine NPDd as is often detailed in the literature as being important (Nohria and Gulati, 1996).

H3g: In the sample population Group Learning and Teaching KMAs (Learning and teaching "on-the-job" and Informal Learning and Interaction) will be positively associated with: a high quality new-product process and adequate resources for new products

In the table there is strong support for **H3g**, with all KMAs correlating with each of the NPDd. This suggests that Group Learning and Teaching KMAs are unlikely candidates for "independent influences" on NPD success. It could be argued that this perfect correlation implies that Group Learning and Teaching KMAs are actually antecedents of effective high quality new-product process and adequate resources for new products NPDd. This will be discussed further in chapter five.

H3h: In the sample population Engineered Work Processes for Codification of Knowledge KMAs (Formal Project Management and Prototyping) will be positively associated with: a high quality new-product process and adequate resources for new products

In the table there is limited support for **H3h**, with about half of the KMAs correlating with NPDd. This suggests that Engineered Work Processes for Codification of Knowledge KMAs could be candidates for "independent influences" on NPD success. Discussion of this would seem appropriate in chapter five.

H3i: In the sample population Sharing of Expert Knowledge within the firm KMAs (Decision Support Systems, Knowledge Mapping Activities, Directory of Internal Expertise, and Electronic Forums for Debate) will be positively associated with: adequate resources for new products and cross-functional teams

In the table there is limited support for **H3i**, with just over half of the KMAs correlating with NPDd. This suggests that Sharing of Expert Knowledge KMAs might be candidates for "independent influences" on NPD success, if they are shown to have a significant influence. Discussion of this would seem appropriate in chapter five.

Given the evidence in relation to **H3a-H3i** it is possible to highlight several elements of the relationship between KMAs and NPDd (**H3**). First, there is no basis to fully support, nor disprove, **H3**. It can be said that some KMAs are related to NPDd, but not all. Of the ones that are significant, several are inversely related, and so are not antecedents but possibly replacements for NPDd. Of course many KMAs are positively related, and so it could be argued that they are sub-components of the already well understood NPDd, a claim that reflects elements of the KM strategy literature (Liu, Chen and Tai, 2005). On the other hand several KM mechanisms, and many KMAs, show independence from one or more NPDd; implying that they might be candidates for independent influence on NPD process success. If the inversely related and unrelated KMAs are combined, then this becomes a list of about ¼ of the total. These ¼ or so would seem to be worthy of further examination during tests of **H2** as they confound hypothesis **H3**.

4.3.3 Is the nature of the relationship between NPDd and NPD success in the study's sample population the same as shown in the literature (H1)?

As discussed in Chapters two and three, a core objective of this study is to understand the relationship between NPDd and NPD success in the sample. This would either confirm that the sample is similar to the known population or that it is not. Hypothesis one states "There is a positive relationship between the presence/use of NPDd and NPD Success". This suggests that each of the nine NPDd should explain some of the variance in one or more success measure (process time, cost, or specification). To this end it is useful to test the data in SPSS in the two following ways:

Table 13 below shows the results of *Test one:* Correlations of NPDd with success to see strength and direction of the relationship. Of note is the statistically significant relationship between variation in the use of a given NPDd and a corresponding variation in the NPD success.

Table 13. Correlations NPDd Vs NPD success:

n=	123	119	122
	Project Time Success	Project Cost Success	Project Specification Success
NPD Process Quality	+	+	+
NPD Strategy Quality	+		+
Resources available for NPD	+	+	+
Senior Management Commitment		+	
Entrepreneurial Climate		+	
Top People Accountable for NPD	+	+	+
NPD takes advantage of Synergy	+	+	+
NPD teams are high quality		+	
Teams are cross-functional		+	+

From this table it is possible to find both broad and specific support for **H1** in the sample population. Each of the nine NPDd is correlated with at least one form of variation in process success, with four (NPD Process Quality, Resources available for NPD, Top People Accountable for NPD, and NPD takes advantage of Synergy) correlated with all three measures of success. This is as was suggested in the literature. This both supports the view that NPDd have a significant affect on NPD success in the sample, and provides further evidence to suggest that the sample is representative of the known population.

Table 14 below shows the results of *Test two* a Stepwise Regression of NPDd with success to find the NPDd which best explains the variation in success. This is a useful follow up test that allows the strongest and most independent NPDd to be identified. These NPDd can later be added to a research model, which will demonstrate which variables have both a significant, strong, and independent effect on variation in success in the sample population.

Table 14. Stepwise Regression NPDd Vs. NPD success:

Dependent Variable: Project Time Success	n=	123	R Square	26%
Stepwise model: NPDd only	Unstandardised Coefficient	Standardised Coefficient	Absolute Coefficient	Relative Strength
Resources available for NPD	0.71	0.51		

Dependent Variable: Project Cost Success	n=	119	R Square	33%
Stepwise model: NPDd only	Unstandardised Coefficient	Standardised Coefficient	Absolute Coefficient	Relative Strength
NPD Process Quality	0.87	0.37	0.37	53%
Entrepreneurial Climate	0.46	0.33	0.33	47%

Dependent Variable: Project Specification Success	n=	122	R Square	44%
Stepwise model: NPDd only	Unstandardised Coefficient	Standardised Coefficient	Absolute Coefficient	Relative Strength
NPD Process Quality	0.83	0.43	0.43	55%
Resources available for NPD	0.50	0.36	0.36	45%

These three tables provide further information about the relationship between NPDd and variation in NPD process success in the sample. While *test one* highlighted that each of the NPDd correlated with variations in success, *test two* shows which of these have a strong and independent effect. This table suggests that NPD Process Quality, Resources Available for NPD, and Entrepreneurial Climate, best explain variation in process success in the sample and should thus be used when building the research model.

4.3.4 Is there a relationship between use of measurable KMAs and NPD success in the sample population, as was inferred by the literature (H2)?

As discussed in Chapters two and three, a core objective of this study is to understand the posited relationship between KMAs and NPD success. This would either allow for KMAs to be regarded as some antecedent of NPDd, for KMA to be independent of known NPDd, or some combination of the two. Hypothesis two states that 'there is a relationship between the presence of KMAs and "known" NPD factors.' This is supported in the literature through a number of instances where KMAs are reported as having a positive influence on the NPD process or innovation (Darroch, 2005; Liu et al., 2005; Hoegl and Schultz, 2005). To this end it is useful to test the data in SPSS in the three following ways.

Table 15 below shows the results of *Test one,* which provides a useful starting point to what is considered in the literature to be a difficult task: providing evidence-linking KMAs to NPD process success. *Test one* shows results of an ANOVA comparing the Presence of KMAs in the company with NPD process success to see strength and direction of any significant relationships. This is a useful test as for *use of KMAs* to be shown to have an effect on NPD process success they should first be shown to have an effect when *present*.

Table 15. ANOVA Presence of KMAs Vs. NPD success:

	Project Time Success	Project Cost Success	Project Specification Success
Use External Research Services	+		+
Survey/Collect External Information			+
Use External NPD Support	+		+
Explore External Opinions	+		+
Use Information Searches			
Attend External TandD			
Consult Specific Outside Experts	+		+
Participate in Communities of Practice	+		+
Empower Knowledge Brokers in SC	+		+
Empower Knowledge Brokers Sales	-		-
Brief Interested Stakeholders		-	-
Publish Findings			+
Demonstrate Products			
Discuss NPD Strategically	+		+
Internal Communications	+	+	+
Document Management Practices			
Reporting and Comm. Structure	+	+	+
Reward Systems		+	+
Slack Time	+	+	+
Reward Development	+		+
Learning and Teaching on-the-job	+		+
Informal Learning and Interaction	+		
Formal Project Management			
Prototyping	+		+
Decision Support Systems		+	+
Knowledge Mapping Activities			
Directory of Internal Expertise		+	+
Electronic Forums for Debate	-		-

Test one provides the fist evidence in support of **H2**. From the table it is possible to see that many of the KMAs have a relationship with variation in NPD process success. It is interesting to note that several of the significant relationships are negative. From this it is possible to argue that not all KMAs aid NPD and what may help in one context may hurt in another. This duality was highlighted in the literature review and is now evidenced in the table.

Table 16 shows the results of *Test two*, a Correlation of KMA use with NPD process success to see strength and direction of the relationship. This follows much the same format of *test one*, but compares the variation in KMA *use* rather then simple KMA *presence*.

Table 16. Correlation KMA use Vs. NPD success:

N=	123	119	122
	Project Time Success	Project Cost Success	Project Specification Success
Use External Research Services	+		
Survey/Collect External Information	+		+
Use External NPD Support	+	+	+
Explore External Opinions	+		
Use Information Searches	-	+	-
Attend External TandD			
Consult Specific Outside Experts	+		
Participate in Communities of Practice	+	+	+
Empower Knowledge Brokers in SC	+		+
Empower Knowledge Brokers Sales	-		-
Brief Interested Stakeholders			-
Publish Findings			+
Demonstrate Products		+	+
Discuss NPD Strategically	+	+	+
Internal Communications	+	+	
Document Management Practices		+	+
Reporting and Comm. Structure		+	+
Reward Systems		+	+
Slack Time	+	+	+
Reward Development	+		+
Learning and Teaching on-the-job		+	+
Informal Learning and Interaction	+	+	+
Formal Project Management	+	+	+
Prototyping	+	+	+
Decision Support Systems		+	+
Knowledge Mapping Activities		+	
Directory of Internal Expertise		+	+
Electronic Forums for Debate	-		-

Test two provides further evidence in support of **H2**. From the table it is clear that 27 out of the 28 KMAs are correlated with variation in NPD process success. The exception is "Attend External Training and Development" which was not correlated with variations in success. It can be argued that external training and development is not always a contributing factor in a project with a highly skilled team. Further more the table supports the position that for some KMAs increased use will result in increased process success variation. It is worthy of note that this variation is not always positive, and in many instances an increase in use will decrease success. Both positive and negative variations in success were predicted by the literature review.

Table 17 shows the results of *Test three*, a Stepwise Regression of KMA Use with NPD process success, to find the KMAs that best explain the variation in success. This is a useful follow up test that allows the strongest and most independent KMAs to be identified. These KMAs can later be added to a research model, which will demonstrate which variables have both a significant, strong, and independent effect on variation in success in the sample population.

Table 17. Stepwise Regression KMA use Vs. NPD success:

Dependent Variable: Project Time Success	n= 123		R Square 47%	
Stepwise model: KMAs only	Unstandardised Coefficient	Standardised Coefficient	Absolute Coefficient	Relative Strength
Discuss NPD Strategically	0.45	0.52	0.45	52%
Use Information Searches	-0.25	-0.28	0.25	-29%
Empower Knowledge Brokers Sales	-0.17	-0.23	0.17	-20%

Dependent Variable: Project Cost Success	n= 119		R Square 51%	
Stepwise model: KMAs only	Unstandardised Coefficient	Standardised Coefficient	Absolute Coefficient	Relative Strength
Slack Time	0.59	0.57	0.57	50%
Demonstrate Products	0.31	0.32	0.32	28%
Empower Knowledge Brokers Sales	0.23	0.26	0.26	22%

Dependent Variable: Project Specification Success	n= 122		R Square 57%	
Stepwise model: KMAs only	Unstandardised Coefficient	Standardised Coefficient	Absolute Coefficient	Relative Strength
Directory of Internal Expertise	0.32	0.41	0.41	27%
Electronic Forums for Debate	-0.29	-0.39	0.39	-25%
Publish Findings	0.30	0.29	0.29	19%
Use External NPD Support	0.25	0.29	0.29	19%
Reward Development	0.15	0.17	0.17	11%

Test three provides further information about the relationship between KMAs and variation in NPD process success in the sample. While *tests one and two* highlighted that most of the KMAs correlated with variations in success, *test three* shows which of these have a strong and independent effect. This table suggest that the KMAs: Discuss NPD Strategically, Use Information Searches, Empower Knowledge Brokers Sales, Slack Time, Demonstrate Products, Directory of Internal Expertise, Electronic Forums for Debate, Publish Findings, Use External NPD Support, and Reward Development best explain variation in process success in the sample and should thus

be used when building the research model. While specific to the sample, each of these tables represents new findings in the field of KM, and so are discussed further in chapter five.

4.3.5 To what extent is any KMA or NPD factor an independent contributor to NPD process success (H3)?

Given the test performed in sections 4.3.2, 4.3.3, and 4.3.4 there is sufficient evidence to support a test of the complete research model. In the method section it was argued that the best method for building such a model would be the use of *Enter regression* on the NPDd found, then stepwise regression using KMAs found, set against each of the three measures of process success (see table 18 below). This will provide evidence to suggest whether KMAs explain any of variation in success not already explained by NPDd (the most statistically significant influences reported in the literature).

Table 18. Enter Method Regression of NPDd, then Stepwise Regression of KMAs:

Dependent Variable: Project Time Success	n= 123		R Square	51%
Enter method NPDd then stepwise method KMAs	Unstandardised Coefficients	Standardised Coefficients	Absolute Coefficient	Relative Strength
Resources available for NPD	0.75	0.54	0.54	44%
Electronic Forums for Debate	-0.26	-0.35	0.35	-29%
Internal Communications	0.32	0.33	0.33	27%

Dependent Variable: Project Cost Success	n= 119		R Square	62%
Enter method NPDd then stepwise method KMAs	Unstandardised Coefficients	Standardised Coefficients	Absolute Coefficient	Relative Strength
Entrepreneurial Climate	0.78	0.56	0.56	34%
Discuss NPD Strategically	0.29	0.27	0.27	17%
Prototyping	0.25	0.25	0.25	15%
Demonstrate Products	0.22	0.22	0.22	13%
Empower Knowledge Brokers Sales	0.17	0.19	0.19	12%
NPD Process Quality	0.34	0.15	0.15	9%

Dependent Variable: Project Specification Success	n= 122		R Square	54%
Enter method NPDd then stepwise method KMAs	Unstandardised Coefficients	Standardised Coefficients	Absolute Coefficient	Relative Strength
NPD Process Quality	0.89	0.46	0.46	40%
Survey/Collect External Information	0.22	0.27	0.27	23%
Resources available for NPD	0.37	0.27	0.27	23%
Informal Learning and Interaction	0.13	0.15	0.15	13%

These three tables provide further information about the relationship between KMAs, NPDd, and variation in NPD process success in the sample. While prior tests highlighted that three NPDd and eleven KMAs explained much of the variation in process success when considered alone, this test shows which of these have a strong and independent effect when considered together. For the purposes of this study, several features of the tables should be highlighted:

First, the stability of the NPDd: In each case of regression the variable accounting for the greatest percentage of the variation is still an NPDd. This supports **H1** and gives further evidence that the sample is reflective of the population (as suggested by the literature).

Second, the Independent KMAs: Probably the most contentious question from this study was whether any KMA could be considered an independent influence on the well-understood NPD process **(H2/H3)**. The table show that 8 of the 28 KMAs measured do have an independent effect on NPD success. This will be a major feature of the discussion to follow in chapter 5.

Third, the increase in the relative strength of the model with the addition of the KMAs: Further to point two, the above tables show that in each case the addition of KMAs will increase the success of projects in the sample population. While this effect is certainly bound up in more complex, context specific processes, it is the first time that KMA had been measured as benefiting bottom line NPD projects given variation in other "known" influencing factors. This finding will be discussed further, but would see the most significant contribution of the study.

4.4 Statistical Limitations

The following are a list of statistical limitations that should be noted when considering the strength of the evidence provided in this findings section. These themes will be picked up and developed further during discussion of conclusions in chapter five:

Using 124 projects across five companies provides little more than the minimum needed for the regressions preformed. It is unfortunate that several of the companies who had agreed to participate pulled out after the questionnaires were sent. If they had responded test significance might be stronger.

There were too few responding companies of each type to separate out specific projects groupings and perform a company size, industry, or phase comparison using regression analysis.

The test assumes existing NPDd should be entered into the model first because of their significance in the literature, where the data collected does not necessarily force this decision.

All significance tests were done at 95% level. A larger sample size would mean some non-significant results could have been found to have a significant relationship.

There were some tests that would have been useful to do, but were not possible. For example, if it had been possible to do a factor analysis on KMAs, we could test the factors to see if they fit well together using reliability analysis (Cronbach's alpha).

4.5 Conclusion

This chapter has detailed the results of the data collection and subsequent statistical analysis as outlined in the method section.

Section 4.2 discussed the make up of the test sample and the response rate within the identified population. Though the number of firms taking part in the sample limit the ability to do certain regressions, such as cross inter-industry or company size based; there were an acceptable number of projects reported, allowing for analysis of the data needed to evidence key research questions.

Section 4.3 had five sub-sections. First, it presented findings to suggest whether KMA and NPDd use is development phase, company size, or industry specific. Second it presented findings on the hypothesised relationship between a firm's ability in the NPDd and the presence/use of KMAs. Third, it presented findings on the hypothesised relationship between NPDd and NPD success in the study's sample population. Fourth, it presented findings on the hypothesised relationship between use of measurable KMAs and NPD success in the study's sample population. Finally, it presented findings on the extent to which any KMA or NPD factor is an independent contributor to NPD process success.

Section 4.4 examined the statistical limitations of the data set and the analysis performed in section 4.3. These will be discussed further in chapter five.

5 Conclusions and implications

5.1 Introduction

In the literature review, KM is characterised as 'An entity's systematic and deliberate efforts to expand, cultivate, and apply available knowledge in ways that add value' (Holsapple and Joshi, 2004). While it is known that this is something that organisations have always done, it has been argued to be of critical importance to organisations that rely on NPD to generate economic returns. Thus, NPD is a process-predating KM that is inherently about the application and imbedding of knowledge and information into goods, but of those nine (Cooper and Kleinschmidt, 1995) processes (NPDd) measured as significant to NPD success (time, cost, specification) many "newer" KM related activities seem to be missing from the list. Whether this disparity has been the driver or not, recently there has been a plethora of academic articles arguing for the value added of KM in the NPD process (Darroch, 2005; Hoegle and Shulze, 2005; Liu et al., 2005; Tranfield et al., 2005). This study has investigated the idea that KM is a determinant of NPD success, and has thus far generated important new findings.

It is important to highlight that the information presented in this study is significantly new. The findings from the study are different from what has been said, and more importantly supported, by research in the field before. This study is, as best known to the author, one of the first to:

1. use empirical data to support the position that the use of one or more specific (9) KM mechanisms (here before represented by 4 general capabilities) will be correlated with NPD performance.
2. deconstruct these component mechanisms (9) of KM to develop a list of specific tools, practices, and behaviours (28 as identified by the sample); for the purpose of studying those that contribute to NPD success.
3. use empirical data to support the position that some of the KM mechanisms at work, or the specific KMAs used to achieve that end, will have an effect on NPD success independent of existing "known" NPDd.
4. highlight specific effects other than the bottom line, in the KM Vs Performance field. In point of fact, this study uses three very different

performance indicators: conformance to budgeted time, cost, and specification.

5. empirical KM Vs Performance study to ask KM tool/practice users rather than executives.

The aim of this chapter is to discuss and develop the significance of the findings from chapter four, draw conclusions given the research agenda, present implications for interested parties, and provide direction for further research in this field. To achieve this, the chapter will discuss and draw conclusions on each of the research questions in order, drawing on both data from chapter four and the existing body of literature presented in chapter two:

Research questions:

1. Is the nature of the relationship between NPDd and NPD success in the study's sample population the same as shown in the literature?
2. Is there a relationship between use of measurable KMAs and NPD success in the sample population, as was inferred by the literature?
3. Is there a relationship between a firm's ability in the NPDd, and the presence/use of KM tools and practices, as was discussed in the literature review?
4. Given knowledge of the statistical data generated in answer to questions 1-3, to what extent is any KMA an independent contributor to NPD process success?

Next it will discuss implications for academic theory, private sector managers, and public policy makers. Each of these implications will be grounded by a discussion of the study's limitations, including reliance on the small sample and the lack of direct observation of the variables. Finally the chapter will present recent research issuing from this study, and make some recommendations on how research in the field should evolve given the new knowledge generated in this thesis.

5.2 Conclusions about each research question

5.2.1 Is the nature of the relationship between NPDd and NPD success in the study's sample population the same as shown in the literature?

a. *For the most part, yes. In the sample all nine NPDd are positively correlated with at least one measure of success, and four are correlated with time, cost, and specification success. Regression shows that three of these are wholly independent effects. These findings are developed further in MacVaugh and Auty (2008, appended).*

While the results of the SPSS tests prompted the response "it is possible to find both broad and specific support for H1 in the sample population" in the findings section, there is more to discuss in relation to research question one than statistical significance.

To construct a useful model for this study the literature review exposed a large and broadly convergent body of research in the field of NPD. This review highlighted that in many other studies predictors of NPD performance could be attributed to a list of 20 or less factors. So, a reasonable point for discussion is to what extent the factors from this test mirrored other major tests. In this study all nine NPD variables (a high quality new-product process; a clear, well-communicated new product strategy; adequate resources for new products; senior management commitment to new products; an entrepreneurial climate for product innovation; senior management accountability; strategic focus and synergy; high-quality development teams; and Cross-functional teams) were significant predictors of performance, with four factors: NPD Process Quality, Resources available for NPD, Top People Accountable for NPD, and NPD takes advantage of Synergy, accounting for most of the variance. Further support may be found through Henard and Szymanski's (2001) 28 factor meta-analysis, where eight factors: Technology synergy, dedicated human resources, dedicated RandD resources, structured approach, technological proficiency, cycle time, cross functional integration, and senior management support, were predictors of positive NPD process performance. Thus it is reasonable to argue that the four most significant NPDd from this study are also seen as important in other work.

Conversely it can be said that this study did not find some NPD variables from the nine to be independent drivers of success. So while the findings section provides evidence to suggest that the sample is similar to the population, it also highlights that existing studies of the total population may be ignoring KM related influences that occur during the internal development process. This seems a reasonable assertion and one worthy of further discussion in the implications section (below).

While it has been useful to consider the relationship between the sample and the broad NPD literature, it is more important to discuss the extent to which the test mirrored Cooper and Kleinschmidt's (1995) study, as this was the one chosen as the basis for the research model. In simple terms it can be stated that each of Cooper and Kleinschmidt's nine NPDd was correlated with variance in process success in the sample. In addition the general pattern of the higher performing projects in the sample mirrored those in the 'solid performer' (Cooper and Klienschmidt, 1995) category, in that good performance occurred when ability in each of the nine NPDd were present. Thus it is clear that these nine constructs are significant in the population, they were understood by the sample, and are supported in the test.

Even so, there were some differences between the test performed and those performed by Cooper and Klienschmidt. First, the addition of time variable as a measurement of NPD process success. In the 1995 work, process success is measured by 10 scaled performance metric variables. These 10 were factored into two significant performance indicators: Program Impact, which roughly tracks technical success; and Program Profitability, a measure of costs and profit. Neither of the two compound indicators nor the 10 variables tracks process or development time. Second, the sample size is much smaller than in Cooper and Kleinschmidt study. Their study was based on a 135 companies, and was sponsored by an industry and trade organisation that recommended participation to their members. Third, in Cooper and Kleinschmidt there were multiple countries surveyed, and while these were all developed nations, the resulting analysis would seem more generalisable than a country specific survey. Fourth, this sample had a lack of truly poor performers as categorised by Cooper and Kleinschmidt. In the 1995 work, they identify four very different types of product developing company. While the projects in this study were not universally successful, the organisations as a whole would seem to have most of the characteristics of the 'solid performers' and none of the projects would have been rated by Cooper and Kleinschmidt's (1995) scale as 'dogs.' Fifth, this sample is only

five out of the 24 industrial sectors identified by the DTI. While Cooper and Kleinschmidt did not use the DTI scale, their population seems to have included most 24 categories, with the exception of the pure service industries.

Of these five, the most significant positive difference would seem to be the new information provided on the effect of the nine NPDd on time. "Time" has often been discussed as way to measure NPD process success (Chiesa and Masella, 1996), though it is rarely measured in the major studies of NPD. This seems unusual considering that it is of great import to those working in NPD. Thus, several new ideas can be added to Cooper and Kleinschmidt's NPDd in relation to time. The evidence from this study is that five NPDd: a high quality new-product process; a clear, well-communicated new product strategy; adequate resources for new products; senior management accountability; strategic focus and synergy, are likely to be significant in keeping projects on time. This is a significant new finding from a set of well-supported existing variables and seems a worthy contribution to the NPD field.

Besides the addition of the time variable, how do each of the NPDd relate to NPD success in this sample?

The Quality of your New Product Process was shown to aid Time, Cost and Specification success. In Cooper and Klienschmidt (1995) they argue that a high quality new product process includes 'sharp, early product definition' and 'a flexible process (where stages and decision points could be skipped or combined)' which would likely reduce the amount of time spent on activity external to the core development task. It would also reduce aspects of the project unlikely to be included in the final good. According to Cooper and Klienschmidt (1995), a high quality new product process includes 'tough go/kill decision points' which would reduce the cost of all projects by focusing resources on those most likely to be successful. Cooper and Klienschmidt (1995) believe that a high quality new product process has 'an emphasis on up-front homework' with 'a focus on quality of execution' and 'where every activity was carried out.' It is likely that if project teams took such quality assurance steps then the specification of the final product would be at least what was projected, if not more so. Cooper and Klienschmidt (1995) rate the Quality of the New Product Process as the most significant contributor to process success. This possibly accounts for its correlation with all three measures of performance and its place on the list of

'independent variables' in the regressions from chapter four. In the meta-study by Henard and Szymanski (2001) the New Product Process is shown to be the variable measured most often by investigators of NPD success.

The Quality of your New Product Strategy was shown to aid Time and Specification success. When NPD strategy is well communicated across an organisation then often 'the role of new products in achieving company goals was [becomes] clearly communicated to all in the firm' (Cooper and Klienschmidt, 1995). This should in turn 'give direction to the firm's total new product program' (Cooper and Klienschmidt, 1995) adding focus to effort spent. It is likely that this focus would include cycle time given time's affect on sales, profits and competitive position; each an element of an effective strategy. Cooper and Klienschmidt (1995) also note that a company with a well-communicated NPD strategy will likely have a 'long-term thrust and focus, including some long-term projects. Longer-term projects, while time consuming and expensive, are often those that yield a higher over all specification. It is worthy to note that Cooper and Klienschmidt (1995) rate the Quality of the New Product Strategy as the second most important factor in effective NPD. Why not cost? Besides the obvious expense created by generating and communicating a formal strategy, it is also the case that strategy can act as a barrier to radical, blue-sky, innovations. While such innovation often fails the unit cost is often much less than for a project that has churned through the multiple regulated stages that are necessitated by involvement in company-wide strategy.

The Resources Available for NPD was shown to aid Time, Cost and Specification success. Cooper and Klienschmidt (1995) state that a firm with adequate resources for NPD had 'the necessary people in place, and had their time freed up for [NPD].' It can be argued that two key determinants of a time success in any project is the number of people allocated to the work, and, their availability. The first reduces the project-length-in-days by increasing available man-hours; the second reduces bottlenecks around staff not available to complete key tasks. Increasing the resource base might also aid the end cost of the project. Cooper and Klienschmidt (1995) argue that when adequate resources for NPD are available then 'senior management had devoted the necessary resources to achieve the firm's new product objectives.' While it might be reasonably argued that this could introduce wasted resources into the process, it could also mean that projects would not be done in a slap-dash fashion, reducing the need for costly reworking after failing to meet specifications. It could

also be argued that having adequate resources would mean that the firm set reasonable cost expectations. Finally it is clear that adequate resources for NPD will increase specification. While it is often reported that a small company with limited resources has achieved some new innovation as yet unachieved by large Multi-national Companies (MNCs), it is also the case that such MNCs consistently deliver hundreds of new products and patents to the market each year, and dominate the incremental innovation market in products such as aerospace, car manufacture, and IT hardware. Cooper and Klienschmidt (1995) note that adequate resources also includes adequate RandD, a key pre development activity in firms such as Pharmaceuticals and Biotechnology. It is also worthy to note that Cooper and Klienschmidt (1995) rate the Quality of the New Product Strategy as the third most important factor in effective NPD, possibly accounting for its affect on all three measures of performance and its place on the list of "independent variables" in the regressions from chapter four. In the meta-study by Henard and Szymanski (2001) the New Product Process is shown to be the variable least measured by investigators of NPD success, but those who did reported a strong relationship with success.

Senior Management's Commitment to NPD was shown to aid Cost success. Cooper and Klienschmidt (1995) state that when the NPD process has strong senior management commitment 'they [senior management] were intimately involved in the key Go/Kill and spending decisions for new projects.' This would aid conformance to budgeted cost in several ways: First, such projects would have budgets that were well known to senior management, providing the correct basis on which to measure cost. Second such projects would be stopped before they ran too far beyond cost expectations. Finally they would have senior management's technical and financial control experiences to access, assuming that in a NPD firm most senior management would have gained their position through success in technical development or in financial discipline. Why not Time and Specification? While Cooper and Klienschmidt argue that senior management involvement would aid in spending decisions this same involvement would likely take time. Assuming that senior management are involved with multiple projects, then in a situation where their approval is needed (such as at a stage gate or for additional spending) then there would likely be a lag in the time taken for that decision. In this respect senior management acts as key resource (as mentioned above) that has not been dedicated exclusively to the project. This involvement might also prove a constraint on the

specification success of a project, as while a senior manager might demand conformance to specification they would likely not approve funding or time requested for adding features beyond those specifications. Due to the level of commitment and depth of involvement of a new product developer, it is often the additional features they develop, or "designers prerogatives," that lead to a product being an uncommon technical success.

In the study an Entrepreneurial Climate was shown to aid Cost success, but not time and specification. This is somewhat of an anomaly. While Cooper and Klienschmidt (1995) argue that an entrepreneurial climate should aid cost success because it allowed team members to use free time and money to work on ideas that would likely reduce future costs, they also argue that this would cost money up front. Further more while the study does highlight that such a climate reduces conformance to budgeted time, it does not show increased technical specification success, which is a predication of the Cooper and Klienschmidt study. So in this study the sample differs from the population in that an entrepreneurial climate has reduced their costs but also reduced specifications. There seems little support for such a phenomenon in the literature, nor through logic, and so it is likely a weakness in the research method or tool. One possible explanation is that the term Entrepreneurial Climate might be attractive to those project members who have a high focus on achieving specification "on budget", but have no interest in exceeding specification or delivering a project earlier than expected. Using the data collection tool/analysis methods outlined in chapter three, organisations that exceed time and specification have their mix of NPDd and KMAs ranked higher; where many organisations would not hold such achievements as important as reducing cost.

Holding Top People Accountable for NPD success was shown to aid Time, Cost and Specification success. Cooper and Klienschmidt (1995) define senior management accountability: 'Not only were senior managers committed, they were also held accountable in [a] real way for new product performance.' This would aid time cost and specification success as 'these same performance measures [become] criteria for senior management compensation.' While the variable 'senior management commitment' hints at input that might aid cost and specification; accountability would seem to ensure that senior managers contributed as a normal or even core part of their working day. As Cooper and Klienschmidt (1995) say 'someone kept score,' and as is commonly mentioned in the literature while

measurement takes time it also helps senior managers set more reasonable goals in the future. Also worthy of note is that Holding Top People Accountable for NPD success is not listed as a stand-alone factor in the Henard and Szymanski (2001) meta-study, possibly explaining why it shows a relationship with success but is not among the list of independent NPDd in chapter four.

A Strategic Focus and takes advantage of synergy was shown to aid Time, Cost and Specification success. As Cooper and Klienschmidt (1995) state, in firms with a strategic focus 'new products did not require technology that was totally new to the firm.' Performing development tasks with familiar bounds would then likely cost less, take less time, and achieve at least expected specifications 'by leverage[ing] in-house or existing technology' (Cooper and Klienschmidt, 1995). For firms who do this often this might also mean having projects regularly exceeding market-based projections. Firms who have a strategic focus may have more reasonable expectations 'staying close to their base' (Cooper and Klienschmidt, 1995). Cooper and Klienschmidt (1995) rate focus and synergy as important in the marketplace but of less clear importance in the process. Worthy of note is that a Strategic Focus on NPD success is not listed as a stand-alone factor in the Henard and Szymanski (2001) meta-study, possibly explaining why it shows a relationship with success but is not among the list of independent NPDd in chapter four.

NPD Teams are of a High Quality was shown to aid Cost success. Cooper and Klienschmidt (1995) argue that high quality teams tend to have 'a dedicated leader' who would be responsible for keeping to the budget and who would be familiar with the development process. An anomaly of the study is that Cooper and Klienschmidt (1995) argue that Time and Specification should also be improved by having a high quality NPD team. They state 'teams tend to have frequent communications' and they made 'efficient decisions.' This should have the affect of reducing time and increasing specification. There seems little support for such a phenomenon in the literature, nor through logic, and so it is likely a weakness in the research method or tool. One possible explanation is that the term high quality team might be attractive to those project members who have a high focus on achieving specification, but have also set that specification. They may also have little interest in delivering a project earlier than expected.

Teams are Cross Functional was shown to aid Cost and Specification success. According to Cooper and Klienschmidt (1995) a project with a cross-functional team

has 'players from different functions in the company' and were 'accountable for all facets of the project.' This could improve cost success, as it would be harder to pass blame between departments. It might also involve finance and accounting staff in the decision making process, aiding conformance to the budget. Teams who are cross-functional would have a greater base of experience and skill, and it can be reasonably asserted that the involvement of many people would increase the ideation needed for a better specification. This is assertion is supported in the Szymanski (2001) study. Why not time? While the communication stream literature (as discussed in chapter two) informs that involving lots of people may improve the quality of the decisions made, it also argues that this will take more time. The tendency to need more meetings with non-dedicated players would clearly add lag-time into a project where a small team (see previous paragraph) would handle decisions 'quickly and efficiently, with a minimum of bureaucracy' (Cooper and Klienschmidt, 1995).

Considering these arguments it is reasonable to assert that the nature of the relationship between NPDd and NPD success in the study's sample population is to a great extent similar to that predicted by the literature. This is not to say that the findings from the study may be exported and generalised to the population as a whole. It is more to say that elements of the existing model of the relationship between NPDd, KMAs, and NPD success have been identified in the sample. This provides a framework within which to discuss both predicted and novel results without the need to "reinvent the wheel."

5.2.2 Is there a relationship between use of measurable KMAs and NPD success in the sample population, as was inferred by the literature?

a. *To a great extent, yes. In the sample 27 of the 28 KMAs had a correlation with at least one measure of success, although some of these were negative (as was suggested possible). 11 KMAs were shown to be independent of the 28, and were strongly correlated with NPD success. These findings are developed further in MacVaugh and Auty (2008, appended).*

In simple terms the results of the SPSS tests in the findings section help conclude that for some KMAs increased use will result in increased process success, thus supporting H2. While not the whole story, this is a good starting point for discussion of research question number two.

The test supports the position that some KMAs have a relationship with NPD success. This is supported in the literature by the results of Liu et al. (2005) study. In their model four KM mechanism are shown to aid NPD performance. Their support also follows this study's theme that the value of KM lays in its ability to move and embed knowledge in the NPD process. They cite Holtshouse (1998) who suggests that knowledge flow can transfer knowledge between supplier and demander. They also cite Ler (1999) who argues that KM involves obtaining, refining, storing, and sharing to increase value. The key idea being that once accessible to an organisation, knowledge can be manipulated by discrete activities rendering it more useful. One down side of this position is that it creates a hypothesis not likely to be falsified.

There are some significant differences between the results of this study and the Liu et al. (2005) work. The unit of analysis for the Liu et al. study was the organisation, based on questionnaire sent to 105 Taiwanese high-tech manufacturers. While this provides a sound N value for statistical tests it provides no information on responder characteristics. In this study it is known that the respondents were reporting only on those projects and tools with which they were involved with; and further that they were not asked to speculate on the successes or ability of the company as a whole.

So, this study supports the Liu et al. findings, but goes further. The main outcome of the Liu et al. work is a headline: ability in general KM methods is statistically linked with better NPD performance in high tech firms. But while useful, this

statement provides little direction as to what the tools and practices used to achieve obtaining, refining, storing, and sharing are, and also ignores questions of who might do them, when they are important, and so forth. This study provides a greater depth of knowledge about the same questions discussed by Liu et al. The findings with regards to question two show that 27 very specific KMAs have a varying affect on NPD success. Even if an organisation could not identify, implement, or afford one of these 27, the study reports on a more generalised list of nine types of knowledge transfer which could likely be achieved through any one of 50 (see appendix C) or more KM practices or techniques. Further more, this study provides support for the value of KM to NPD success as measured pre-market. This seems more robust as increasing conformance to budgeted time, cost, and specification is of equal value to firms working on major innovation as those simply developing incrementally new products.

Thus, it can be argued that while this study does support the relationship between KMA and NPD success posited by Liu et al., it also goes further to expose the "black box" activities of KM. These activities are then more amenable to falsification in later testing, but also to application by those working in the field.

The idea that KM is directly related to success in innovation is also supported by the work of Darroch (2005). She follows a line of argument using Penrose (1959) as support, stating that knowledge is an asset that shapes capability. She also referrers to Nelson and Winter (1982) arguing that knowledge is the core coordinating mechanism for management of other assets. Her study shows that having key knowledge inputs, and coordinating them through effective organisational routines (KM), will bring about better physical output and financial performance. While this study did not examine the inputs to the process, it does mirror the Darroch work in highlighting the importance of capability to acquire and share knowledge to effective innovation.

However, the Darroch work does differ from this study in several important ways. In the Darroch paper empirical results were derived from survey responses from 443 CEOs. They were asked about their knowledge resources and KM capability. In her work KM capability is defined as acquisition, dissemination, and responsiveness. Again it can be questioned as to whether the results of such questioning (due to those asked and their likely beliefs in their organisation) can ever show anything but positive results.

This study supports the results of the Darroch work in that KMA is an organisational routine that aids the embedding of knowledge resources to achieve innovation, but goes further. Like the Liu et al. work the Darroch study fails to reveal the specific activities that make up organisational routines. Thus it is hard to know if a tool or practice is part of the routines, and what if any positive effect it has on the process. As mentioned above, the results of this test associated with research question two provides such specifics. Furthermore the evidence from this test provides both positive and negative associations, which seems more likely given the myriad of different forms of KM and the, often contradictory, success measures used within the NPD process.

Not all of the existing literature on the relationship between KMA and NPD supports the findings generated in this study. Comparing the results of this study with Hoegl and Schulze (2005) shows significant differences. In the Hoegl and Schulze (2005) work the explicit focus is on measuring the extent to which KMA supports the creation of new knowledge. So while the unit of analysis is the same (project), the conceptualisation of the contribution of KM is different (knowledge creation Vs knowledge transfer). However, there is not a major difference in the KM tools to which this ability is attributed. This difference comes from the theoretical framework used to support the study. In Hoegl and Schulze (2005), they cite Ruggles (1998) who argues that while the KMA of capture, access, and transfer of knowledge can increase efficiency; generation is the real driver of growth.

Of course there are some weaknesses to Hoegl and Schulze's approach. They use satisfaction and familiarity with KMA as the key measure, not KMA as present or applied. While they use the very useful unit of analysis of the project, they do not measure the success of those projects. Thus while the paper provides a very good account of Human Resource related KMAs, it does not discuss technical ones.

This study supports a few of the ideas related in the Hoegl and Schulze (2005) work, but goes further. A key aim of this study was to examine the effect of discrete KMAs. While knowledge creation is obviously of great import to NPD, Hoegl and Schulze's approach empirical approach does not really access the new tacit knowledge being created, but rather provides evidence for the value of certain soft KMAs. From the literature review it is clear that a wide range of both human and technical KM tools, practices and behaviours are used in the pursuit of NPD. Thus this study provides evidence to suggest which of these KMAs (or which general

mechanisms if the reader is unfamiliar with the specific practice) contributes to NPD success without researcher bias towards human or technical solutions.

So what new information on the relationship between KMAs and NPD success does this study provide, beyond that which is supported in previous literature? First, this study has outlined the affect of 27 specific KM tools and practices on NPD process time, cost, and specification. While some previous studies had measured part of the relationship on a detailed level (Hoegl and Schulze, 2005; Tranfield et al. 2003), or a broad view of the relationship from a high level of abstraction (Liu et al., 2005; Darroch, 2005), this study has uncovered the detail while keeping in mind other major moderating factors. Second, this study was constructed so the hypothesis and sub-hypothesis are clear, falsifiable, and measurable. This has yielded neutral and negative results along with the more publicised positives. Third, this study provides a sounder basis for supporting claims made in other KM work. It does this by both accessing cross-disciplinary literature (such as that from NPD, HR, Strategy and economics) and by providing hard empirical evidence to support claims made about each type of KMA.

Given what has been said about the value of KMA in the existing literature, and applying the findings with regard to research question number two, what can be inferred about the significance of each KMA to NPD success?

In the findings: Using External Research Services was shown to (positively) influence time success. Surveying/Collecting External Information was shown to (positively) influence time and specification success. These are the two component parts of the general KM mechanism "A. Systematic scanning of / interaction with the external environment and collection of information." In the literature review this KM mechanism was said to: provide appropriate resources (Darroch, 2005), identify knowledge in the environment and make it available to an appropriate activity (Holsapple and Joshi, 2004). Essentially these KMAs aim to ensure that the organisation has up to date information in the same manner as they might procure the most recent word processing software or grade of raw material. In many ways it is even more important than that, as the information might not be what is being used but rather what might be used, and to what effect. So, it is understandable that by having such KMAs in place, a project would reduce the time needed to access key externally available information and likely have the resources needed to make better specified

end products. This is not to say that other organisational mechanisms might not have the same role, an idea considered (below) in response to research question three.

In the sample: Use of External NPD Support was shown to (positively) influence time, cost, and specification success. Explore External Opinions was shown to influence (positively) time success. Using Information Searches was shown to (negatively) influence time, specification, and (positively) cost success. Attending External Training and Development was not shown to significantly influence any of the success measures (but had a negative no significant relationship with time). These are the four component parts of KM mechanism " B. Enhance extent of staff information from outside sources." In the literature review this was said to: increase overall product performance through the integration of external and internal ideas (Clark and Wheelwright, 1993; Teece and Pisano, 1994) give team members market information (Moorman, 1995) and recognise other knowledge needs (Tranfield et al., 2003). So it can be argued that a project with effective KMAs that enhance the extent of staff information from outside sources might: increase the time needed to make decisions about that which is already known; but may reduce cost by accessing at least market equalling information about resources and practices, and could increase specification by extending the boundaries of the project team to include those people or capabilities located outside of the firm which would increase the products final specification. Conversely, it is also possible to speculate that 'Attending External Training and Development' is not seen by those in the sample as fitting into the category: 'Enhance extent of staff information from outside sources.' It may be that this KMA is seen as of little value, or that non-directed personal training is not as material to actual product development as specific External NPD Support. It is important to note that the statistics are mixed with regards to the positive or negative influence of these four KMAs, and so should be considered as context specific approaches to KM, rather then as key drivers of success within the population as a whole.

In the study: Consulting Specific Outside Experts was shown to (positively) influence time and specification success. Participating in Communities of Practice was shown to (positively) influence time, cost, and specification success. Empowering the Knowledge Brokers in the projects supply chain was shown to (positively) influence time and specification success. Empowering Knowledge Brokers involved in sales was shown to (negatively) influence time and specification

success and have a (positive) relationship with cost success. These are the four component parts of KM mechanism " C. External Networking." In the literature review this was said to bring about Encultured knowledge (Blackler, 1995) a key driver in developing new recipes for action. For Nonaka (1994) it is these networks that create knowledge about how to complete the process. Many authors have commented that such external networking is key for project cost success in markets where multiple organisations are developing products from the same core innovation (see Spencer, 2003; Laat, 1999). So it is possible to argue that the presence of KMAs that facilitate External Networking may partially increase specification success; has a mixed effect on the time taken to complete a project, but makes a distinct contribution to the end cost of the project.

In the findings: Briefing Interested Stakeholders was shown to have a slight (negative) influence on specification success. Publishing Findings was shown to (positively) influence specification success. Demonstrating Products was shown to (positively) influence cost and specification success. Discuss NPD Strategically was shown to (positively) influence time, cost, and specification success. These are the four component parts of KM mechanism "D. External communications." In the literature review this was said to be significant as key users often shape development trajectories (Hippel, 2001). It is also important in accessing resources (Allen, 1971; Darroch, 2005). Hansen (2002) argues that this KM mechanism is key to knowledge sharing across multiple units in a single company. So it can be argued, in both the sample and the population as a whole, KMAs that aid the project communicating its purpose to externally stakeholders, users, and those involved in company strategy: could reduce the time taken to develop the product through reduction of barriers; will increase cost success through gaining access to resources and attracting user support; and may increase specification given appropriate feedback from interested stakeholders.

In the sample Effective Internal Communications was shown to (positively) influence time and cost success. Document Management Practices were shown to (positively) influence cost and specification success. Reporting and Communication Structures were shown to (positively) influence cost and specification success. Reward Systems were shown to (positively) influence cost and specification success. These are the four component parts of KM mechanism "E. Enhance extent of staff information from internal sources." In the literature review this mechanism was said

to positively affect the ability of the project team to respond to changes in knowledge (Darroch, 2005). Effective internal communication is *the* key driver of project success for many "innovation field" authors (see Allen, 1971; Tushman and Scanlan, 1981; Ancona and Cladwell, 1990; Keller, 1986; Dougherty, 1990). So it is reasonable to argue that KMAs which 'enhance the extent of staff information from internal sources' will reduce the time needed to access key information and decisions regarding the development of the project, will reduce the cost of duplicated effort, and will increase the end specification as a result of effective communication across departments and functions.

In the findings: Slack Time was shown to (positively) influence time, cost, and specification success. Rewarding development was shown to (positively) influence time and specification success. These are the two component parts of KM mechanism "F. Personal learning and development." In the literature review this KM mechanism was said to 'be at the very core of organisation theory' (Nohria and Gulati, 1996). Slack resources foster a culture of innovation (Bourgeois, 1981). Slack resources provide additional resources in a constrained/market-led environment (Cyert and March, 1963). Rewarding development is a key part of developing an innovative culture, especially in the western tradition of personal rewards and professionalism. So it can be asserted that in an environment where much of the value of a product can come from the unique and discretionary contribution of a few key developers, it is important to have mechanisms (be they KM or otherwise) that increase the skill of those developers, and which encourages them to contribute as much as possible. When effective, this Personal learning and development would very obviously reduce project development time, save wasted cost, and bring about a higher over all specification.

In the study Learning and teaching "on-the-job" was shown to (positively) influence cost and specification success. Informal Learning and Interaction was shown to (positively) influence time, cost, and specification success. These are the two component parts of KM mechanism "G. Group learning and teaching "on the job." From the literature review Senge (1990) argues that learning would render all people and processes more informed and effective. Orr (1990) highlights that only through learning and teaching on the job can solutions to new technical problems be both effectively developed and tacitly shared. Hoegl and Schulze's (2005) study rates informal events and experience reports (both forms of group learning) as among the

top three most well known and deployed of KM methods in innovative organisations, arguing that they create new insights, increase technical ability, and increase the knowledge resource base. So it seams clear that a project that has mechanisms that aid "Group learning and teaching "on the job" may develop projects quicker than expected, with less cost and possibly higher specification. Given that learning is such a key element of development, and being a contributor to the resource base, it is worth exploring under questions three and four below if this is not likely already accounted for in existing determinants of NPD success.

In the sample Formal Project Management was shown to (positively) influence time, cost, and specification success. Prototyping was also shown to (positively) influence time, cost, and specification success. These are the two component parts of KM mechanism "H. Engineered work processes for codification of Knowledge." In the literature review this KM mechanism was said to be the backbone of the technocratic school (Earl, 2001). As such it formalises knowledge creation process, and ensures retention of this knowledge embedded in the system (Blackler, 1995). Hansen and Nohria (1999) refer to this as a codification strategy and note this has clear cost and time saving advantages. Furthermore, Blumentritt and Johnson (1999) argue that explicitly addressing development of mechanisms at the knowledge-information interface is the most important goal of formal KM. So, there is reasonable support in both this studies findings and in the literature to suggest that Engineered work processes for the codification of Knowledge will: quicken project development time, especially for incremental or repetitive innovations; will reduce the cost of lost information and increase the resource base, and will increase specification in cases where best practise has already been developed.

In the study: Decision Support Systems were shown to (positively) influence cost and specification success. Knowledge Mapping Activities were shown (positively) to influence cost success. Directories of Internal Expertise were shown to (positively) influence cost and specification success. Electronic Forums for Debate were shown to (negatively) influence time and to some extent specification success. These are the four component parts of KM mechanism I. Sharing of expert knowledge within the firm, which produced some of the most interesting yet mixed results of the investigation. In the literature review Sharing of expert knowledge was said to underpin the personalisation strategy (Hansen and Nohria, 1999) and the behaviour KM school (Earl, 2001). Sharing knowledge is key to innovation in the well-respected

learning model of Nonaka (1994). Conversely, Hoegl and Schulze (2005) point out that while electronic discussion forums are well known, they are among the least deployed of the knowledge sharing mechanisms in their sample, and users find them among the least satisfactory KM practices when they are deployed. So it can be reasoned that the most KMAs employed in the pursuit of sharing expert knowledge will result in reduced cost through access to better practice, and increased specification, through the contributions of key experts outside the project development group. On the other hand the use of unpopular knowledge sharing tool, such as Electronic Forums for Debate, will increase the time taken to develop a product and may even result in a poorer specification through inadequate access to enlightened decision makers.

5.2.3 Is there a relationship between a firm's ability in the NPDd, and the presence/use of KM tools and practices, as was discussed in the literature review?

a. *Not to the extent suggested by the associations of KM mechanisms and NPDd posited at the end of the literature review. While some KMAs are strongly correlated with NPDd, many were not at all. The literature suggests that all of the mechanisms, and by proxy, the tools that enable that mechanism, could be accounted for by existing NPD practice. This was not the case in the sample.*

The short answer to research question number three comes from the findings section response to H3, which states: "there is no basis to fully support, nor disprove, H3. It can be said that some KMAs are related to NPDd, but not all." The long answer is that the question deserves a more detailed discussion in the context of what is known in the field to date and what might be logically derived from synthesis results from the findings section.

The results with regards to research question number three are difficult to discuss in the context of other research to date. While an oft-used term in academic work, the relationship between KM and other NPD process mechanisms is surely an under researched area. As recently as the year 2000 Karl Sveiby stated that there have been

no statistically validated linkages between KM, NPD, and performance. On the one hand it could be argued that a key reason for this is that many of the KMAs seen in organisations today have been derived from the NPD field. If this is the case then comparing KMAs and NPDd becomes a game of semantics. On the other hand it can be argued that taking an explicit approach to the management of knowledge rather than the management of a process has generated fundamentally different tools and practices, and as was discussed in chapter two, some of these KMAs have been taken up by those practicing NPD. Thus it seems important to examine statistical linkages between KMAs and NPDd; those that are linked become useful antecedents of effective NPDd, those that are not linked become candidates for consideration under research question number four.

Thus it is important to examine what is known about the relationship between KM and NPDd from the few papers that discuss the phenomenon. While Darroch (2005) claims that her paper is 'one of the first to find empirical support for the role of knowledge management' within innovative firms, the study does little to consider the contextual, strategic, and other moderators likely to influence firm performance. A host of other research papers have also examined the phenomenon of KM as driver of NPD, or NPD as a process of KM (see Armbrecht et al., 2001; Ferrari and Toledo, 2004; Herder et al., 2003; Madhavan and Grover, 1998 Snowden, 2003; Suh et al., 2004; Tranfield et al., 2003). Unfortunately, to date none of these investigations has examined the real detail of the relationship, preferring to talk about the abstract NPD processes that encode knowledge, assist knowledge flow, or embed knowledge into the process. Not withstanding some recent conceptual frameworks, the best existing basis for comparison with empirical clout is with Liu et al. (2005).

Liu, et al., argue that on the one hand while their data shows some support for a direct relationship between KM methods and NPD success, there is a far stronger relationship between KM methods and formulation of an effective NPD strategy. They support this with Clark et al. (1987) and Clark and Wheelwright (1993) who argue that development and implementation of an NPD strategy is essentially an information processing procedure. Liu et al.'s (2005) research supports the position that obtaining, refining, storing, and sharing KMAs practices are related to NPD strategy, which is one of Cooper and Kleinschmidt's (1995) NPDd. They go further to say that this is essentially new information on the relationship between KMA and NPDd. One drawback of the work is that the variables they use to examine NPD

strategy only very partially explore what processes are going on inside the NPD process. So, Liu et al. (2005) provide useful support for the relationship between obtaining, refining, storing, and sharing KMAs and NPD strategy; but what else can be derived given the many other relationships generated in the findings chapter?

In the table there is limited support for H3a, with one of the two KMAs correlating with new product strategy, one with adequate resources and neither for strategic focus and synergy. Given that the unit of analysis is the project it can be reasoned that a project's ability to scan and collect information (via a KMA) will have little to do with an organisation's strategy development. By the same token, if a project has effective methods for regularly scanning for outside information this would not necessarily be associated with the adequate resources, such as equipment and people, which are usually considered to be in place prior to development. Following this logic, and the results from the sample, it is possible to argue that Scanning and Collecting KMAs should be candidates for "independent influences" on NPD success.

So why has not other research in the field considered some form of 'Scanning and Collecting' mechanisms in the drivers of NPD success? There are several reasons that can be deduced from the NPD field: First, Cooper and Kleinschmidt's (in this case, 1995) "New Prod" surveys, among others, operate on the level of the organisation. It would seem hard to quantify an organisation's capacity to scan and collect data relevant to NPD as compared to any other organisation. It could be argued that this is done "sufficient unto the need" on average in most organisations; but that the real difference might be at the project or even individual level at which this is pursued or applied. Second, it can be reasoned that organisations would be keen to show how they developed ideas in house, and might not report their dependence on outside input for long-term success. Finally, it is possible to assume that Scanning and Collecting is a common task, but is so discrete that it has never been classified as an NPDd; but with the advent of KM and the codification of such practices, this study has uncovered the numerical impact by assigning a term to the behaviour. In any case it is clear that Scanning and Collecting are not strongly related to the nine NPDd, and so make candidates for further discussion under research question four.

In the table there is broad support for H3b, with three of the four KMAs correlating with each of the NPDd. This suggests that Enhancing Staff External Knowledge KMAs are unlikely candidates for "independent influences" on NPD

success. In the literature review it was posited that organisations that can enhance staff knowledge from external sources should increase the chance that they may participate constructively in developing a clear new product strategy (Liu et al., 2005). The staff would be provided with the information resources (Darroch, 2005) needed to develop new products, while also being provided the external market information necessary to understand the organisation's strategic focus. Given both the theoretical link between Enhancing Staff External Knowledge and resource base and strategy development, it is no surprise that these KMAs correlate strongly with known NPDd. One unexpected outcome of the data is that the specific KMA 'Explore External Opinions' is negatively correlated with NPDd. This suggests that project groups may use a KMA (or similar existing, but as yet un-codified, practice) to Explore External Opinions when they are not as competent in the NPD practices used to develop strategy, understand strategic focus, or garner resources. A reasonable assertion given the importance of such abilities to NPD success!

In the table there is some support for H3c, with three of the four KMAs correlating with each of the NPDd, except in the instance of strategic focus, where two of four are related. This suggests that most Networking KMAs are unlikely candidates for "independent influences" on NPD success. In addition to the comments made with regards to H3b, it can be said that having knowledge of outside information, and in turn discussing and internalising this knowledge within a work related context, it can be argued that these staff would be more likely to develop into high-quality NPD teams (Keller, 1986). Thus it is no surprise that these KMAs correlate strongly with known NPDd. One possible exception to this is the KMA Empower Knowledge Brokers in Sales. This specific KMA is negatively correlated with most of the expected NPDd, meaning that when they are present the KMA is usually not. The KMA is, therefore, related to NPDd, but is not an antecedent of them. If this KMA is shown to be an influence on process success, then this could mean that some NPD project groups may use the KMA (or similar existing, but as yet un-codified, practice) Empower Knowledge Brokers in Sales in order to add value to the NPD project when they cannot adequately generate resources, develop strategy, or build a high quality team.

In the table there is broad support for H3d, with three of the four KMAs correlating with each of the NPDd. This suggests that Externally Facing Communication KMAs are unlikely candidates for "independent influences" on NPD

success. The mechanisms involved in developing effective externally facing communication would arguably increase senior management commitment to new products and senior management accountability for new product success through exposure of NPD to relevant external stakeholders (Hardy et al., 2003; Ribie`re and Sitar, 2003). Thus it can be reasonably assumed that while KM devotees may consider Externally Facing Communication as a knowledge management activity, it is already accounted for in major studies of NPD success. One possible exception to this is the KMA Discuss NPD Strategically, which is not strongly linked to existing NPDd This suggests that project groups, regardless of their NPDd capability, may have only recently begun to rely on tight inter-firm networks to add value during the NPD process; possibly choosing a practice or tool from a KM consultancy. This idea will be developed further under discussion of research question number four.

In the table there is limited support for H3e, with about half of the KMAs correlating with NPDd. This suggest that Enhancing Staff Internal Knowledge KMAs could be candidates for "independent influences" on NPD success, but others are likely part of existing NPDd. As was stated in the literature review: 'An organisation that has an effective system for enhancing their staff's knowledge of internal information increases the likelihood that individuals know what 'everyone is supposed to know' (Faraj, S, and Sproull, l 2000). This would likely: increase the quality of the new-product process; give individuals access to shared knowledge resources necessary for the development of new products; 'evangelise' (Bontis, 2001) any message that NPD matters thus supporting an entrepreneurial climate; ensure that development teams have a 'shared-ness' and 'intensity,' while providing a communication channel to facilitate the development of cross-functional teams (Hansen, 2002). On the other hand there are KMAs that are more likely to be independent than be associated with known NPDd. Of these Internal Communications seems to be the most interesting as the KMA is negatively correlated to NPDd, and so is not an antecedent of them. If this KMA is shown to be an independent influence on process success (see question four), then this could mean that some project groups rely on effective/frequent internal communications to add value in the NPD process when they cannot adequately resource other NPDd. This would seem more than likely in firms/projects with fewer employees or in those NPD teams who have worked together over a long period of time.

In the table there is strong support for H3f, with KMAs correlating with each of the NPDd in all but one case. This suggests that Personal Learning and Development KMAs are unlikely candidates for "independent influences" on NPD success. These KMAs do arguably report what is a well-known part of the nine existing NPDd (Madhavan and Grover, 1998), and they are often detailed in the literature as being important (Nohria and Gulati, 1996).

In the table there is strong support for H3g, with all KMAs correlating with each of the NPDd. This suggests that Group Learning and Teaching KMAs are unlikely candidates for "independent influences" on NPD success. It could be argued that this perfect correlation implies that Group Learning and Teaching KMAs might actually be antecedents of effective high quality new-product process and adequate resources for new products NPDd. This is the position of Senge (1990) who argued that organisational learning would change an organisation's trajectory and location on a traditional life cycle by rendering all people and processes more informed and effective.

In the table there is limited support for H3h, with about half of the KMAs correlating with NPDd. This suggest that some Engineered Work Processes for Codification of Knowledge KMAs could be candidates for "independent influences" on NPD success, but that others are already accounted for in the nine NPDd. On the one hand it can be argued that an obvious part of NPD is the embedding (Blackler, 1995) of knowledge into a NPD system. As is evidenced by the success of incremental innovation in Japan, there is clear importance and value generated by organisations in the continuous development of codified best practice (Hansen et al. 1998). On the other hand the idea of 'codification' (Hansen et al., 1999) is at the heart of IT centred KM (Blumentritt and Johnston, 1999). While the industrial process control history and influence behind such developments is well documented; it seems likely that only through fairly recent advances in ICT and KM technique have sustainable and effective Engineered Work Processes for Codification come about. This would seem then to make the case that KMAs aimed at codification might be fairly recent and as yet unmeasured contributors to NPD process success.

In the table there is limited support for H3i, with just over half of the KMAs correlating with NPDd. This suggest that Sharing of Expert Knowledge KMAs might be candidates for "independent influences" on NPD success, if they are shown to have a significant influence, but that others are already accounted for under existing NPDd.

On the one hand it can be said that sharing expert knowledge has always been a significant part of effective NPD; and it would seem a necessary precursor to adequate resources and cross-functional teams. On the other hand, as was suggested in the previous paragraph, there are many newer ICT or managerially enabled methods for sharing expert knowledge. Such KMAs would therefore constitute a new, and as yet un-measured, part of effective NPD.

5.2.4 Given knowledge of the statistical data generated in answer to questions 1-3, to what extent is any KMA an independent contributor to NPD process success?

a. 8 of the 28 KMAs were wholly independent and correlated with success in the test model derived from the sample population. They also increase the model's ability to predict variance in all three measures of success. These findings are developed further in MacVaugh and Auty (2008, appended).

Research question four deals with the unique contribution of this thesis, the ability to identify KMAs as a notional "10th driver" in the successful pursuit of NPD. An initial answer to this question comes from the findings section, which states: '8 of the 28 KMAs measured do have an independent effect on NPD success.'

It should be made clear that no simple accumulation of numbers can prove or disprove the independence of KMAs from known NPDd. So how does the study demonstrate their independence? Three key methods were employed.

The first is statistical regression. Given a list of significant variables, the author was able to construct a statistical model amenable to stepwise regression. This form of regression adds significant independent variables to an equation based on dependant variables. If the independent variables added no longer independently account for changes in the dependant variables then they are removed from the model. This generates a list of independent variables best able to account for changes in the dependant variables, without overlapping effect. Of the statistical methods available to show the link between independent and dependant variables, the stepwise model is the most stringent, allowing only those that are both significant, independent, and that explain more of the variation then they did prior to their addition. In fact, this method

is so stringent that five of the "known" NPD drivers were not included in the final model when it had been previously shown that they were all at least correlated with success. Thus, in statistical terms, the eight KMAs listed are both significant and independent contributors to NPD success.

Second, the pilot used prior to data collection gained respondents conceptual distinctions. This allowed the construction of a survey tool that was based on users own understanding of the difference between KMA and NPDd, rather then assuming some conceptual distinction derived from the literature. Thus when the statistics report that a given KMA is used and leads to variation in success beyond that which can be attributed to NPDd, it is reasonable to argue that this variation can be attributed to the KMA and not a misunderstanding of the distinction between the variables.

Third, this study (as is evidenced by the literature review and section three above), has examined in some detail where KMAs are more likely to contribute to NPD success than existing NPDd. It has also considered which of the 28 KMAs identified by the sample might overlap with the 9 NPDd. Thus rather than discussing the results of all relationships found through statistical methods, this study has highlighted (and supported with previous research) the most probable; and has then ensured results outside of these predictions are treated with appropriate scepticism.

While this broadly answers and justifies the findings in regards to research question four, it also provides a useful starting point for developing an understanding of this relatively new phenomenon in light of prior research. So, a discussion of the effect of the 8 independent KMAs on NPD success, as follows, will underscore the statistics and aid in the development of implications:

The KMA Electronic Forums for Debate had a relative strength effect on NPD time success of -29%. Thus of the 51% of the variance in NPD success explained by the test model, 29% is the negative effect of using Electronic Forums for Debate. So in the sample project groups who used such forums were significantly more likely to complete the NPD process late, irrespective of other contributing factors. Why might this be? Support from the literature provides insight. Earl, (2001) discusses the case of British Telecom, who's development teams and executives agreed that e-mail discussions were a 'tyranny.' As Blumentritt and Johnston (1999) point out, there needs to be a balance between knowledge and information, so no matter how much information is being shared through an Electronic forum, it never provides core tacit

knowledge. It is not hard to envision a geographically disperse NPD team overloaded with information about *what* each other have done without knowing *how* to make different elements of the product work together. In Nonaka's (2004) most recent work, he posits the idea of 'Ba;' a shared mental space for effective knowledge creation of this sort. As anyone who is familiar with electronic discussion is aware, it takes much longer to get a sense of 'Ba' when communicating in this manner. So it seems very reasonable to argue from the results of this study that in the population as a whole, there will likely be a negative effect on project time success when team members make extensive use of electronic forums for debate.

The KMA Internal Communications had a relative strength effect on NPD time success of +27%. Thus of the 51% of the variance in NPD success explained by the test model, 27% is the positive effect of using good Internal Communications. So in the sample project groups who used such communications were significantly more likely to complete the NPD process early, irrespective of other contributing factors. Why might this be? Support from the literature overlaps with what is known about effective project management in general. The work of Allen (1971) was the first to measure communication and performance variables in parallel. He found that the flow of information through effective communication lead to marked project performance. Katz and Tushman, (1981), Von Hippel (1986), Ancona and Caldwell (1990), and Keller (1986) have since built on this work and agree that effective internal communication increases cohesion and brings greater product development success. Of these though, none explicitly mentions time. Furthermore Katz (1982) argued that development group tenure and communication had a positive effect only for the first five years, after which the difference dropped off, possibly attributed to the negative aspects of 'groupthink' (Janis, 1972). Support in the KM specific literature comes from Madhavan and Grover (1998) who argue for the importance of information redundancy facilitated by KM, which would increase the cognitive performance of the team. Still this does not mention the time effect of using the KM. So while there is sufficient support for highlighting the *generally* positive effect of internal communications, this study is the one of the first to highlight that KMA facilitated communications may positively contribute to project *time*. While it can be said to hold true in the sample, there has not yet been academic support for *why* the internal communication KMA may have an independent effect on time; so is not an attribute easily generalised to the population as a whole.

The KMA Discussing NPD Strategically had a relative strength effect on NPD cost success of +17%. Thus of the 62% of the variance in NPD success explained by the test model, 17% is the positive effect of Discussing NPD Strategically. So in the sample project groups who discussed NPD strategically were significantly more likely to complete the NPD below the budgeted cost, irrespective of other contributing factors. Why might this be? Discussing NPD strategically is an external communications KMA. It essentially allows a team to connect to or lead a discussion of the strategic development of a project. As Moorman (1995) points out, the KM driven ability to absorb market information generates greater project success. But this success is measured in terms of the market profitability, not the internal cost. As to the internal cost, Darroch (2005) points out that responsiveness to knowledge is a key KM mechanism. Thus project groups who discuss NPD strategically could be said to have a better responsiveness. While a useful contribution to the resource-centred approach Darroch posits, this responsiveness does not address the issue of reducing cost. Probably the best explanation for the reduction in cost comes from the notion of *strategic architecture* (see Brown, 1998; Prahaled and Hamel, (1994) which gives a firm competitive advantage based on its ability to respond and lead in a shifting environment (Tranfield et al., 2003). In the absence of direct links with KM, it is possible to reason that a KMA facilitating a development team's involvement in the external flux of information would reduce the cost of obtaining key information. More importantly, discussing what the group was working on with key stakeholders would reduce the possibility that a project would not meet expectations in pre-completion tests, often known as "betas." This is further supported by findings from the sample that show the KMA Demonstrating Products had a relative strength effect on NPD cost success of +13%. Thus of the 62% of the variance in NPD success explained by the test model, 13% is the positive effect of Demonstrating Products. So when NPD teams and external partners have shared strategic understanding, then the costs associated with the development could even be lower than those expected. It is therefore logical to argue that, in the general population, teams who spend time participating in the KMA of strategically communicating will reduce the cost of development expected. This reduction in cost will come from the comparative disparity with teams who do not share strategic understanding with external partners and are thus exposed to costly, but often expected, redevelopment at the beta stage.

The KMA Prototyping had a relative strength effect on NPD cost success of +15%. Thus of the 62% of the variance in NPD success explained by the test model, 15% is the positive effect of Prototyping. So in the sample project, groups who prototyped were significantly more likely to complete the NPD below the budgeted cost, irrespective of other contributing factors. Why might this be? Prototyping is an engineered work processes for codification of Knowledge. As such it is likely to reduce project cost through capturing new learning (Armbrecht et al., 2001). This KMA is said to be of value to firms engaging in NPD specifically (Ferrari and Toledo, 2004). It is also worthy of note that while prototyping is not among the list of nine NPDd, it is a necessary development activity, arguably older than any other. So while this study has listed prototyping as a KMA, this is merely an academic label printing exercise. Prototyping is representative of the core notion of the KM mechanism; the desire to engineer work processes for codification of knowledge. So it while this study is one of the first to highlight prototyping as a strong and independent KMA reducing project costs, it is not a claim that this is substantially new knowledge. Clearly any project group in the general population that spends more effort effectively prototyping should see a reduction in, or conformance to, budgeted costs.

The KMA Empower Knowledge Brokers working in Sales had a relative strength effect on NPD cost success of +12%. Thus of the 62% of the variance in NPD success explained by the test model, 12% is the positive effect of Empowering Knowledge Brokers working in Sales. So in the sample project groups who Empowered Knowledge Brokers working in Sales were significantly more likely to complete the NPD below the budgeted cost, irrespective of other contributing factors. Why might this be? Empowering Knowledge Brokers working in Sales is part of the KM mechanism of External networking. The core purpose of external networking through knowledge brokers is to allow the NPD team to access externally located tacit knowledge (Hoegl and Shulze, 2005). Of the many ways possible to access tacit knowledge, an important one is access to buyers and users of products. Often NPD teams only have access to such knowledge in its explicit form; such as marketing reports, design specifications, or calls for tender. On the other hand a project group might usefully develop a relationship with a knowledgeable sales person, who might be able to "story-tell" ideas from the market place in such a way that they are tacitly understood by those in the NPD team. This knowledge could be parlayed into greater focus and intensity, ignoring development trajectories unlikely to please consumers.

While intuitively appealing, there is little in the literature to support claims that speaking with sales people is a new KMA. As with prototyping, speaking to sales people is an activity pre dating academic research on NPD. Thus attributing it to KM is more to say that it reflects the core of the KM mechanisms, not that it is a KM innovation. So while this study is one of the first to highlight Empower Knowledge Brokers working in Sales as a strong and independent KMA reducing project costs, it is not a claim that this is substantially new knowledge. It is therefore logical to argue that, in the general population, teams who spend time speaking with knowledge brokers in sales will reduce the cost of development expected. This reduction in cost will come from the comparative disparity with teams who only have a surface awareness of what is expected in development of a project, and who are likely spend more money on developments different from the core of market expectations.

The KMA Surveying/Collecting External Information had a relative strength effect on NPD specification success of +23%. Thus of the 54% of the variance in NPD specification explained by the test model, 23% is the positive effect of Surveying/Collecting External Information. So in the sample, project groups who Surveyed/Collected External Information were significantly more likely to complete the project with a higher specification then was originally planned, irrespective of other contributing factors. While every NPD team throughout history has arguably collected explicit outside information, the addition of ICT enabled practices are only a prime feature of newer, Knowledge Management focused, strategies (Hansen et al., 1999). Bonner (2000) argues that finding out what information is available and devising a way to capture and use it is fundamental to any KM program. If it can be accepted that Surveying/Collecting External Information is a KMA and not, like prototyping, an un-labelled NPDd, why does it make so much of a difference to specification success? The KMA Surveying/Collecting External information is part of the KM mechanism of Systematic scanning of / interaction with the external environment and collection of information. The purpose of this mechanism is to formalise the process by which a project group or organisation gather explicit information from external sources; such as what materials are available or what tools can be bought. As Darroch (2005) argues, innovation both depends on information as a core resource, and requires information to make decisions about those resources. Thus, as Darroch's empirical results and those of this study show, organisations with formal mechanisms to Surveying/Collecting External information have produced

better outputs (in her words innovations) such as a better end product specification. In a business environment where NPD is increasingly dependant on the innovation of external partners, supply chain members, and even competitors; it is clear to see that end product specification success will be dependent on an organisation's ability to keep track of a myriad of changes to inputs, technology, tools, materials, and processes. Thus performing the KMA of Surveying/Collecting External information will be likely to have a positive effect on specification success in the general population.

The KMA Informal Learning and Interaction had a relative strength effect on NPD specification success of +13%. Thus of the 54% of the variance in NPD specification explained by the test model, 13% is the positive effect of Informal Learning and Interaction. So in the sample project groups who supported Informal Learning and Interaction were significantly more likely to complete the project with a higher specification than was originally planned, irrespective of other contributing factors. Why might this be? Informal Learning and Interaction is part of the KM Mechanism Group learning and teaching "on the job." Learning and teaching seems intuitively part of any innovative business and has fairly obvious links with NPD success (Madhavan and Grover, 1998). Some organisations, such as universities and research laboratories, have historically been centres for informal (as well as formal) learning and interaction through shared proximity. Staff who learn on the job, and in turn who take the time to teach others would: assist in the development of adequate human resources (Robertson and Hammersley, 2000); their actions would foster a collegiate and entrepreneurial climate where innovation is "the norm," and in turn would increase the quality of NPD teams to which they belong. Senge (1990) argued that learning would change an organisation's trajectory and location on a traditional life cycle by rendering all people and processes more informed and effective. If learning and interaction is encouraged and rendered a conscious KMA, it should therefore lead to the development of a high quality new-product process. Simply put, informal learning and interaction has always been necessary for teams to develop and share adequate tacit skills. The KM movement has formalised this activity, and there are many examples in industry where learning and interaction are being encouraged through design of buildings, breakout spaces, mentor programs, and the like. Thus performing the KMA of Informal Learning and Interaction, either through a new KMA, or by a long-standing group dynamic, will likely have a positive effect on

specification success in the general population.

5.3 Conclusions about the research problem

Principal Question: Is KMA an independent influence on NPD process success in organisations that rely on NPD to generate economic returns?

This study has found broad support in the literature that this could be the case.

In the literature review, KM is characterised as 'An entity's systematic and deliberate efforts to expand, cultivate, and apply available knowledge in ways that add value' (Holsapple and Joshi, 2004). While it is known that this is something that organisations have always done, it has been argued to be of critical importance to organisations that rely on NPD to generate economic returns. Thus, NPD is a process-predating KM that is inherently about the application and imbedding of knowledge and information into goods, but of those nine (Cooper and Kleinschmidt, 1995) or more (see Montoya-Weiss and Calantone, 1994; Henard Szymanski, 2001) processes (NPDd) measured as significant to NPD success (time, cost, specification) many "newer" KM related activities seem to be missing from the list.

Whether this disparity has been the driver, or perhaps some academic hype around the notion of knowledge management, there has been a plethora of academic articles arguing for the value added of KM when: considering investigation of methods for handling Innovation Processes (Darroch, 2005; Tranfield et al., 2003; Takaya et al., 2003; Snowden, 2003), Knowledge Coordination in projects and organisations (Armbrecht et al., 2001; Herder et al., 2003; Faraj and Sproull, 2000; Silva and Agusti-Cullel, 2003), focusing on innovation (Ribie`re and Sitar, 2003) or using Open Vs Closed Sharing Strategies (von Hippel, 2001; Munsch, 2004). KMA has been viewed as the formal implementation of institutional mechanisms, tools, and technology for project information management, including research into: Leadership, Management, and Line Roles (Bontis, 2001; Lang, 2001; Ribie`re and Sitar, 2003), ICT Tools such as KM Software, Databases, Shareware, Networks, and Telecommunications, Internal Sharing mechanisms (Hansen, 2002) and Alignment of HR to KM (Robertson and Hammersley, 2000; Hafeez and Abdelmeguid, 2003). KM theory is also related to classic financial management activities applied to Knowledge Assets (KA); Accounting, protecting, measuring, valuing; Choice of KM Method

based on a protectionist innovation strategy, KA Accounting for measurement's sake and Linking KM/Innovation to measures of performance (Edvinsson and Malone, 1997). Recently KM has been specifically linked with NPD success via knowledge creation (Hoegl and Schulze, 2005; Madhavan and Grover, 1998; Nonaka, 2004) or through contribution to strategy and performance (Liu et al., 2005).

Under question numbers two and four in this conclusions chapter the literature from both NPD and KM fields has been re-examined for evidence to support the specific KMAs shown in the study to independently influence NPD success. In each case there was at least some support from existing literature; though it was shown to be likely that not all of the activities deemed independent were necessarily new or exclusively part of the KM movement.

In conclusion, this study argues that there is significant support from the literature that some KMAs *should* be an influence on NPD success, and furthermore, that there is limited support that the eight specific KMAs identified in the study *are* independent influences on NPD process success.

This study has demonstrated that in the sample this is the case.

The results from the findings section clearly demonstrate that, in the sample population, eight KMAs (Electronic Forums for Debate, Internal Communications, Discuss NPD Strategically, Prototyping, Demonstrate Products, Empower Knowledge Brokers Sales, Survey/Collect External Information, Informal Learning and Interaction) have a significant effect on NPD process success; one that is independent of the established effect of the nine NPDd (Cooper and Kleinschmidt, 1995).

If yes, but later falsified.

Furthermore, if the results from this small sample and literature review were later found not to apply in the population as a whole, they would likely still find that many non-independent KMAs are antecedents of NPDd. This argument has been well supported in the literature and was demonstrated as applicable in the sample as is demonstrated by the findings of this study.

Further discussion: What is the contribution of this study?

It is important to highlight that the information presented in this study is significantly new. The findings from the study are different from what has been said, and more importantly supported, by research in the field before. How so? This study is, as best known to the author, one of the first to:

1. use empirical data to support the position that the use of one or more specific (9) KM mechanisms (here before represented by 4 general capabilities) will be correlated with NPD performance.
2. deconstruct these component mechanisms (9) of KM to develop a list of specific tools, practices, and behaviours (28 as identified by the sample), for the purpose of studying those that contribute to NPD success.
3. use empirical data to support the position that some of the KM mechanisms at work, or the specific KMAs used to achieve that end, will have an effect on NPD success independent of existing "known" NPDd.
4. highlight specific effects other than the bottom line, in the KM Vs Performance field. In fact, this study uses three very different performance indicators: conformance to budgeted time, cost, and specification.
5. empirical KM Vs Performance study to ask KM tool/practice users rather than executives.

5.4 Implications for theory

Given the arguments presented above, there are several extant implications for academic theory in the fields of NPD and KM. These are as follows:

First, the study finds support for the nine NPDd (Cooper and Kleinschmidt, 1995) as significant influences on NPD success, even in KM enabled environments. This need not have been necessarily so given the massive interest in KM field techniques and the erosion of traditional manufacturing in the UK. The findings highlight for those involved in the burgeoning literature on the relationship between KM and NPD success that it is impossible to measure either without consideration of contextual factors. This study supports the position that of those known contextual factors, the nine NPDd will influence NPD success at least as much if not more than other new KM variables. Thus future empirical studies of KM must take note and account for NPDd's exclusion or inclusion if they wish to carry any academic weight.

Second, and in direct relation to point one, this study gives further evidence to support the inclusion of KMA as a significant new influence in NPD success; a

veritable "10th NPDd." Using the logic above, this study argues that investigations of NPDd must in future consider that some of the knowledge embedding occurring during the process (by the list of 8 KMAs or labelled otherwise) is the result of newer KM practices and techniques. When examining success, they must therefore account for the value, specification, or time saving attributable to deliberate KMAs. If not such future work will likely only be able to predict an ever-decreasing amount of NPD success, as KMAs become more widely used for NPD in the growing knowledge economy.

Third, this study has developed and tested what can be simplified as a useful "measuring stick" for KMAs in the NPD process. As is often highlighted in the literature, the measurement of Knowledge is not an easy task (Sveiby, 2000). This study does not claim to have solved the problem, but has highlighted the value of examining the tools, practices, and general mechanisms by which an organisation might transfer or embed knowledge in the NPD process, and the potential ramifications for conformance to internal time, cost and specification requirements. This is a significant implication for theory given a lack of such methods in the past, where NPD seems to have had many.

Fourth, this study has highlighted a significant deficit in academic understanding of the antecedents of the known NPDd. In prior work, some of the antecedents have been discussed (such as Cooper et al., 2004, among others), but again these have not included KMAs. In the works of Darroch (2005) and Liu et al., (2005) KM is said to have a generally positive affect on NPD processes, such as strategy and coordination, but as this study has show there are a myriad of possible positive and negative antecedent relationships, not one single generalisable positive affect. Thus the relationships exposed by consideration if H3 (and sub-hypotheses) should be inform future studies, and act as a call to action to those in the NPD field who had not yet considered KM in this respect.

Finally, this study provides both empirical and literature support for a revised model of the relationship between KMA, NPDd, and NPD process success. While there is at least one other existing model of this relationship (Liu et al., 2005) this study has both accounted for its implications, and collected data providing a much deeper understanding of the forces at work. Below are one simple (Diagram 12) and one detailed model (Diagram 13) of the relationship between KMA, NPDd, and NPD process success as should usefully inform future investigations in the field.

Diagram 12. Simple model of the relationship between KMA, NPDd, and NPD success:

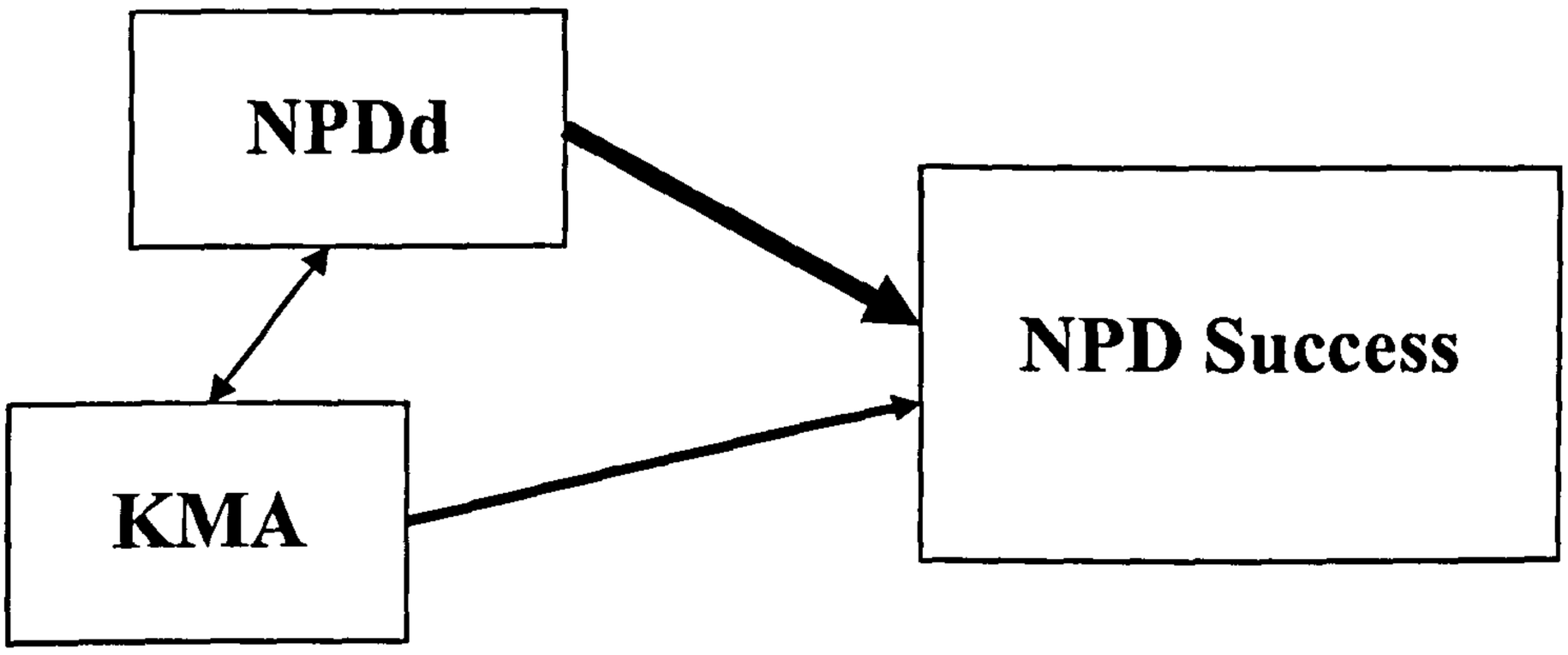
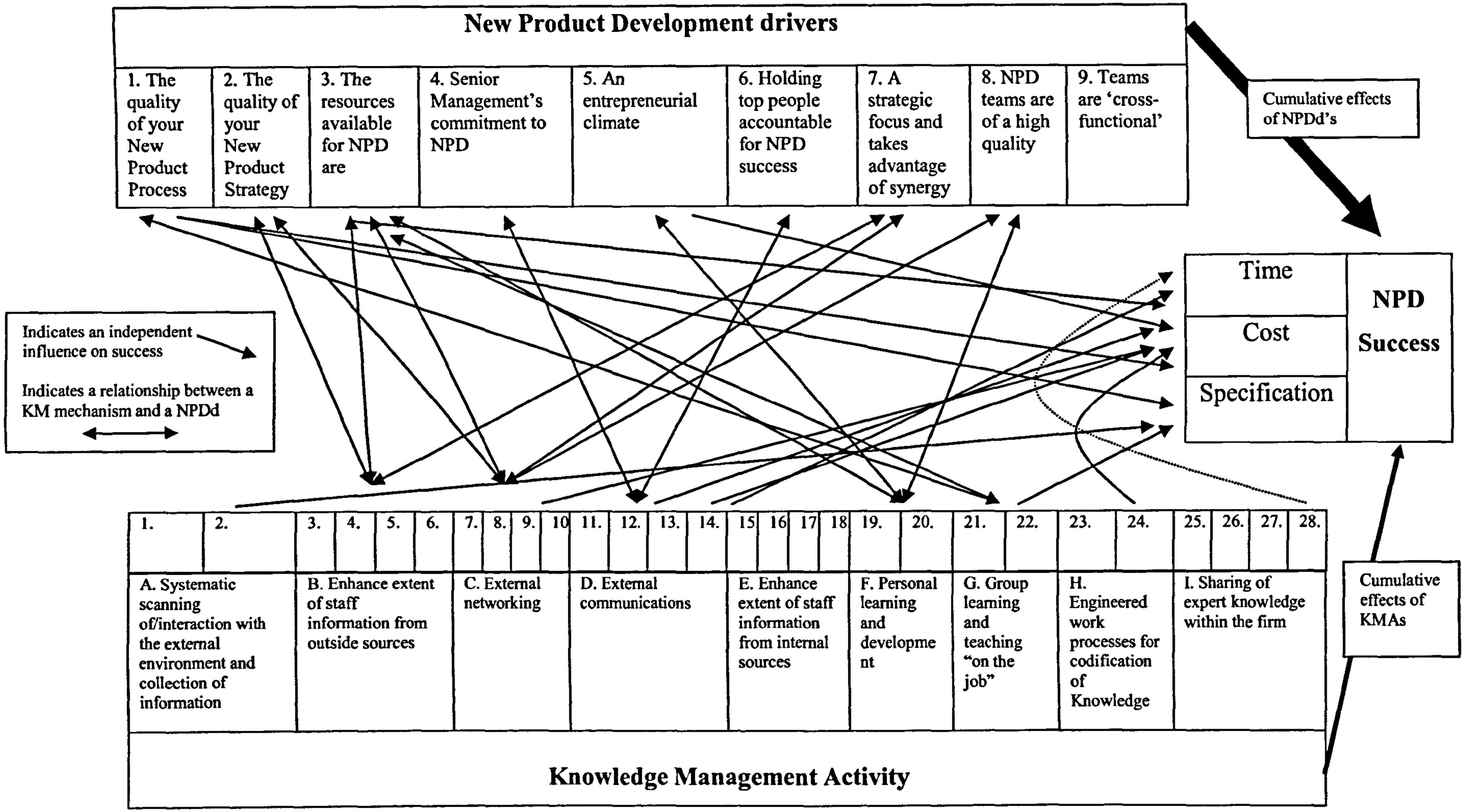


Diagram 13. A detailed model of the relationship between KMA, NPDd, and NPD process success:



5.5 Implications for policy and practice

The fields of KM and NPD have a considerable weight of academic literature concerned with theory and principles abstract from the practice of the discipline; but much larger still is the practical and applied empirical research available. In fact, most research in NPD, and an increasing amount in KM, is aimed at highlighting better practice and underscoring success in the field. This thesis was inspired by two factors emanating from such practical research; one, to design a test that would add empirical weight to KM's claims; and two, to examine the importance of KM in the well understood NPD field. This study has shown that KM is both measurable and a significant influence on NPD success. Given such knowledge, what are the implications for managers working in the private and public sector?

5.5.1 Private sector managers

First, managers who have a choice over the tools and practices used in the NPD process need to consider context prior to selection. While not among the four major research questions, the study has highlighted that company size, industry sector, and what stage in the development process the project is in, are all correlated with the KMAs used. This is surely nothing radical, but seems worthy to emphasise given that many KM "solutions" are sold on the basis of their success in other organisations. It is worth asking where such tools have been successful, and why they might help given an individual project's context.

This being said, most organisations involved in NPD were shown to be at least aware of the nine NPDd, possibly because they have become part of the vocabulary in the field, and had considered the implications of KM. So two related considerations become: to what extent they are already competent in the nine, and if so, do their NPD teams use the seven (positive) KMAs prescribed by this study. In the first instance this study has shown that increased proficiency in the NPDd leads to increased process success. Organisations deficient in the nine NPDd might do well to concentrate efforts in what have become industry standard practices (at least among larger organisations). Second, if already proficient at the nine NPDd, then (considering context) they should focus effort on the acquisition and use of the seven KMAs. In this study the seven KMAs are shown to increase process performance at

the project level above and beyond that which can be achieved by company level ability in the NPDd.

While it is possible to make such simple suggestions based on the statistical averages provided by the study, the simple addition of the seven KMAs to a well-rounded NPD firm is unlikely to create true competitive advantage. Thus this study underscores the principles from the conclusions sections: there is a need for organisations that rely on NPD to generate economic returns to track and evaluate their knowledge embedding process. A reoccurring phrase in this study was that NPD is inherently a process of knowledge embedding. KMAs are said to be of importance because they provide direct mechanisms for transferring knowledge. This is simple to understand and simple to apply. Unfortunately the KMAs recommended in the findings section are not enough; so the broader task for senior managers is to consider the extent to which the entire process embeds knowledge. Does it? As the literature review highlights: does it loose knowledge? Does it know what it knows? Can it use what it knows? Can it create really new knowledge? Can it keep it? This study highlights that organisations use as many different combinations of NPDd and KMAs to achieve NPD success, as there are projects to apply them to. The question therefore becomes an ongoing one, and cannot end at the addition of a single new system or recognition of best practice.

If organisations have considered their knowledge flow or embedding process, then they might have a better idea of which activities are necessary, and which simply replicate effort. This study has highlighted that four general KM mechanisms, and many more KMAs, are directly correlated with existing NPD practices. On the one hand this could mean that they are valuable antecedents of the applicable NPDd's, and so should be attended to less the company fail to achieve what has become the industry standard level of competency. On the other hand, it is also possible that such KMAs merely replicated the existing NPDd, as is often claimed by those who call KM "old wine in new skins." Thus the astute company manager or NPD project leader will consider why a given KMA is being used, possibly in the light of having considered the knowledge embedding process discussed above.

A more simple implication of this study comes from consideration of the success measures used. Private sector managers working in NPD have fairly simple tools available to measure performance. So, it is worth asking which performance variable they, their shareholders, or the industry at large, values. While it may be considered to

be important to some to conform to all budgeted process factors (time, cost and specification), other organisation will seek new tools and practices on the basis of one critical process variable. It is possible to suggest that process time has become more important in clothes development in recent year. Conversely, it seems that the introduction of new operating systems has slowed, with a focus on truly revolutionary specification, those likely to be unique when they are finally unveiled to the marketplace.

Finally, private sector managers, even those working outside of NPD, need to consider the totality of the knowledge issues in their organisation. While this study has focused on the value of KM to NPD process success, it is impossible to ignore that the management of knowledge has much wider ramifications. Without stepping too far away from the work conducted in this study, the literature examined warns private sector managers to be weary of: where and in what state the knowledge they need for NPD is; how they might then find and apply it; how much remains or is formed in human head; that they might loose some through the process of by it "walking out the door;" and that knowledge is they key added value here in the UK, so to consider what their actions do to the knowledge base as more important than what happens to the capital base, in the long run.

5.5.2 Public sector analysts

The UK, with its high property and human capital costs, is unlikely to ever again be a viable location for the development and manufacture of low value goods. Thus organisations must continue to invest in their knowledge capital and capability. This was recognised as early as the 1960 by many countries in Northern Europe, as is evidenced by some of the large, NPD driven, organisations in the region. This private industrial ability has been developed in conjunction with the government, such as Finland's well-known development policies of the 1970s. Even in the USA, with its highly non-interventionist government, support has been given to the private sector through partnerships with national research councils and through the university sector. In short, this is to say that if the UK is to have success in building a robust knowledge economy, it must provide the support for industry seen in other countries on the knowledge issue. KMAs are becoming an increasingly well-understood body of practice, but knowledge of them is distributed, and they are often misunderstood. It is

the suggestion of this study, therefore, that the public sector become more involved in providing information about how to manage knowledge. This is closely related to the economics literature on national systems of innovation. Freeman (1995) argues that organisations have historically only prospered in the field of NPD where they are supported by public sector agencies, workforce training, and knowledge sharing. To some extent this is already being done through the DTI, university knowledge Transfer Partnerships, and through the Public Private Initiatives. By the same token this study suggests that this should not simply be limited to knowledge about what to do (know what) but rather how to evaluate why this may or may not work (know why). This study provides some guidance for public sector analysts, who may wish to advise SMEs on how to capture, transfer, and embed knowledge through consideration of KM mechanisms. The question remains how can the public sector share this information effectively to those most likely to help the UK's economy in the future.

From a less interventionist perspective, the public sector could also use this study as the basis for a new measure of NPD firm performance. While the DTI has good external measures of innovation and investment, there are very few decent internal measures. This has helped narrow the UK's public and private sector's view on what is good NPD to simple short term cost and profit measures when, like Northern Europe (Werner and Souder, 1997) or Japan, they might do better to consider the importance of technical skill, product quality, and long-term capability leadership. This study provides tools to evaluate if organisations pursue efficient and effective NPD, without confusing this ability with immediate success in the market place.

5.6 Limitations to the generalisability of the conclusions

In chapter four a number of limitations to this study were outlined. In the light of the discussions and conclusions above, it is necessary to extend, and in some cases revise these limitations, as follows:

The final test group represented a mere 5, out of 24 possible, industries in the UK. Furthermore, while the pilot attempted to gain a representative sample of the top 200 firms based on RandD spend (in addition to the SMEs asked), the number that responded was smaller than what would have constituted a representative sample. This is to say that while many of the data patterns reflect those outlined in

the literature; it is not possible to argue that the statistical results of this study can support replication of the findings in the population as a whole. The study is also, of course, UK centric as all of the organisations were located and headquartered in the UK. This is in contrast to the foundation work taken from the literature, which is often done across multiple (if usually western) countries.

Using 124 projects across five companies provides little more than the minimum needed for the regressions preformed on the KMAs. It does not, however, provide enough n values per attribute to do factor loading, which may have uncovered the significance of each correlated KMA to the strength of their corresponding NPDd.

It is also unfortunate that several of the companies who had agreed to participate pulled out after the questionnaires were sent. If they had responded test significance would be stronger. Furthermore, this forced the significance tests to be done at the 95% level. A larger sample size would mean some non-significant results could have been found to have a significant relationship.

In the final sample there were too few responding companies of each type to separate out specific projects groupings and perform a company size, industry, or phase comparison using regression analysis. Given a larger sample size in the future, this could yield more specific data on where and when to best apply each NPDd or KMA.

The test model used assumes that existing NPDd should be entered into the stepwise regression first because of their significance in the literature, but there was no clear indication from the data analysis or responses to the survey tool that this must be the case. Entering the NPD factors first ensures they are given the best chance to explain variance, as is demonstrated by their position at the top of each list in the findings tables under question number four, chapter four.

It had been recognised early on in this study that it was not possible to do a factor analysis of the 28 KMAs. To generate factorised KMAs would have taken an impossibly large sample size considering the scope and scale of a doctoral thesis. If it had been possible to do a factor analysis on KMAs, it would be possible to test the factors to see if they fit well together using reliability analysis (Cronbach's alpha). Given that the study used pilot responses and literature to support the claim that the 28 factors are representative of 9 more general

mechanisms, such factor and reliability analysis would have provided valuable empirical support.

While the use of questionnaires is common research practice in the NPD and KM fields, the study is still limited in its validity as there was no observation of the activities performed or products developed. Thus, it is possible to argue that many of the KMAs are used either more or less depending on the likelihood that the respondents desired the researcher think about their NPD activities and procedures. It is also possible to argue that the respondents who reported solid NPDd capability would have reported generally positive process results. This "positive leads to positive" academia was a major criticism levelled against other authors in the NPD and KM fields.

5.7 Further research

The majority of the literature review and data analysis was completed prior to the author's ability to submit the finalised thesis. In the intervening months the author evolved some ideas from the thesis into further research in the form of agendas, articles, and conference papers. As they are direct consequences of this study, and show where the work may develop in the future, it seems pertinent to include them (below).

The first development of research associated with this thesis was an Article (Subsequently accepted for publication in Journal of Knowledge Management, citation pending), which sought to expand the theoretical implications of deliberate KM for NPD. While the models and conclusions were mainly the work of the first author (Martyn Pitt), the grounding literature review linking KM and NPD issued from the research done to write chapter two of this thesis. Interestingly, the published article provides a unique model underscoring the importance of knowledge transfer between locations and states in the NPD process, which in retrospect can be supported by some of the empirical findings in chapter four.

The second development of research associated with this thesis was the presentation of a limited set of findings at the 14th International Product Development Management conference in Porto (June 2007). Prior to the conference, the author submitted an 5,000 word article which posited that some KM tools and practices, supported by appropriate KMA, were new and independent influences on NPD

success; that KM was the "10th NPDd." The presentation was well received and the article was published as part of the proceedings of the conference. The author plans to use feedback from the conference to publish an empirical paper dealing with the increased explanation of variance independent KMAs/KM mechanisms add to the existing models of NPDd.

The final development of research associated with this thesis was an informal discussion held with three of the respondents from the sample (August, 2007). During the discussion the author showed the NPD project members the results and highlighted the independent drivers of success. The major question for discussion was why any of the independent drivers may or may not have been a critical success factor in the project on which they had reported. After the discussion and a brief review of the notes taken, three key themes emerged:

1. Resource dependence (a NPDd) was considered the most significant in each case. Numerous "stories" were told about resource dependent issues, as could be expected to be the case in any project.
2. The idea that Internal Communications (a KMA) was important was also noted, though there was some general derision over how some organisations did this. Accordingly the group agreed they did not like to use electronic forums, nor email, for debate. The preference was one-on-one discussion, often with physical or paper representations of the issue at hand.
3. The group agreed that prototyping was a key activity for success in specification. They did not see it as a KM activity, though conceded that it had implications along the lines of embedding knowledge.

The author notes that this discussion was conducted speculatively, but he found it rewarding. This experience points to the value of qualitative enquiry in the KM field to an extent he had not previously realised. For the author, this meeting has confirmed some of the thinking that took place during the results analysis. In other respects it provides an impetus for action, as while the group espoused to use certain tools and practices, there was not enough time to fully explain why each may or may not have worked. This theme is continued under 'future research,' below.

5.8 Future research

The author considers this dissertation as a substantial and unique contribution to the fields of KM and NPD, but also finds that as many interesting new questions have developed over the past four years of study as have been answered herein. Accordingly the author would like to highlight three further areas of study he is likely to undertake after the completion of this PhD.

The most pressing issue from the study is the need to do a more qualitative/case-based investigation of why these KMAs have this effect on NPD projects. As the brief discussion with some of the respondents has show, there are mixed feelings about the value of any given tool or practice, which is also likely to influence their uptake and use. The author is likely to ask one of the project organisations to allow greater access for a case study based around the KMAs of projects teams, asking *when* they use the KMAs, and more significantly *why* they think they might be of import. Such a study would take some time and the problem of agreeing access is not an insignificant one.

A second issue from the study is the need to further examine relationships between non-independent KMAs and NPDd. While it is possible to argue that some of these KMAs merely replicated or are re-labelled NPDd; the statistics hint that others may be genuine antecedents, not independent influences on success, but influences on the capabilities that make up the NPDd. In many respects this work has done by other researchers (Darroch, 2005; Liu, et al., 2005) and some is apparently in progress (Sveiby, 2000). On the other hand this work remains at the level of the organisation, and does not consider the relationships between specific activities, as was critiques in chapter two. Again, collecting data for such a study would not be an easy task given the need to survey a large number of NPD project teams about their working practices.

Finally, the author would like to study the knowledge embedding chain without using specific labels for NPD and KM activities taking place. The most repeated phrase from this thesis has been: NPD is a knowledge embedding process. As this is the case it would be valuable to know more about how knowledge gets embedded, and to what extent this can be managed. Given the current fascination in academia with knowledge creation, it would also serve to underscore the value of the process to NPD as of equal import to one off discoveries or novel innovation.

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Interview with Karl-Eric Sveiby accessible via:
http://www.sveiby.com/articles/FAQ.htm

Appendices:

A Discussion of three Streams of NPD research:

1. Product development as an exercise in "Rational Planning";

This rational plan perspective emphasises that successful product development is the result of (a) careful planning of a superior product for an attractive market and (b) the execution of that plan by a competent and well-coordinated cross-functional team that operates with (c) the blessing of senior management...The focus in this stream is on discovering which of many independent variables are correlated with the financial success of a product-development project (Brown and Eisenhardt, 1995).

The importance of researching the NPD phenomenon was understood as early as the 1960's (Myers and Marquis). Much of the work done at that time focused on "market-pull" as the driving force for innovation. These early studies provided an atheoretical methodology, which characterises much of the work that followed. Carrying on with a chronological perspective, the next "period" of rational planning research exposed the importance of process cost and the support of leaders to the NPD mix. More detailed studies tracked failures, the external environment, and industry differences (Rothwell, 1972, Gerstenfeld, 1976). From about 1979 the field became more popular in the wake of the expansion of high-tech firms and the "technology-push" of other dynamic industries. The seminal "NewProd" studies were carried out by Cooper and Kleinschmidt, and repeated several times since (often re-evaluating the hypothesise and results from the previous work). These provide a greater depth of data to claims made about the importance of certain development mix variables as correlated with known "success measures". This list varies in size, but has at least four or five components that are commonly agreed to be important, including the market context, leadership influence, product advantage, internal organisation, and more recently NPD throughput speed.

Rational Planning research is usually exploratory. These studies seek to capture independent variables of success via questionnaires and interviews in companies developing new products. Research programs initially used single informants and a wide range of possible variables. Their results are often argued to be less than academically rigorous. One reason for this is the direct correlated of hypothetical variables with financial measures. This led to prescriptive thought that was supported

by no theoretical understanding of the relationships implied. Later studies include more refined methods, such as multivariate analysis, multiple informants, and cross-industry comparisons. Such studies are still part of academic practice today. While this work has become more empirically rigorous, it still mainly produces descriptive theory. Sensibly, authors in this field now write their prescriptions more like: "X set of positive variables tends to impact companies in Y industry, with Z market conditions...and so following set of recommendations Xr should tend to improve NPD success, if measured by the set of industry standard financial and non-financial indicators used in this study".

According to Brown and Eisenhardt (1995):

> *This broad-brush approach leads to an excellent and a comprehensive overview of the product, internal organisation, and the market. This same breadth, however, also undermines the contribution of this stream...the findings of many studies read like a "fishing expedition" too many variables...not uncommon for a study to report 40 or 50 important findings...*

Even with increasingly complex regressions of the data, it seems impossible to measure or predict the exact effect of management's chosen NPD mix. If this is true, how can researchers then expect to separate positive variables from the wider context of organisational behaviour and the modern dynamic operating environment?

2. Product Development and the importance of the Communication Web;

> *This research has evolved from the pioneering work of Allen (1971, 1977). The underlying premise is that communication among project team members and with outsiders stimulates the performance of development teams. Thus, the better that members are connected with each other and with key outsiders, the more successful the development process will be* (Brown and Eisenhardt, 1995).

This NPD field differs in two important ways from the Rational Plan perspective. First, it is narrowly focused, with internal and external communication as the subject. Second, it tends to examine the team as a unit of analysis, not the organisation. With this focus researchers first examined the communication habits of various NPD professionals (e.g., Allen, 1971 and Tushman and Scanlan, 1981). Researchers asked these professionals to note how and to whom they were communicating. Hypothesise generated from these initial studies suggested that external communication is the most important to process success. Of these professionals, an important sub-class were

labelled *Gatekeepers*. The Gatekeepers were the highest performing external communicators, and were observed both bringing external information to their group, as well as facilitating outgoing communication from group members. Groups with Gatekeepers tended to outperform those without them, even when the individually high contribution of the Gatekeeper was discounted. Von Hipple (1986) adds that such Gatekeepers often also aid in communication with key customers, which became regarded as the second most important form of communication exercise. Reviewing the chronological midpoint of this field, Brown and Eisenhardt (1995) point out *'The authors (Ancona and Cladwell, 1990) developed a typology of external communication or "boundary-spanning" behaviours.'* These include Political Activity, Task Coordination, Scouting, and Guarding. Furthermore, this typology posits that communication; is influenced by strategy, politics, task orientation, frequency of use, and selection of method. Further ideas generated include the purpose of the communication, the resources generated by politicking, and the measured effectiveness of the mix employed.

While the explanations generated in this first "period" became well know, as an outline for research in NPD communication the theories seem overly one sided. More recent research in this field has taken up the idea of coordination. This research implies that internal communication among team members has a significant effect on NPD performance. Keller (1986) Dougherty (1990, 1992) among others found that teams with "better" internal communication outperformed those whose communication appeared to be "less skilful". Reviewing this research exposes several important concepts. First, the process of planning and communicating the plan tend to correlate highly with successful projects. Second, different departments tend to have different systems of knowing, systems of learning, and systems of sharing what they knew. Understanding how others communicated was key to group cohesion. Third, any number of internal barriers may exist that will prevent normal team communication and negatively impact overall NPD performance. Although, it is not the presence of the barriers, but the ability to overcome them, that seems to distinguishes good NPD performers from the rest. Fourth, overcoming cross-functional communication issues in teams seems to be correlated with increasing communication, setting concrete tasks, and generating a common understanding of the process ahead. This discovery goes against more classical perspectives on management (as espoused by Taylor, Weber, Fayol etc.) that it is functional

specialisation and formality that correlates with high efficiency and effectiveness. Fifth, the effect of time is considered to be significant to team communication (Katz, 1992), but the effects of this factor seem to be related to the context debate.

After examining both sides of the communication web literature, Brown and Eisenhardt (1995) suggest:

> Two themes emerge in the literature. One, an information-processing view, emphasizes that frequent and appropriately structured task communication (both internal and external) leads to more comprehensive and varied information flow to team members and, thus, to higher performing development processes. The second, a resource dependence view, emphasizes that frequent political communication (typically external) leads to higher performing development processes by increasing the resources...available to the team.

Critically reviewing this body of work, it seems that the information processing theme may be the most significant area for investigation of the effect of KMA. Specifically I propose that KMAs may impact NPD success if they can be shown to act as a moderating influence/variable on the communication activity of the NPD group.

3. Product development as a Disciplined Problem Solving Exercise:

> *This stream evolved from studies of Japanese product-development practices in the mid-1980's (e.g., Imai et al., 1985; Quinn, 1985). In this case, successful product development is seen as a balancing act between relatively autonomous problem solving by the project team and the discipline of a heavyweight leader, strong top management and an overarching project vision. The result is a fast, productive development process and a high-quality product concept* (Brown and Eisenhardt, 1995).

The Disciplined Problem Solving stream of NPD research is typified by its focus on effective work *organisation* and the importance of the *process* employed. It differs from Rational Planning as it tends to ignore financial success data; and from the Communication Web as it counts communication as just one element of a broader system, not a means of its own.

Early research findings include the following key concepts. First, companies with *strong formal ties* to suppliers and *RandD networks* were always perceived to have high technical skill. Technical skill is empirically linked to NPD success in studies across all three NPD research streams, and in the Problem Solving stream it is seen as

even more important. Second, cross-functional development teams, especially those composed of members with varied functional knowledge and access to information, tend to correlate highly with NPD success. This has been attributed to the ability to overlap development phases, gain the commitment of internal stakeholders, and bring diverse problem solving skills to the3 process. This is also one of the key findings in the Communication web literature stream. Furthermore, the *overlapping development phases* facilitated by these cross-functional teams is proven to reduce NPD cycle time, although the findings of the Problem Solving stream often ignore the complexity of this goal. To overcome this weakness, researchers point to *support by continuous communication,* as a regulating variable in the *overlapping development phase* process. Third, Communication Web researchers such as Imai have highlighted the *importance of subtle control by senior management*, to NPD success. This concept is not present in either of the other two major NPD literature streams. The reasoning behind "subtle control" is that it helps maintain the delicate balance between creative problem solving and central corporate control and over al strategy alignment. While other researchers have deepened these claims, they still rely on case studies, which makes it difficult to actually measure what level of control is being exerted and how much freedom the NPD team members actually think they have.

According to Brown and Eisenhardt (1995) it is possible to identify a 'more recent' set of findings in the Problem Solving stream. This includes the importance of: redundant information and communication, team leaders, product integrity, and predevelopment activities. The problem with this thought process is that it becomes hard to separate such findings from the findings of the other two research streams. In fact, much of the "newer" NPD literature has become convergent, as is demonstrated by Brown and Eisenhardt's attempt to build a single theoretical framework from an analysis of these three streams. What might be justifiable as actually new in this stream is the exposition of the applicability of earlier findings to more scientific NPD processes; and, the value of a high systems focus to overall NPD success. This "systems focus" can include: technical integration, systems integration, accumulation of knowledge, and the interaction of knowledge users. According to Brown and Eisenhardt (1995):

> Thus, these results suggest there are two relevant problem-solving models for organizing product development. One focuses on factors such as planning and

overlap that are relevant for more stable products...and the other focuses on experiential product design that is relevant for less predictable products...

Either of these two solutions seems interesting for those interested in NPD, but it is important to understand key flaws in this line of thinking before it is generalised across all NPD teams within organisations. First, as Brown and Eisenhardt (1995) point out:

> *One is that there is a lack of political and psychological realism...there is little appreciation of the problems of actually motivating people...moreover the heavyweight leaders seem almost "superhuman" in their skills an duties. Second, some of the constructs are challenging to comprehend...this lack of clarity may reflect the complexity of the subject...it also impairs the usefulness of the perspective. Finally, there is an extensive reliance on a Japanese viewpoint...makes it unclear which features are important to product development and which are simple Japanese.*

Second, from an academic perspective, even though the metaphor of problem solving is a very powerful one, the stream is often still no closer to proving the links between what is observed and success as it is measure. This seems a flaw in fully exploring the "black box" that the literature espouses to expose.

<u>Towards an integrated model of NPD:</u>

While it proves useful, in some respects, to categorise NPD literature as Brown and Eisenhardt do, it is also important to consider how the combination of the work to date informs a more general understanding of NPD practice. The NPD research papers written by Cooper and Klienschmidt; van der Panne, van Beers and Kleinknecht; Brown and Eisenhardt, among others, each include an element of integration. This aims at solving the "problem" of NPD, in the sense that most important variables are "known". Which threads do these key figures see as most important?

Cooper and Klienschmidt (1995) use detailed questionnaires and complex statistics to support their opinion that the following nine constructs drive NPD performance:

1. A high quality new-product process, 2. A clear, well-communicated new product strategy, 3. Adequate resources for new products, 4. Senior management

commitment to new products, 5. An entrepreneurial climate for product innovation, 6. Senior management accountability, 7. Strategic focus and synergy, 8. High-quality development teams, and 9. Cross-functional teams.

Brown and Eisenhardt (1995) create an 'Integrative Model' from their three strand investigation of the NPD literature:

> *The organizing idea behind the model is that there are multiple players whose actions influence product performance...Thus, process performance is driven by the amount, variety, and problem-solving organization of information... and by the resources available to the team. Product effectiveness is driven by the input of leaders, senior management, and customers into the formation of a clear product vision (and less well-understood process). Both product effectiveness and process performance influence the financial success of the product.*

More recently van der Panne, van Beers and Kleinknecht (2003) examined 43 of the more well known NPD/innovation project papers and found agreement about the following seven factors that will enhance success:

- *A firm's culture that is dedicated to innovation and explicitly recognizes the collective nature of innovation efforts.*
- *A firm's prior experience with innovation projects.*
- *The multidisciplinary character of the RandD team: in particular a balance between technological and marketing skills, and the presence of a product champion.*
- *A clearly articulated innovation strategy and a management style suited to that.*
- *Compatibility of the project with the firm's core competencies.*
- *An innovation's product quality and price relative to those of established products.*
- *A good timing of market introduction.*

B Knowledge Management Definitions and Axioms (Holsapple and Joshi, 2004):

Definitions:

Knowledge – That which is conveyed in usable representations.

Much of the current KM theoretical literature base deals with the concept of knowledge, and Blackler's 1995 piece is no exception. He writes that knowledge can be considered as '*Embrained, Embodied, Encultured, Encoded, and Embeded*'. This being said, he also reminds the reader in the abstract that '*Attention should be focused on the systems through which people achieve their knowledge and on the processes through which new knowledge may be generated*', which seems to imply that organisations and universities would be better served through research into how to conduct KM rather than ever finer perceptual definitions of knowledge. Some take this to mean broad systems of learning, but it may also be taken to mean a focus on how organisations achieve their knowledge activities. An analysis of the effectiveness of such systems and practices, therefore, seems a significant goal for academic research in this field.

Knowledge Management – An entity's systematic and deliberate efforts to expand, cultivate, and apply available knowledge in ways that ass value to the entity, in the sense of positive results in accomplishing objectives or fulfilling its purpose.

The key phrase in this chosen definition is '*systematic and deliberate efforts*'. The reason for this is two fold. First, the word *effort* implies that KM is an activity to be carried out, not some valued object that sits in a room to store wealth. Later on in this document Activity Theory will be posited as the way to understand how KM may affect NPD outcomes. Without the explicit choice of KM as *effort* it is much more difficult to prove that KM has any impact on the success/failure of the development process. Second, the seemingly best way to highlight the value of KM is to examine those activities explicitly known as KM. If KM can be anything, then there is no way to separate KM from all the other context bound activities of the subject company, and therefore, no way to make broader generalisations from the study data.

Personal Knowledge Management – Knowledge Management conducted by an individual.

Organisational Knowledge Management – Knowledge Management conducted by an organisation.

Holsapple and Joshi (2004) list four kinds of KM. For this study the two that best represent KMAs have been chosen as they both relate to organisations involved in NPD.

Knowledge Resource – Knowledge that an entity has available to manipulate in ways that add value.

Schematic Knowledge Resource - A KR whose existence depends on the existence of the organisation.

Content Knowledge Resource – A KR that exists independently of an organisation to which it belongs.

Environmental Knowledge Resource – Knowledge that exists in an organisation's environment that is potentially accessible/available for acquisition.

Knowledge Artefact – An object that has no innate knowledge processing skills, but which is (or holds) a representation(s) of knowledge that may be usable to at least one knowledge processor in the organisation.

Participants Knowledge – Knowledge possessed by a knowledge processor that participates in an organisation.

Knowledge Processor – A part of (i.e., a participant in) an entity that possesses skills allowing it to implement some range of knowledge manipulation activities with varying degrees of effectiveness.

Knowledge Manipulation – The processing of usable representations.

Knowledge Processors and Knowledge Manipulation are the closest theoretical definitions to this study's posited Knowledge Management Practice. A variety of possible KMAs are discussed in the next section of this review (Knowledge Management Practices and Links with the process of New Product Development).

Knowledge Manipulation Activity – A kind of knowledge processing that can be recognised and characterised independent of the nature of the knowledge representations being processed.

Knowledge Acquisition – A KMA comprised of identifying knowledge in the entity's environment and making it available in a suitable representation to an appropriate activity.

Knowledge Selection – A KMA comprised of identifying knowledge within an organisation's existing base of KRs and providing it in an appropriate representation to an activity that needs it.

Knowledge Assimilation – A KMA that alters an entity's KR, resulting in learning.

Knowledge Generation - A KMA whereby an entity derives or discovers knowledge in the context of exiting knowledge.

Knowledge Emission – A KMA that uses existing knowledge to produce projections for release into the environment.

Numbers 14 through 18 are Holsapple and Joshi's five KMAs. While they do *represent* the bulk of what can be called KMAs, this study will highlight some more numerous and common activities as the "indicators" of KMA in the observed organisation.

Knowledge Flow – The transfer of knowledge form one KMA to another instance, possibly involving a transformation of the knowledge representation.

Ancillary Message – A message that an instance of a KMA sends to another activity instance in order to issue a request or provide feedback, clarification, or evaluation.

Knowledge Management Influence – A factor that determines how an entity's manipulation of knowledge unfolds in the course of knowledge management.

Things that influence KM are also listed amongst those that influence NPD. This both adds value to, and complicates, the collection of data for comparing and contrasting the various NPD groups.

Knowledge Management Episode – An entity's execution of some configuration of KMAs by some collection of processors, triggered by its intent to satisfy a knowledge need or opportunity, operating on available KRs, subject to knowledge management influences, and yielding learning and/or projections.

Conduct of Knowledge Management – An entity's ongoing execution of various knowledge management episodes, often configured in interrelated patterns and governed by knowledge management influences.

Understanding *how* the test organisation 'Conducts KM' is one half of the equation in evaluating the affect of KM on NPD.

Axioms:

Knowledge has a variety of attributes including mode (tacit vs. explicit), type (descriptive vs. procedural vs. reasoning), orientation (domain vs. relational vs. self) applicability (local vs. global), accessibility (public vs. private), immediacy (latent vs. currently actionable), perishability (shelf life), and so forth.

This Axiom helps this study given that much time could be wasted evaluating various attributes and definitions of knowledge. All that is really needed for this study is the understanding that knowledge may mean different things based on a number of contextual variables. The choice of *what* it means is unimportant if what the study aims at is an understanding of management process, and not the theory behind the existence of the variables under examination. This ontology gives the broadest

meaning possible and so encompasses most of what respondents might think knowledge is.

An organisation's knowledge resources can be manipulated by human resources and/or material resources (i.e., computer systems).

This will be discussed in the section titled 'Knowledge Management Practices and Links with the process of New Product Development'. It will list the selected KMAs that represent what *manipulates an organisations KRs.*

Effectiveness of a processor's action can be impacted by the context within which that action is implemented.

This is a key method issue. How does the study control for those elements that impact KMAs, NPD, or both, without explicitly changing the selected mix of KMAs

A knowledge processor may be individual or collective.

There are five types of knowledge manipulation activities that can occur in the conduct of knowledge management.

There are four kinds of schematic resources: culture, infrastructure, strategy, and purpose.

The six types of knowledge resources (participants' knowledge, knowledge artefacts, culture, infrastructure, purpose, and strategy) are both distinct and interrelated.

C KMAs, NPD metrics, and Known NPD Moderating Variables generated from the literature:

KMAs list: (as used in the pilot)

- Document Management tool/practice
- Data/information management tool/practice
- Searching tool/practice
- Indexing tool/practice
- Expertise locating tool/practice
- Communication tool/practice
- Problem solving tool/practice
- Information/knowledge sharing tool/practice
- Information storing tool/practice
- Knowledge/information mapping tool/practice
- Knowledge/information creation tool/practice
- Information gathering/capture tool/practice
- Disruptive/inspirational tool/practice
- Power/political tool/practice

- Decision making tool/practice
- Information subscription tool/practice
- Notification tool/practice
- Publishing tool/practice
- Filtering tool/practice
- Contextualisation tool/practice
- Data entry tool/practice
- Valuing tool/practice
- Measuring tool/practice
- Evaluating tool/practice
- Currency estimating
- Validation tool/practice
- Identification tool/practice
- Monitoring tool/practice
- Purchasing tool/practice
- Selling tool/practice
- Planning tool/practice
- Security tool/practice
- Leadership tool/practice/role
- Other Knowledge Information Data tools/practices
- Knowledge/information Abstraction tool/practice
- Knowledge/information Translation tool/practice
- Knowledge Delivery tool/practice
- Knowledge Strategy development tool/practice
- Knowledge Recovery tool/practice
- Knowledge review tool/practice
- Formal notification tool/practice
- Knowledge Accounting tool/practice
- Knowledge Validating tool/practice
- Human Resource and Knowledge Management tool/practice

NPD metrics list:

1. Time to Market
2. Total cost
3. % over/under targeted cost (Known as Budget)
4. % over/under targeted time (Known as Plan)
5. Group/product contribution to sales (Known as NPD Impact)
6. % successes/failures (Closely tied to the contribution of the Development stage)
7. % over/under targeted successes/failures (important to PD managers)
8. % accepted by next stage/management (Key metric in Germany)
9. Other Bayer metrics (Population specific)

Factors known to affect NPD:

- Process has strong focus on Execution
- Process has strong focus on Completeness
- Process has strong focus on Quality
- Process has strong focus on Pre-development Activities
- Process has strong focus on Product Definition
- Process has strong focus on Market Orientation
- Process has strong focus on Customers Involved
- Process has tough rules for Go/Kill Decisions
- Process has strong focus on Flexibility
- Process has strong focus on Performance Measurement Metrics
- Has a multidisciplinary team
- Fast management decisions
- Fast team lead decisions
- Slack time/Creative time available to group
- Senior management commitment for team/group
- NPD metrics part of senior management objectives
- Senior management commit resources to group
- RandD Inputs adequate
- RandD funding adequate
- NPD group has adequate Human Resources
- RandD has adequate Human Resource
- NPD stages have metrics and measures
- Senior management involved in Go/Kill decisions
- Clear corporate goals for NPD
- Group rolls clear to all
- Group goals clear to all
- Long term thrust for NPD
- New products aimed at familiar markets
- Strong ties to key suppliers/partners
- Involvement of gatekeepers
- Commitment of internal political leaders
- Adequate access to information resources
- Adequate access to technical resources
- Adequate access to communication resources
- Experienced PD team
- Low barriers to communication outside of group
- Links with related networks/communities of practice
- Opinion of communication
- Overlapping development stages
- Creation of redundant information
- Rigidity of functional structure

D Criteria for evaluating theory (Gioia and Pitre, 1990, Bacharach, 1989):

Opening work:

Selecting a topic:
What are the issues?
What are the research questions?
Reviewing literature:
What do we know?
Finding a gap:
What is missing?
Putting together a framework:
What are the relevant theories and variables?
Formulating hypotheses:
Designing research:
What are the data?
Where to find data?
How to measure the data?

Data Collection:

Probing representative samples of subjects:
According to hypotheses formulated

Analysis:

Testing hypotheses:
Evaluate the significance of the data according to initial problems and
Hypotheses

Theory Building:

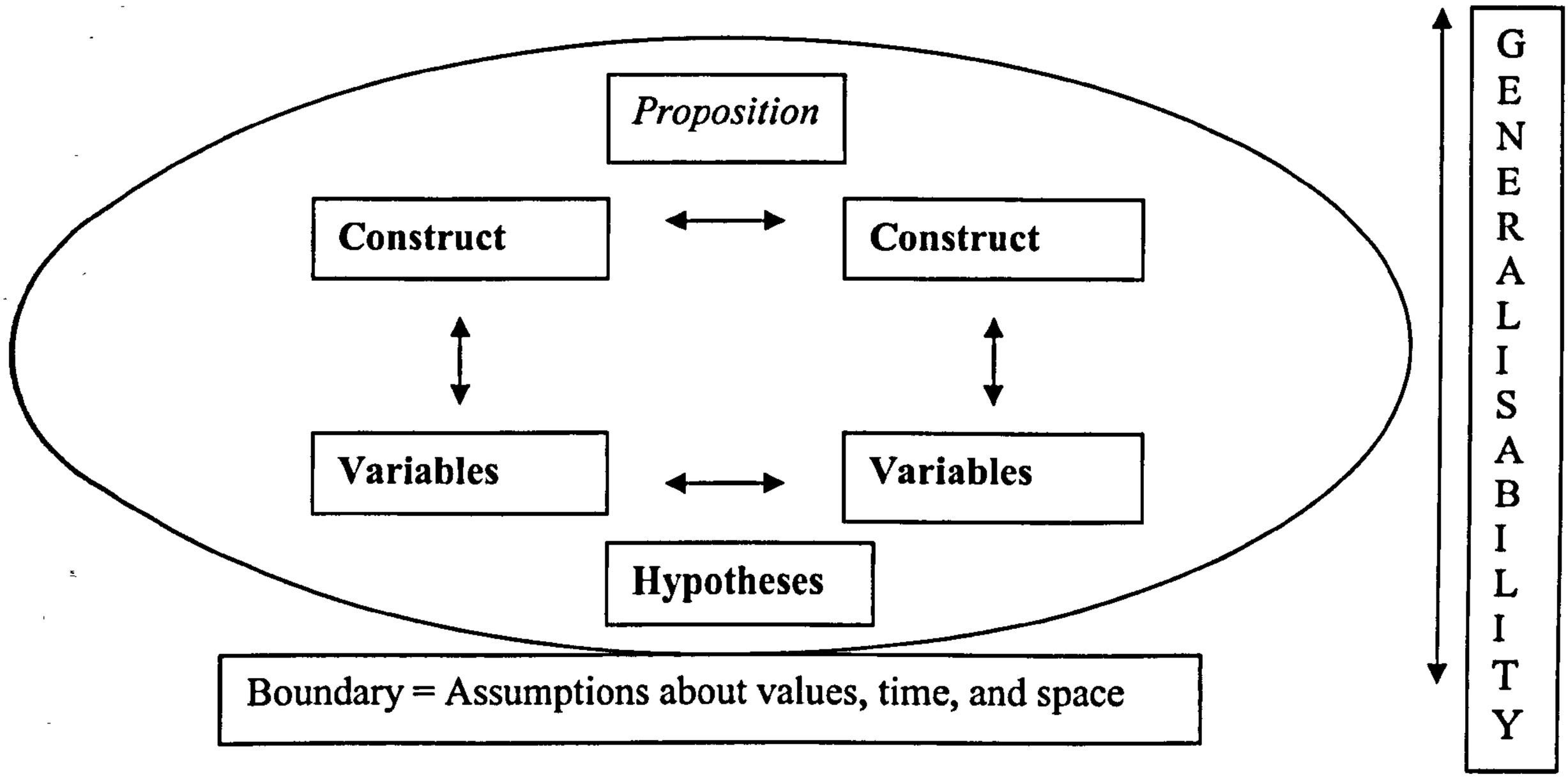
Writing up results:
Show how the theory is refined, supported, or disconfirmed
Show what it tells scientific community and the practitioners

These methods represent a synthesis of scientific criteria from many authors, but significantly, Popper, Dubin, Nagel, Cohen, Hempel and Bierstedt.

Bacharach's definitions, criteria, models and evaluation ideas include:

- *Theory:* 'A statement of relations among concepts within a set of boundary assumptions and constraints' (a device used to organise and explain an overly complex observable world). (Bacharach, 1989)
- *Theory in research:* 'A statement of relationships between units observed or approximated in the empirical world' (where approximated units means constructs which cannot be observed directly and Observed units meaning variables which are operationalised empirically by measurement). (Bacharach, 1989)

- *The goal of theory:* 'to answer the questions of how, when, and why' (description, which is not theory, is made up of data, typologies, and metaphors, whose goal is to answer 'what'). (Bacharach, 1989)
- *Construct:* "Terms which, though not observational either directly or indirectly, may be applied or even defined on the basis of the observables" (Kaplan, 1964, p. 55)
- *Variable:* "An observable entity which is capable of assuming two or more values" (Schwab, 1980)
- *Proposition:* State the relations among constructs…and are more abstract and all encompassing. (Bacharach, 1989)
- *Hypotheses:* Are more concrete operational statements, built from specific variables. (Bacharach, 1989)
- *Falsifiablity:* determines whether a theory is constructed such that empirical refutation is possible. While the idealistic goal of science is the pursuit of universal truth, most philosophers of science agree that theories can never be proven, only disproved (Popper and Nagel are the significant influences in this philosophy). (Bacharach, 1989)
- *Utility:* Refers to the usefulness of theoretical systems…at the core of utility is explanation and prediction. (Bacharach, 1989)
- *Values:* Are the implicit assumptions by which a theory is bounded (tending to be the idiosyncratic product of creative imagination, ideological orientation or life experience). (Bacharach, 1989)
- The components of a theory model*:



Criteria for evaluating a theory*:

	Falsifiability	*Utility*
Variables	Operationally defined? Measurement Issues: • Face and content validity • Noncontinuousness • Reliability	Variable Scope
Constructs	Clarity and Parsimony Construct Validity: • Convergent • Discriminant	Construct Scope
Relationships	Logical Adequacy: • Nontautological • Specified nature of relationship Empirical Adequacy: • More than one object or time frame	Explanatory Potential: • Specificity of assumptions regarding objects • Specificity of assumptions regarding relations • Scope and parsimony of propositions Predictive Adequacy: • Probabilistic Vs theory based

E Letters sent to sample population

PhD research. An access request from Brunel University.
Dear Contact Officer,

My name is Jason MacVaugh, and I am a third year PhD Candidate from Brunel University, West London. I am writing to inquire about your policies and procedures regarding access to _____ RandD locations in the UK.

In brief: my goal, in the next 12 months, is to collect survey data from a large sample of New Product Development Teams, Project managers, and NPD Professionals, regarding the presence and use of Knowledge Management tools and practices. The survey will also track team and project performance. The survey tool is a 15-minute, paper-based mail-in questionnaire, and requires at least 6 respondents from each participating organisation.

All stages of this research would, of course, be confidential, and upon completion, become accessible to _____. The questionnaire itself could be edited by_____, and the final data screened for any sensitive data, should you wish to.

Beyond Academia I believe the study has bottom-line merit, and I would be happy to discuss 'what I can do for you' at any time.

I realise your time is valuable, and that you may not be able to help me directly but I would be grateful to hear from you, or anyone you might direct me to, either way. So thank you in advance,

Jason MacVaugh

PhD Office, Brunel Business School
Brunel University, West London
(0)1895 265502
jason.macvaugh@brunel.ac.uk

Draft of Brunel Knowledge Management and New Product Development Survey

Dear _____,

Thank you for agreeing to participate in my survey of Knowledge Management (KM) Activity within New Product Development (NPD) teams. Attached are questionnaires for you to preview prior to data collection next February.

My hope is that you will take some time over the next two to four weeks to consider how well this tool may or may not work in your organisation. This also is your chance to let me know if you would like to remove or add any questions to the document. Please feel free to comment on clarity, layout, or content as you see fit. Furthermore, I would like you to consider the following points when reviewing the documents:

1) Do you feel it is reasonable for your employees to list the names and types of projects they worked on, or would you prefer to circulate some kind of internal code for this purpose?
2) Which of the KMAs do you know/have in your company/use? Should I include some kind of appendix, or provide more examples to aid clarity?
3) Do most NPD employees know what their team's 'plan' is in terms of time, cost, and specification?
4) Would it be possible to ensure they have enough time to complete the document during February or March? Rushed answers will provide both your company and my study with invalid data.

Thank you.

I look forward to hearing your opinions in the New Year!

Best regards and happy holidays,

Jason MacVaugh

PhD Office, Brunel Business School

Brunel University, West London

(0)1895 265502

jason.macvaugh@brunel.ac.uk

Thank you for participating in my survey 'An examination of Knowledge Management and New Product Development Success.' Enclosed in this pack are a number of envelopes. Each should be distributed to selected members of your New Product Development staff. The envelopes contain the questionnaire and 1 self addressed and stamped envelope. Staff should complete the questionnaire to the best of their ability and then return it in the post within the next four weeks. If you have any questions, please feel free to call me anytime on 0778 6868 209.

Sincerely,

Jason MacVaugh

PhD Office, Brunel Business School

Brunel University, West London

(0)1895 265502

jason.macvaugh@brunel.ac.uk

F Questionnaire

NPD Project I.D. Section

Introduction:

This part of the 'Brunel Questionnaire' is used to help integrate your company's data with that of others, and to 'qualify' the relative impact of Knowledge Management (KM) on the NPD process. ***Please read all text in italics*** before each question and try to **complete all 5 questions** where possible.

As in any survey, all data collected will be kept private, but aggregates of the scores will be published as part of a PhD Thesis. After you have completed this questionnaire, **please also complete the second part** of the questionnaire.

Thank you. Your time is very much appreciated!

Section one. Company Identifiers.

Text: ***This section helps the researcher compare your organisation's questionnaire results with others. Please complete all questions to the best of your knowledge.***

Q1. Identify the primary industry your company works within. (Circle one only)

A. Aerospace and Defence	B. Automobiles and Parts	C. Banks
D. Beverages	E. Chemicals	F. Construction
G. Diversified Industrials	H. Utilities	I. Electronics
J. Engineering and Machinery	K. Food Production and Processing	
L. Forestry, Paper and Mining	M. Oil, Gas and Processing	N. Retailing
O. Health	P. Household goods, Textiles and Personal care	
Q. Insurance and Finance	R. Transport	S. Tobacco
T. Pharmaceutical and Biotechnology	U. Telecommunication Services	
V. Steel and Metals	W. Media	X. Support services
Y. Software and computer services	Z. Mobile Technology Hardware and Software	

Q2. Estimate how many employees work within your company. (Please estimate how many employees your company has. Do not include any holding companies or broader networks of firms.)

Q3. Estimate what percentage of employees in your company work specifically within the New Product Development Process. (Please write a percentage between 1 and 100%. This should include concept work, research, development, manufacture-design, and related customer contact roles)

Section two. Key NPD Inputs.

Text: This section explores key inputs in your New Product Development Process. Both academic and practitioner literature suggest that much of the variance in NPD success can be explained by the presence, absence, or relative 'gravity' of 9 common NPD inputs. These inputs have little to do with KM, but if they vary significantly from a theoretical norm, would probably account for more of an NPD project's performance than their KMA counterparts. This is a significant issue for the researcher, so please consider the text below each question as much as possible before you answer.

Q4. Rate your workgroup and/or organisation on the following 9 key NPD inputs. (Each sub-question asks you to rank your organisations key inputs/practices regarding NPD. Consider the last 6-12 months as a timeframe. Please circle one number only.)

J. The quality of your New Product Process is:

(Think of the steps you use: are they explicit or implicit? How well coordinated are they? What is the quality of execution like? Is the system flexible? Is it planned in advance? Are poor projects 'killed' early enough? Is the process 'known to all?'):

Of high quality, with well defined steps, careful planning, and a focus on solid execution.	5	4	3	2	1	Hasty and haphazard, with confusion over stages in the process, little planning, and late decision making.

K. The quality of your company's New Product Strategy is:

(Think of your company's goals and objectives. Are they clear? Are they well communicated? Do they focus on specific markets/customers? Has this been the case for at least the last three years?)

Clear, easily understood, and well communicated. We've always had this strategy.	5	4	3	2	1	Poorly understood; with many changes in focus, market, and objectives. Seems to change every year.

L. The resources available for NPD are:

(Has senior management devoted the resources to achieve its own goals? NPD project budgets are adequate? Are the necessary people and other resources are also in place?)

More than enough to get the job done. We have people, equipment, and a solid budget.	5	4	3	2	1	Less than we need to get the job done. Too many expectations; not enough time, money, or people.

M. Senior Management's commitment to NPD is:

(Is your senior management strongly committed to NPD? Do they get involved when necessary? Do they have input on 'go/kill' decisions? Do they slow you down or help you finish?)

Strongly committed to NPD and my workgroup. They are involved, but not invasive.	5	4	3	2	1	Distant and/or not committed. They are rarely involved, and if involved waste valuable time.

N. Do you work in an entrepreneurial climate:

(Are lots of new ideas solicited/floating around? Do you have the free time to work on them? Are resources available for 'blue sky' ideas? Are there any 'unofficial projects'?)

Yes. We have lots of ideas floating around, free time to work on them… and some resources too.	5	4	3	2	1	No. It's hard to develop any real 'new ideas' in our work environment. We never do 'blue sky'.

O. Your organisation holds top people accountable for NPD success:

(Are NPD metrics an explicit part of senior managements annual objectives? Is performance and pay linked at this level? Are the people at the top 'keeping score'?)

Yes. NPD success measurement is a serious management activity, and they are rated on it.	5	4	3	2	1	No. Senior management are rated on scales that don't include NPD metrics. Nobody 'keeps score'.

P. You organisation has a strategic focus and takes advantage of synergy:

(Are new products in line with current market and technical knowledge? Is the firm 'sticking to the knitting'?)

Our new products are in line with our abilities. Our strategy is focused and existing market-oriented.	5	4	3	2	1	Our products, technical skills, marketing, and objectives have never really had 'synergy'.

Q. Your NPD teams are of a high quality:

(Do you have dedicated team leaders? Does the team communicate well as a matter of course? Are decisions made efficiently and effectively?)

Yes, we have team leaders, frequent communication, and the teams make high quality decisions.	5	4	3	2	1	No, not all teams have leaders, communication is haphazard, and decisions are poor.

R. Your Teams are 'cross-functional':

(Do they include a leader, some of the 'old guard', people with new ideas, people from other business functions?)

Yes, we have everyone you would expect plus a few extra who extent into other functional areas.	5	4	3	2	1	No, our teams are made up of highly specialised members and don't include 'outsiders'.

Q5. Please write any comments with regard to questions 1-4:

End of part one. Please continue on to the second part. Thank you.

Exploring Knowledge Management and New Product Development Success Section

Introduction:

There is a **glossary** on the last page of this questionnaire, which may help you with any **unfamiliar** terminology, but it is important that you **answer questions in the way you think best.** When you have finished, please place this questionnaire inside the enclosed envelope, **seal it,** and put it in the post.

Thank you. Your time is very much appreciated!

Section One: You and your workplace.

Text: This section is designed to help integrate your answers with those of others who work in your firm, and with those in similar roles in other organisations.

Q1. How would you categorise your Job Role? (You have the option to list a **primary** *and* a secondary *Role.* Please place a number 1 to the right of a letter if you **only** have one role or it's your primary role; place a number 2 to the right of a letter if **it's** your secondary role)

F. ____ An Engineer, Scientist, Technical Developer

G. ____ A Manager, Team Leader

H. ____ An Administrator, Personal Assistant, or Similar

I. ____ A Technical Assistant, Research Assistant, or Similar

J. ____ None of those. I'm _____

Text: It is often observed in practice, and written about in academic literature, that NPD has many 'stages.' These stages can number from 2 to 20 and most certainly overlap, get 'fuzzy', and feed back into one another.

Q2. How many 'stages' would characterise NPD in your firm, and what are they? (Please write down a name for each of the stages in your NPD process as you might refer to them in your organisation)

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

Text: ***Many believe that NPD can be split into 3 more general phases:***

D. ***Research, Discovery and Strategy: Where a business opportunity is identified and preliminary technical research is conducted.***

E. ***Development and Realisation: Where technical possibilities are developed into real products.***

F. ***Manufacturing and Commercialisation: Where products are manufactured and delivered to end-users.***

Q3. In your opinion, do you think it is possible to identify these 3 phases in your organisation's NPD process?

C. Yes
D. No

Q4. If you answered YES to Q3, which phase would you say you primarily work in?

D. Research and Discovery
E. Development and Realisation
F. Manufacturing and Commercialisation

Section Two. Knowledge Management in your workplace.

Text: *This section is designed to discover how knowledge is managed in your workplace.* ***Knowledge*** *Management is often described as: 'An entity's systematic and deliberate efforts* ***to expand****, cultivate, and apply available knowledge in ways that add value.' The following* ***question*** *evaluates KM in a variety of forms.*

Q5. Rate *presence and frequency of use* in regards to KM activities in your **organisation. (Please circle the letter P *if the KM tool or practice is present* in your workplace. Next circle a number between 5 and 1 once per line to the KMA in terms of *your frequency of use, or its significance to you.* Please only rate the frequency of use for KM *tools and practices you actually use.* The list starts on the next page, below is an example answer.)**

Frequency of use:

I use the tool/ practice every day

Or

This kind of KM is important in my company/job

I haven't used the tool/ practice in the past year

Or

This kind of KM is not usual in my company/job

Example:

Name of Tools or Practice P(5) 4 3 (2 1)
(Examples or definition of this Tool /Practice)

1) Circle the letter P if the line item is Present and Available to your Workgroup. This doesn't mean you use it.

2) Rate any of the 'Present Items' YOU use. **The higher the number, the more important the item is** to you/your firm.

Use External Research Services P 5 4 3 2 1
(Commissioned RandD/market studies from external agencies, benchmarks of best practice)
Survey/Collect External Information P 5 4 3 2 1
(Published industry data, trade journals, customer feedback documents)
Use External NPD Support P 5 4 3 2 1
(Engage in alliances or joint ventures)
Explore External Opinions P 5 4 3 2 1
(Interview product users or interested stakeholders)

Use Information Searches P 5 4 3 2 1
(The Internet, a company intranet, a specialist information database)
Attend External Training and Development P 5 4 3 2 1
(Any form of technology, skill, or product training – off site)

Consult Specific Outside Experts P 5 4 3 2 1
(Ask questions of outside experts via interviews or Delphi methods)
Participate in Communities of Practice P 5 4 3 2 1
(Staff participation in communities of practice or professional organisations)

Empower Knowledge Brokers (supply chain) P 5 4 3 2 1
(Consulting with people who span boundaries between suppliers and your firm)
Empower Knowledge Brokers (sales) P 5 4 3 2 1
(Consulting with your sales people)

Brief Interested Stakeholders P 5 4 3 2 1
(Produce website updates, press bulletins, product briefs)
Publish Findings P 5 4 3 2 1
(Apply for patents, publish research papers)

Demonstrate Products P 5 4 3 2 1
(To end users, to your partner firms)
Discuss NPD Strategically P 5 4 3 2 1
(With members of your supply chain, with business partners)

Internal Communications P 5 4 3 2 1
(Produce bulletins to report on findings, best practice, success stories, finances)
Document Management Practices P 5 4 3 2 1
(Document management systems, databases, information search tools)

Reporting and Communication Structures P 5 4 3 2 1
(Structure appropriate to encourage initiation of innovation and NPD at multiple levels)
Reward Systems P 5 4 3 2 1
(To ensure data doesn't 'walk out the door,' to encourage trust and sharing, to encourage proactive use of internal communication systems)

Slack Time P 5 4 3 2 1
(Personal time allowed to encourage integration and reflection on information)
Rewarding development P 5 4 3 2 1
(Job/reward structures that value specific types of development and achievement)

Learning and teaching 'on-the-job' P 5 4 3 2 1
(Structured job rotation, targeted team selection, technology champions, mentoring programs)

Informal Learning and Interaction P 5 4 3 2 1
(Storytelling, 'Water cooler chats.' Or for Management: consideration of the physical space available to do this)

Formal Project Management P 5 4 3 2 1
(Use of project management systems, following a project plan, using project briefs)
Prototyping P 5 4 3 2 1
(Development of a physical representation of previously theoretical products)

Decision Support Systems P 5 4 3 2 1
(Software and expert systems that help codify 'what's in your head')
Knowledge Mapping Activities P 5 4 3 2 1
(To identify links between disparate knowledge types in an attempt to codify)

Directory of Internal Expertise P 5 4 3 2 1
(To help link people with questions to those who may know the answers)
Electronic Forums for Debate P 5 4 3 2 1
(To discuss as yet unanswered questions)

In addition, please list and rate any KM tools and/or practices not mentioned above, but present in your workplace. **(First, please name and describe the KM tool or Practice, and then rate it using same usage scale as previously.)**

Item A:_____

5 4 3 2 1

Item B:_____

5 4 3 2 1

Item C:_____

5 4 3 2 1

Item D:_____

5 4 3 2 1

Q6. List any recent additions to the KM tools or practices YOU have used in the last 12 months. **(Line by line, please list the names of any *KM tools or practices you have begun to use in the past 12 months*, followed by how long ago you started using them i.e. 1 month ago, 2, 3, through 12 months ago. Please feel free to use the names from Q4 or Q5. I will assume that you have used *all other KMAs not listed below longer than 12 months.*)**

Item 1:_____:___ Item 4:_____:___

Item 2:_____:___ Item 5:_____:___

Item 3:_____:___ Item 6:_____:___

If you wish to make any additional comments concerning the KM tools you use, please do so below:

Section Three. Measuring Performance. This is the last section.

Text: *This section asks you to reflect on the performance of projects you have worked on. Consider projects you have worked on in the past 12 months. The following question asks you to rate these projects along the dimensions of Time, Cost, and Specification. Responses will be kept anonymous and confidential. If you give a negative rating of your workgroup's performance in any one area it does not mean that the project as a whole underperformed or that any specific team did anything wrong.*

Q7. Complete the multi-project assessment based on your workgroup's relative performance along the dimension of Time. **(First, please give a name to the most recent project you worked on, and enter it on line 1. Then do the same for less recent projects extending out until 12 months ago, using lines 2-6. List no more than 6 projects. After each, give your own opinion of success in terms of TIME on the scale provided.)**

	The project was completed far ahead of the original schedule. **Or** At least 30% earlier than the original schedule		"On Time'		The project was completed far behind the original schedule. **Or** At least 30% later than the original scheduled	
Most Recent Project 1:_____:	7	6	5	4	3	2	1
2:_____:	7	6	5	4	3	2	1
3:_____:	7	6	5	4	3	2	1
4:_____:	7	6	5	4	3	2	1
5:_____:	7	6	5	4	3	2	1
6:_____:	7	6	5	4	3	2	1

Project nearest 12 months ago

Q8. Complete the multi-project assessment based on your workgroup's relative performance along the dimension of Cost. **(Using the same six projects as in Q7)**

	The project was completed far UNDER the original budget **Or** At least 30% UNDER budget			"On Budget"			The project was completed far OVER the original budget **Or** At least 30% OVER budget
1:_____:	7	6	5	4	3	2	1
2:_____:	7	6	5	4	3	2	1
3:_____:	7	6	5	4	3	2	1
4:_____:	7	6	5	4	3	2	1
5:_____:	76	5	4	3	2	1	
6:_____:	7	6	5	4	3	2	1

Q9. Complete the multi-project assessment based on your workgroup's relative performance along the dimension of Specification. **(Using the same six projects as in Q7 and Q8)**

	The project EXCEEDED the original specification **Or** Delivered several valuable features not included in the original specification			'Met Specification'			The project was completed, but lacked several features included in the original specification
1:_____:	7	6	5	4	3	2	1
2:_____:	7	6	5	4	3	2	1
3:_____:	7	6	5	4	3	2	1
4:_____:	7	6	5	4	3	2	1
5:_____:	7	6	5	4	3	2	1
6:_____:	7	6	5	4	3	2	1

Q10. To what do you attribute the relative success (or failure) of the (1-6) projects you have mentioned in Questions 7-9? **(Please comment on anything - other than the hard work of you and your colleagues of course - that contributed directly to project outcomes along the dimensions of Time, Cost, and Specification.)**

Project:_____ What contributed to success or failure: _____-

Project:_____ What contributed to success or failure: _____-

Project:_____ What contributed to success or failure: _____-

Project:_____ What contributed to success or failure: _____-

Project:_____ What contributed to success or failure: _____-

End of Questionnaire. Thank you for your participation.

Glossary of Terms (in Non-MBA Speak):

Knowledge Brokers:	**People who may have more knowledge because they span traditional organisational boundaries**
Tacit Knowledge:	**The knowledge that's in your head**
NPD:	**New Product Development**
Externalisation/Codify:	**Write down what's in your head**
KM:	**Knowledge Management**
Internalisation:	**The process of learning previously written information**
KMA:	**Knowledge Management Activity - the pursuit of**
KM Project:	**What you and your team is working on, not NPD as a whole**
Supply Chain:	**From raw materials through to the end user**

G. Timeline

Progression of this PhD:

1. Desk research in the field of KM to develop a basic conceptual framework and problematisation of the issue March 2004
2. General approval from supervisors on the topic area May 2004
3. Development of a methodological base, and supporting document June 2004
4. Presentation of research issue at (Internal) PhD seminar and an academic conference in Germany August 2004
5. Approval from supervisors for specific question and theoretical framework October 2004
6. First upgrade draft (Introduction, Literature and Methodology) January 2005
7. Final draft of upgrade February 2005
8. Upgrade Document, Presentation, and Mini-Viva March-April 2005
9. Finalisation of research outline/study program and approval June 2005
10. Upgraded to PhD Candidate status August 2005
11. Population identification, sample contact and selection, research tool development September-November 2005
12. Research tool and sample finalised December 2005
13. Approval for method and sample. Survey tool pilot January 2006
14. Revised questionnaire phase one mail out February 2006
15. Results collected and additional contact April 2006
16. Data entry and analysis May-July 2006
17. Post analysis write up July-September 2006
18. Initial results presented at 14th Annual International Product Development Management Conference, Porto June 2007
19. First draft December 2007
20. Application to complete at the University of Gloucestershire January 2008
21. Submission of Thesis Autumn 2008

H. Research ethics

1 Introduction

1.1 The primary responsibility for the conduct of ethical research lays with the researcher. It is a fundamental principal that staff and students engaged in research adopt a continuing personal commitment to act ethically, to encourage ethical behaviour in those with whom they collaborate, and to consult where appropriate concerning ethical issues.

1.2 The University acknowledges the importance of the professional codes of conduct of external agencies and organisations, and accords them primacy as a default position.

2 General Responsibilities

2.1 Towards research participants

Researchers have a responsibility to ensure as far as possible that the physical, social and psychological well-being of their research participants is not detrimentally affected by the research. Research relationships should be characterised, whenever possible, by mutual respect and trust.

2.2 Towards other researchers

Researchers should avoid, wherever possible, actions which may have deleterious consequences for other researchers or which might undermine the reputation of their discipline. Those directing research should bear in mind their responsibilities towards members of their research teams and should aim to anticipate and guard against the possible harmful consequences of the research for team members.

3 Informed Consent

3.1 Research should be based, as far as possible and practicable, on the freely given informed consent of those under study. However, it is recognised that in some cases it

may be necessary to employ covert methods should these constitute the only means to obtain the required data. In such cases, please refer to section 4 below.

3.2 It is the responsibility of the researcher to explain as fully as is reasonable and appropriate, and in terms meaningful to the participants: the aims and nature of the research, who is undertaking it, who is funding it, its likely duration, why it is being undertaken, the possible consequences of the research, and how the results are to be disseminated.

3.3 The power imbalance between researcher and researched should be considered. Care should be taken to ensure that the latter are not pressurised into participation. Research participants should be aware of their right to refuse participation at any time and should not be given the impression that they are required to participate. It should also be recognised that research may involve a lengthy data-gathering period and that it may be necessary to regard consent not as obtained once and for all, but subject to re-negotiation over time.

3.4 The researcher should explain how far research participants will be afforded anonymity and confidentiality and participants should have the option of rejecting the use of data-gathering devices such as tape-recorders and video cameras.

3.5 If there is a likelihood of data being shared with or divulged to other researchers, the potential uses of the data should be discussed with the participants and their agreement to such use should be obtained.

3.6 Where access to a research setting is gained via a 'gatekeeper' external to the University, researchers should also obtain the informed consent of research participants, while at the same time taking account of the gatekeeper's interests. It should be borne in mind that the relationship between research participant and gatekeeper may well continue long after the research has been undertaken.

3.7 Where research participants are young children or other vulnerable groups such as elderly, disabled or sick people, or people with learning difficulties whose understanding is impaired in some way so that they are unable to give full informed

consent, it may be necessary to use a proxy in order to gather data. In this case great care must be taken not to intrude upon the privacy of the vulnerable participants. The researcher should consult relevant professionals, parents/guardians and relatives, as appropriate. Researchers should attempt to obtain the informed consent of children and their parents and in relation to schoolchildren those who are in loco parentis.

3.8 In addition to obtaining the informed consent of those under study, researchers should attempt to anticipate and guard against the possible harmful consequences of their research for participants.

4 Deceptive and Covert Research

4.1 While it is recognised that there is a continuum of covert-overt research (and therefore difficulty in defining research simply as entirely covert or overt), researchers should endeavour, wherever possible and practicable, to avoid the use of deception in their research methods, as this violates the principle of informed consent and may invade the privacy of those under study, particularly in non-public spaces.

4.2 Any researcher considering deceptive methods in research must seek approval from the Research Ethics Sub-Committee. The burden of proof will rest on the investigator to show that no alternative methods are possible, and that the data sought are of sufficient value to over-ride the issues of free and informed consent. Where approval has been given, the potential implications arising from publication must be fully considered.

4.3 Covert research in non-public spaces (that is, where persons would not normally expect to be under observation), or experimental manipulation of research participants without their knowledge should be a last resort when it is impossible to use other methods to obtain the required data. It is particularly important in such cases to safeguard the anonymity of participants.

4.4 If covert methods are approved and employed, and informed consent has not been obtained prior to the research, every attempt should be made to obtain this post hoc.

5 Confidentiality and Anonymity

5.1 The anonymity and privacy of research participants should be respected and personal information relating to participants should be kept confidential and secure. Researchers must comply with the provisions of the Data Protection Act and should consider whether it is proper or appropriate even to record certain kinds of sensitive information.

5.2 Where possible, threats to the confidentiality and anonymity of research data should be anticipated by researchers and normally the identities and research records of participants should be kept confidential, whether or not an explicit pledge of confidentiality has been given.

5.3 Whilst the researcher should take every practicable measure to ensure the confidentiality and anonymity of research participants, s/he should also take care not to give unrealistic assurances or guarantees of confidentiality. Research participants with easily identifiable characteristics or positions within an organisation should be reminded that it may be difficult to disguise their identity totally without distorting the data.

6 Procedures for Approval

6.1 Set against the principles expressed above, specific approval is required for:

i) research which involves biomedical or clinical intervention (with the exception of those approved under standard protocols - see Standard Protocols in the Exercise Physiology Laboratory (95Kb Adobe PDF));

All research related to the National Health Service (its personnel, plant, referrals etc) must abide by the NHS Research Governance framework. The RESC will neither consider nor approve research proposals that should be submitted to the Local Research Ethics Committee (LREC) representing the NHS.

Further information can be found at: http://www.corec.org.uk

The local research ethics committee for NHS approval is based at Gloucester. Information can be found at: http://www.gloshospitals.org.uk/acutetrust and http://www.gloshospitals.org.uk/acutetrust/sept02/item7b.pdf

Members of staff and students may, of course, use the relevant gatekeepers for advice prior to submission to the LREC or indeed subsequent to such.

ii) deceptive research which is defined as research where an investigator actively sets out significantly to misrepresent himself or herself, the nature of the research, and/or any other significant characteristics of the research;

iii) certain classes of covert research in particular, those where the data are not recorded in a manner that protects the anonymity of subjects or participants, where the research topic is one dealing with sensitive aspects of the subject's or participant's behaviour, or where proposals for research involve vulnerable populations (see Appendix 4: British Psychological Society Code of Conduct (405Kb Adobe PDF) for further guidance).

Procedures for gaining approval are contained in Part B.

6.2 Other than adherence to the principles expressed in this section, no specific approval is required for research that does not fall into these categories. Where researchers have any doubts, they should consult the appropriate University 'gatekeeper' whose role is described in the following sections covering procedures.

I. Findings tables

Stage of project - NPDd

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
NPD Process Quality	Between Groups	8.47	2	4.236	8.74	0.00
	Within Groups	56.23	116	0.485		
	Total	64.71	118			
NPD Strategy Quality	Between Groups	27.01	2	13.507	30.82	0.00
	Within Groups	50.83	116	0.438		
	Total	77.85	118			
Resources available for NPD	Between Groups	27.51	2	13.755	16.68	0.00
	Within Groups	95.65	116	0.825		
	Total	123.16	118			
Senior Management Commitment	Between Groups	12.82	2	6.412	8.76	0.00
	Within Groups	84.87	116	0.732		
	Total	97.70	118			
Entrepreneurial Climate	Between Groups	39.95	2	19.976	16.72	0.00
	Within Groups	138.60	116	1.195		
	Total	178.55	118			
Top People Accountable for NPD	Between Groups	27.18	2	13.590	10.79	0.00
	Within Groups	146.10	116	1.259		
	Total	173.28	118			
NPD takes advantage of Synergy	Between Groups	12.54	2	6.268	14.33	0.00
	Within Groups	50.76	116	0.438		
	Total	63.29	118			
NPD teams are high quality	Between Groups	23.79	2	11.895	7.58	0.00
	Within Groups	182.06	116	1.569		
	Total	205.85	118			
Teams are cross-functional	Between Groups	20.64	2	10.320	22.92	0.00
	Within Groups	52.23	116	0.450		
	Total	72.87	118			

ANOVA	
	Sig.
NPD Process Quality	0.00
NPD Strategy Quality	0.00
Resources available for NPD	0.00
Senior Management Commitment	0.00
Entrepreneurial Climate	0.00
Top People Accountable for NPD	0.00
NPD takes advantage of Synergy	0.00
NPD teams are high quality	0.00
Teams are cross-functional	0.00

Industry - NPDd

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
NPD Process Quality	Between Groups	57.99	4	14.497	173.14	0.00
	Within Groups	9.88	118	0.084		
	Total	67.87	122			
NPD Strategy Quality	Between Groups	73.31	4	18.327	218.87	0.00
	Within Groups	9.88	118	0.084		
	Total	83.19	122			
Resources available for NPD	Between Groups	46.25	4	11.562	16.80	0.00
	Within Groups	81.23	118	0.688		
	Total	127.48	122			
Senior Management Commitment	Between Groups	99.54	4	24.886	3053.96	0.00
	Within Groups	0.96	118	0.008		
	Total	100.50	122			
Entrepreneurial Climate	Between Groups	144.27	4	36.068	118.26	0.00
	Within Groups	35.99	118	0.305		
	Total	180.26	122			
Top People Accountable for NPD	Between Groups	97.51	4	24.377	34.20	0.00
	Within Groups	84.12	118	0.713		
	Total	181.63	122			
NPD takes advantage of Synergy	Between Groups	56.40	4	14.100	142.64	0.00
	Within Groups	11.66	118	0.099		
	Total	68.07	122			
NPD teams are high quality	Between Groups	171.96	4	42.989	130.49	0.00
	Within Groups	38.87	118	0.329		
	Total	210.83	122			
Teams are cross-functional	Between Groups	73.71	4	18.427	2234.84	0.00
	Within Groups	0.97	118	0.008		
	Total	74.68	122			

ANOVA	
	Sig.
NPD Process Quality	0.00
NPD Strategy Quality	0.00
Resources available for NPD	0.00
Senior Management Commitment	0.00
Entrepreneurial Climate	0.00
Top People Accountable for NPD	0.00
NPD takes advantage of Synergy	0.00
NPD teams are high quality	0.00
Teams are cross-functional	0.00

Size - NPDd

Correlations		
	Correlation Coefficient	Sig.
NPD Process Quality	0.21	0.02
NPD Strategy Quality	0.48	0.00
Resources available for NPD	0.51	0.00
Senior Management Commitment	-0.02	0.84
Entrepreneurial Climate	-0.23	0.01
Top People Accountable for NPD	0.28	0.00
NPD takes advantage of Synergy	0.14	0.11
NPD teams are high quality	-0.17	0.06
Teams are cross-functional	-0.20	0.02

Correlations	Direction of relationship	Sig.
NPD Process Quality	+	0.02
NPD Strategy Quality	+	0.00
Resources available for NPD	+	0.00
Senior Management Commitment	-	0.84
Entrepreneurial Climate	-	0.01
Top People Accountable for NPD	+	0.00
NPD takes advantage of Synergy	+	0.11
NPD teams are high quality	-	0.06
Teams are cross-functional	-	0.02

Stage – KMA present in company

Pearson Chi-Square Tests		
Use External Research Services	Chi-square	34.23
	df	2
	Sig.	0.00
Survey/Collect External Information	Chi-square	5.99
	df	2
	Sig.	0.05
Use External NPD Support	Chi-square	15.69
	df	2
	Sig.	0.00
Explore External Opinions	Chi-square	1.83
	df	2
	Sig.	0.40
Use Information Searches	Chi-square	.
	df	.
	Sig.	.
Attend External TandD	Chi-square	19.56
	df	2
	Sig.	0.00
Consult Specific Outside Experts	Chi-square	38.56
	df	2

	Sig.	0.00
Participate in Communities of Practice	Chi-square	30.57
	df	2
	Sig.	0.00
Empower Knowledge Brokers in SC	Chi-square	26.41
	df	2
	Sig.	0.00
Empower Knowledge Brokers Sales	Chi-square	15.91
	df	2
	Sig.	0.00
Brief Interested Stakeholders	Chi-square	1.73
	df	2
	Sig.	0.42
Publish Findings	Chi-square	16.47
	df	2
	Sig.	0.00
Demonstrate Products	Chi-square	53.06
	df	2
	Sig.	0.00
Discuss NPD Strategically	Chi-square	34.93
	df	2
	Sig.	0.00
Internal Communications	Chi-square	8.21
	df	2
	Sig.	0.02
Document Management Practices	Chi-square	.
	df	.
	Sig.	.
Reporting and Comm. Structure	Chi-square	3.09
	df	2
	Sig.	0.21
Reward Systems	Chi-square	4.15
	df	2
	Sig.	0.13
Slack Time	Chi-square	5.33
	df	2
	Sig.	0.07
Reward Development	Chi-square	9.87
	df	2
	Sig.	0.01
Learning and Teaching on-the-job	Chi-square	11.91
	df	2
	Sig.	0.00
Informal Learning and Interaction	Chi-square	100.11
	df	2
	Sig.	0.00
Formal Project Management	Chi-square	7.25
	df	2
	Sig.	0.03
Prototyping	Chi-square	16.90
	df	2
	Sig.	0.00

Decision Support Systems	Chi-square	9.43
	df	2
	Sig.	0.01
Knowledge Mapping Activities	Chi-square	20.11
	df	2
	Sig.	0.00
Directory of Internal Expertise	Chi-square	4.17
	df	2
	Sig.	0.12
Electronic Forums for Debate	Chi-square	5.73
	df	2
	Sig.	0.06

Pearson Chi-Square Tests	Sig.
Use External Research Services	0.00
Survey/Collect External Information	0.05
Use External NPD Support	0.00
Explore External Opinions	0.40
Use Information Searches	.
Attend External TandD	0.00
Consult Specific Outside Experts	0.00
Participate in Communities of Practice	0.00
Empower Knowledge Brokers in SC	0.00
Empower Knowledge Brokers Sales	0.00
Brief Interested Stakeholders	0.42
Publish Findings	0.00
Demonstrate Products	0.00
Discuss NPD Strategically	0.00
Internal Communications	0.02
Document Management Practices	.
Reporting and Comm. Structure	0.21
Reward Systems	0.13
Slack Time	0.07
Reward Development	0.01
Learning and Teaching on-the-job	0.00
Informal Learning and Interaction	0.00
Formal Project Management	0.03
Prototyping	0.00
Decision Support Systems	0.01
Knowledge Mapping Activities	0.00
Directory of Internal Expertise	0.12
Electronic Forums for Debate	0.06

Industry – KMA present in company

Pearson Chi-Square Tests		
Use External Research Services	Chi-square	49.91
	df	4
	Sig.	0.00
Survey/Collect External Information	Chi-square	13.43
	df	4
	Sig.	0.01
Use External NPD Support	Chi-square	42.12
	df	4
	Sig.	0.00
Explore External Opinions	Chi-square	29.29
	df	4
	Sig.	0.00
Use Information Searches	Chi-square	.
	df	.
	Sig.	.
Attend External TandD	Chi-square	112.18
	df	4
	Sig.	0.00
Consult Specific Outside Experts	Chi-square	38.94
	df	4
	Sig.	0.00
Participate in Communities of Practice	Chi-square	45.91
	df	4
	Sig.	0.00
Empower Knowledge Brokers in SC	Chi-square	112.18
	df	4
	Sig.	0.00
Empower Knowledge Brokers Sales	Chi-square	46.10
	df	4
	Sig.	0.00
Brief Interested Stakeholders	Chi-square	17.96
	df	4
	Sig.	0.00
Publish Findings	Chi-square	65.80
	df	4
	Sig.	0.00
Demonstrate Products	Chi-square	70.61
	df	4
	Sig.	0.00
Discuss NPD Strategically	Chi-square	39.52
	df	4
	Sig.	0.00
Internal Communications	Chi-square	21.93
	df	4
	Sig.	0.00
Document Management Practices	Chi-square	.
	df	.
	Sig.	.
Reporting and Comm. Structure	Chi-square	42.23

	df	4
	Sig.	0.00
Reward Systems	Chi-square	56.14
	df	4
	Sig.	0.00
Slack Time	Chi-square	49.24
	df	4
	Sig.	0.00
Reward Development	Chi-square	59.87
	df	4
	Sig.	0.00
Learning and Teaching on-the-job	Chi-square	44.33
	df	4
	Sig.	0.00
Informal Learning and Interaction	Chi-square	42.83
	df	4
	Sig.	0.00
Formal Project Management	Chi-square	13.18
	df	4
	Sig.	0.01
Prototyping	Chi-square	40.21
	df	4
	Sig.	0.00
Decision Support Systems	Chi-square	59.91
	df	4
	Sig.	0.00
Knowledge Mapping Activities	Chi-square	39.98
	df	4
	Sig.	0.00
Directory of Internal Expertise	Chi-square	67.94
	df	4
	Sig.	0.00
Electronic Forums for Debate	Chi-square	64.70
	df	4
	Sig.	0.00

Pearson Chi-Square Tests	
	Sig.
Use External Research Services	0.00
Survey/Collect External Information	0.01
Use External NPD Support	0.00
Explore External Opinions	0.00
Use Information Searches	.
Attend External TandD	0.00
Consult Specific Outside Experts	0.00
Participate in Communities of Practice	0.00
Empower Knowledge Brokers in SC	0.00
Empower Knowledge Brokers Sales	0.00
Brief Interested Stakeholders	0.00
Publish Findings	0.00
Demonstrate Products	0.00
Discuss NPD Strategically	0.00

Internal Communications	0.00
Document Management Practices	.
Reporting and Comm. Structure	0.00
Reward Systems	0.00
Slack Time	0.00
Reward Development	0.00
Learning and Teaching on-the-job	0.00
Informal Learning and Interaction	0.00
Formal Project Management	0.01
Prototyping	0.00
Decision Support Systems	0.00
Knowledge Mapping Activities	0.00
Directory of Internal Expertise	0.00
Electronic Forums for Debate	0.00

Size – KMA present in company

ANOVA		Sum of Squares	df	Mean Square	F	Sig.
Use External Research Services	Between Groups	5.9E+07	1	5.9E+07	17.79	0.00
	Within Groups	4.0E+08	121	3.3E+06		
	Total	4.6E+08	122			
Survey/Collect External Information	Between Groups	1.0E+07	1	1.0E+07	2.80	0.10
	Within Groups	4.5E+08	121	3.7E+06		
	Total	4.6E+08	122			
Use External NPD Support	Between Groups	3.6E+07	1	3.6E+07	10.24	0.00
	Within Groups	4.2E+08	121	3.5E+06		
	Total	4.6E+08	122			
Explore External Opinions	Between Groups	2.3E+07	1	2.3E+07	6.54	0.01
	Within Groups	4.3E+08	121	3.6E+06		
	Total	4.6E+08	122			
Use Information Searches	*N/A*					.
Attend External TandD	Between Groups	1.4E+06	1	1.4E+06	0.38	0.54
	Within Groups	4.6E+08	121	3.8E+06		
	Total	4.6E+08	122			
Consult Specific Outside Experts	Between Groups	4.9E+07	1	4.9E+07	14.59	0.00
	Within Groups	4.1E+08	121	3.4E+06		
	Total	4.6E+08	122			
Participate in Communities of Practice	Between Groups	3.1E+07	1	3.1E+07	8.83	0.00
	Within Groups	4.3E+08	121	3.5E+06		
	Total	4.6E+08	122			
Empower Knowledge Brokers in SC	Between Groups	3.4E+06	1	3.4E+06	0.90	0.34
	Within Groups	4.5E+08	121	3.8E+06		
	Total	4.6E+08	122			
Empower Knowledge Brokers Sales	Between Groups	3.3E+07	1	3.3E+07	9.56	0.00
	Within Groups	4.2E+08	121	3.5E+06		

	Total	4.6E+08	122			
Brief Interested Stakeholders	Between Groups	2.0E+07	1	2.0E+07	5.62	0.02
	Within Groups	4.4E+08	121	3.6E+06		
	Total	4.6E+08	122			
Publish Findings	Between Groups	3.9E+06	1	3.9E+06	1.04	0.31
	Within Groups	4.5E+08	121	3.7E+06		
	Total	4.6E+08	122			
Demonstrate Products	Between Groups	4.7E+07	1	4.7E+07	14.01	0.00
	Within Groups	4.1E+08	121	3.4E+06		
	Total	4.6E+08	122			
Discuss NPD Strategically	Between Groups	2.9E+07	1	2.9E+07	8.20	0.00
	Within Groups	4.3E+08	121	3.5E+06		
	Total	4.6E+08	122			
Internal Communications	Between Groups	1.3E+07	1	1.3E+07	3.60	0.06
	Within Groups	4.4E+08	121	3.7E+06		
	Total	4.6E+08	122			
Document Management Practices	*N/A*					.
Reporting and Communication Structure	Between Groups	1.5E+07	1	1.5E+07	4.19	0.04
	Within Groups	4.4E+08	121	3.7E+06		
	Total	4.6E+08	122			
Reward Systems	Between Groups	1.5E+05	1	1.5E+05	0.04	0.84
	Within Groups	4.6E+08	121	3.8E+06		
	Total	4.6E+08	122			
Slack Time	Between Groups	1.4E+06	1	1.4E+06	0.38	0.54
	Within Groups	4.6E+08	121	3.8E+06		
	Total	4.6E+08	122			
Reward Development	Between Groups	5.2E+07	1	5.2E+07	15.58	0.00
	Within Groups	4.1E+08	121	3.3E+06		
	Total	4.6E+08	122			
Learning and Teaching on-the-job	Between Groups	3.7E+07	1	3.7E+07	10.57	0.00
	Within Groups	4.2E+08	121	3.5E+06		

	Total	4.6E+08	122			
Informal Learning and Interaction	Between Groups	2.7E+07	1	2.7E+07	7.52	0.01
	Within Groups	4.3E+08	121	3.6E+06		
	Total	4.6E+08	122			
Formal Project Management	Between Groups	8.9E+06	1	8.9E+06	2.41	0.12
	Within Groups	4.5E+08	121	3.7E+06		
	Total	4.6E+08	122			
Prototyping	Between Groups	3.5E+07	1	3.5E+07	9.91	0.00
	Within Groups	4.2E+08	121	3.5E+06		
	Total	4.6E+08	122			
Decision Support Systems	Between Groups	3.5E+04	1	3.5E+04	0.01	0.92
	Within Groups	4.6E+08	121	3.8E+06		
	Total	4.6E+08	122			
Knowledge Mapping Activities	Between Groups	6.0E+06	1	6.0E+06	1.62	0.21
	Within Groups	4.5E+08	121	3.7E+06		
	Total	4.6E+08	122			
Directory of Internal Expertise	Between Groups	6.8E+04	1	6.8E+04	0.02	0.89
	Within Groups	4.6E+08	121	3.8E+06		
	Total	4.6E+08	122			
Electronic Forums for Debate	Between Groups	8.2E+05	1	8.2E+05	0.22	0.64
	Within Groups	4.6E+08	121	3.8E+06		
	Total	4.6E+08	122			

ANOVA	Sig.
Use External Research Services	0.00
Survey/Collect External Information	0.10
Use External NPD Support	0.00
Explore External Opinions	0.01
Use Information Searches	.
Attend External TandD	0.54
Consult Specific Outside Experts	0.00

Participate in Communities of Practice	0.00
Empower Knowledge Brokers in SC	0.34
Empower Knowledge Brokers Sales	0.00
Brief Interested Stakeholders	0.02
Publish Findings	0.31
Demonstrate Products	0.00
Discuss NPD Strategically	0.00
Internal Communications	0.06
Document Management Practices	.
Reporting and Comm Structure	0.04
Reward Systems	0.84
Slack Time	0.54
Reward Development	0.00
Learning and Teaching on-the-job	0.00
Informal Learning and Interaction	0.01
Formal Project Management	0.12
Prototyping	0.00
Decision Support Systems	0.92
Knowledge Mapping Activities	0.21
Directory of Internal Expertise	0.89
Electronic Forums for Debate	0.64

NPD – KMA

KMA:	NPDd:	NPD Process Quality	NPD Strategy Quality	Resources available for NPD	Snr. Mgt. Commitment	Entrepreneurial Climate	Top People Accountable for NPD	NPD takes advantage of Synergy	NPD teams are high quality	Teams are cross-functional
Use External Research Services	Pearson Correlation	-0.17	-0.05	0.45	-0.65	-0.40	0.03	0.06	-0.50	-0.46
	Sig. (2-tailed)	0.07	0.56	0.00	0.00	0.00	0.72	0.50	0.00	0.00
Survey/Collect External Information	Pearson Correlation	-0.13	-0.26	0.09	-0.52	-0.28	-0.23	0.15	-0.42	-0.17
	Sig. (2-tailed)	0.14	0.00	0.31	0.00	0.00	0.01	0.09	0.00	0.06
Use External NPD Support	Pearson Correlation	0.43	0.49	0.61	-0.04	-0.20	0.37	0.29	-0.11	-0.09
	Sig. (2-tailed)	0.00	0.00	0.00	0.65	0.02	0.00	0.00	0.22	0.33
Explore External Opinions	Pearson Correlation	-0.17	-0.18	0.10	-0.61	-0.60	-0.23	-0.04	-0.64	-0.37
	Sig. (2-tailed)	0.06	0.04	0.25	0.00	0.00	0.01	0.70	0.00	0.00
Use Information Searches	Pearson Correlation	-0.01	0.02	-0.43	0.65	0.53	0.05	-0.20	0.61	0.35
	Sig. (2-tailed)	0.95	0.85	0.00	0.00	0.00	0.59	0.02	0.00	0.00
Attend External TandD	Pearson Correlation	0.23	0.72	0.25	0.64	0.09	0.58	-0.35	0.40	-0.12
	Sig. (2-tailed)	0.01	0.00	0.01	0.00	0.34	0.00	0.00	0.00	0.19
Consult Specific Outside Experts	Pearson Correlation	0.00	0.02	0.51	-0.53	-0.28	0.13	0.14	-0.35	-0.33
	Sig. (2-tailed)	0.98	0.82	0.00	0.00	0.00	0.14	0.12	0.00	0.00
Participate in Communities of Practice	Pearson Correlation	0.42	0.19	0.14	0.13	0.02	0.03	0.37	0.03	0.31
	Sig. (2-tailed)	0.00	0.03	0.11	0.17	0.81	0.79	0.00	0.76	0.00
Empower Knowledge Brokers in SC	Pearson Correlation	0.28	0.25	0.32	-0.25	-0.53	0.07	0.09	-0.40	-0.15

	Sig. (2-tailed)	0.00	0.01	0.00	0.01	0.00	0.48	0.33	0.00	0.10
Empower Knowledge Brokers Sales	Pearson Correlation	-0.24	-0.75	-0.66	-0.34	-0.08	-0.79	0.20	-0.33	0.31
	Sig. (2-tailed)	0.01	0.00	0.00	0.00	0.38	0.00	0.02	0.00	0.00
Brief Interested Stakeholders	Pearson Correlation	-0.48	-0.55	-0.26	-0.67	-0.43	-0.54	-0.12	-0.61	-0.26
	Sig. (2-tailed)	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00
Publish Findings	Pearson Correlation	0.42	0.66	0.49	0.51	0.30	0.61	0.11	0.45	0.06
	Sig. (2-tailed)	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.53
Demonstrate Products	Pearson Correlation	0.16	0.29	0.09	0.32	0.09	0.31	-0.20	0.28	-0.01
	Sig. (2-tailed)	0.08	0.00	0.34	0.00	0.33	0.00	0.03	0.00	0.95
Discuss NPD Strategically	Pearson Correlation	0.40	0.18	0.38	-0.15	-0.16	0.11	0.39	-0.15	0.10
	Sig. (2-tailed)	0.00	0.04	0.00	0.10	0.09	0.24	0.00	0.09	0.27
Internal Communications	Pearson Correlation	-0.10	-0.44	-0.22	-0.32	-0.02	-0.39	0.20	-0.20	0.16
	Sig. (2-tailed)	0.26	0.00	0.02	0.00	0.86	0.00	0.03	0.02	0.08
Document Management Practices	Pearson Correlation	0.07	-0.04	0.35	-0.18	0.25	0.20	0.25	0.12	-0.01
	Sig. (2-tailed)	0.48	0.68	0.00	0.04	0.01	0.03	0.01	0.18	0.91
Reporting and Comm. Structure	Pearson Correlation	0.47	0.26	0.23	0.32	0.34	0.27	0.34	0.37	0.36
	Sig. (2-tailed)	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Reward Systems	Pearson Correlation	0.41	0.39	0.12	0.53	0.31	0.30	0.16	0.42	0.30
	Sig. (2-tailed)	0.00	0.00	0.20	0.00	0.00	0.00	0.08	0.00	0.00
Slack Time	Pearson Correlation	0.68	0.36	0.40	0.43	0.56	0.42	0.60	0.56	0.52
	Sig. (2-tailed)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reward Development	Pearson Correlation	0.32	0.23	0.46	-0.28	-0.35	0.12	0.32	-0.33	-0.10

	Sig. (2-tailed)	0.00	0.01	0.00	0.00	0.00	0.20	0.00	0.00	0.28
Learning and Teaching on-the-job	Pearson Correlation	0.36	0.22	0.22	0.12	0.04	0.16	0.26	0.09	0.17
	Sig. (2-tailed)	0.00	0.02	0.01	0.20	0.68	0.08	0.00	0.35	0.07
Informal Learning and Interaction	Pearson Correlation	0.28	0.26	0.34	0.01	-0.04	0.22	0.19	0.01	0.02
	Sig. (2-tailed)	0.00	0.00	0.00	0.91	0.64	0.01	0.04	0.93	0.81
Formal Project Management	Pearson Correlation	0.33	0.19	0.08	0.07	-0.21	0.00	0.19	-0.11	0.15
	Sig. (2-tailed)	0.00	0.03	0.40	0.45	0.02	0.99	0.03	0.22	0.09
Prototyping	Pearson Correlation	0.13	0.07	0.28	-0.37	-0.44	0.00	0.11	-0.40	-0.18
	Sig. (2-tailed)	0.15	0.43	0.00	0.00	0.00	0.99	0.24	0.00	0.05
Decision Support Systems	Pearson Correlation	0.68	0.29	0.17	0.54	0.59	0.21	0.68	0.54	0.69
	Sig. (2-tailed)	0.00	0.00	0.06	0.00	0.00	0.02	0.00	0.00	0.00
Knowledge Mapping Activities	Pearson Correlation	0.26	0.05	-0.14	0.41	0.44	-0.03	0.33	0.37	0.48
	Sig. (2-tailed)	0.00	0.58	0.12	0.00	0.00	0.74	0.00	0.00	0.00
Directory of Internal Expertise	Pearson Correlation	0.38	0.36	0.22	0.51	0.45	0.44	0.12	0.56	0.25
	Sig. (2-tailed)	0.00	0.00	0.02	0.00	0.00	0.00	0.19	0.00	0.01
Electronic Forums for Debate	Pearson Correlation	-0.22	0.16	-0.11	0.44	0.37	0.28	-0.42	0.47	-0.10
	Sig. (2-tailed)	0.02	0.08	0.23	0.00	0.00	0.00	0.00	0.00	0.25

NPDd: / KMA:	NPD Process Quality	NPD Strategy Quality	Resources available for NPD	Snr. Mgt. Commitment	Entrepreneurial Climate	Top People Accountable for NPD	NPD takes advantage of Synergy	NPD teams are high quality	Teams are cross-functional
Use External Research Services			+	-	-			-	-
Survey/Collect External Information		-		-	-	-		-	

Use External NPD Support	+	+	+		-	+	+		
Explore External Opinions		-		-	-	-		-	-
Use Information Searches			-	+	+		-	+	+
Attend External TandD	+	+	+	+		+	-	+	
Consult Specific Outside Experts			+	-	-			-	-
Participate in Communities of Practice	+	+					+		+
Empower Knowledge Brokers in SC	+	+	+	-	-			-	
Empower Knowledge Brokers Sales	-	-	-	-		-	+	-	+
Brief Interested Stakeholders	-	-	-	-	-	-		-	-
Publish Findings	+	+	+	+	+	+		+	
Demonstrate Products		+		+		+	-	+	
Discuss NPD Strategically	+	+	+				+		
Internal Communications		-	-	-		-	+	-	
Document Management Practices			+	-	+	+	+		
Reporting and Comm. Structure	+	+	+	+	+	+	+	+	+
Reward Systems	+	+		+	+	+		+	+
Slack Time	+	+	+	+	+	+	+	+	+
Reward Development	+	+	+	-	-		+	-	
Learning and Teaching on-the-job	+	+	+				+		
Informal Learning and Interaction	+	+	+			+	+		
Formal Project Management	+	+			-		+		
Prototyping			+	-	-			-	-
Decision Support Systems	+	+		+	+	+	+	+	+
Knowledge Mapping Activities	+			+	+		+	+	+
Directory of Internal Expertise	+	+	+	+	+	+		+	+
Electronic Forums for Debate	-			+	+	+	-	+	

NPDd – success

	n=	123	119	122
		Project Time Success	Project Cost Success	Project Specification Success
NPD Process Quality	Pearson Correlation	0.31	0.49	0.58
	Sig. (2-tailed)	0.00	0.00	0.00
NPD Strategy Quality	Pearson Correlation	0.28	0.17	0.44
	Sig. (2-tailed)	0.00	0.07	0.00
Resources available for NPD	Pearson Correlation	0.51	0.19	0.54
	Sig. (2-tailed)	0.00	0.04	0.00
Senior Management Commitment	Pearson Correlation	-0.18	0.31	0.15
	Sig. (2-tailed)	0.05	0.00	0.10
Entrepreneurial Climate	Pearson Correlation	-0.17	0.46	0.12
	Sig. (2-tailed)	0.06	0.00	0.19
Top People Accountable for NPD	Pearson Correlation	0.23	0.22	0.38
	Sig. (2-tailed)	0.01	0.02	0.00
NPD takes advantage of Synergy	Pearson Correlation	0.30	0.45	0.48
	Sig. (2-tailed)	0.00	0.00	0.00
NPD teams are high quality	Pearson Correlation	-0.16	0.44	0.17
	Sig. (2-tailed)	0.08	0.00	0.07
Teams are cross-functional	Pearson Correlation	-0.07	0.48	0.21
	Sig. (2-tailed)	0.44	0.00	0.02

n=	123	119	122
	Project Time Success	Project Cost Success	Project Specification Success
NPD Process Quality	+	+	+
NPD Strategy Quality	+		+

Resources available for NPD	+	+	+
Senior Management Commitment		+	
Entrepreneurial Climate		+	
Top People Accountable for NPD	+	+	+
NPD takes advantage of Synergy	+	+	+
NPD teams are high quality		+	
Teams are cross-functional		+	+

Regression – NPD only

Dependent Variable: Project Time Success	n=	123	R Square	26%
Stepwise model: NDPd only	Unstandardised Coefficient	Standardised Coefficient	Absolute Coefficient	Relative Strength
Resources available for NPD	0.71	0.51		

Dependent Variable: Project Cost Success	n=	119	R Square	33%
Stepwise model: NDPd only	Unstandardised Coefficient	Standardised Coefficient	Absolute Coefficient	Relative Strength
NPD Process Quality	0.87	0.37	0.37	53%
Entrepreneurial Climate	0.46	0.33	0.33	47%

Dependent Variable: Project Specification Success	n=	122	R Square	44%
Stepwise model: NDPd only	Unstandardised Coefficient	Standardised Coefficient	Absolute Coefficient	Relative Strength
NPD Process Quality	0.83	0.43	0.43	55%
Resources available for NPD	0.50	0.36	0.36	45%

Pres KMAs – Success

	Project Time Success	Project Cost Success	Project Specification Success
Use External Research Services	+		+
Survey/Collect External Information			+
Use External NPD Support	+		+
Explore External Opinions	+		+
Use Information Searches			
Attend External TandD			
Consult Specific Outside Experts	+		+
Participate in Communities of Practice	+		+
Empower Knowledge Brokers in SC	+		+
Empower Knowledge Brokers Sales	-		-
Brief Interested Stakeholders		-	-
Publish Findings			+
Demonstrate Products			
Discuss NPD Strategically	+		+
Internal Communications	+	+	+
Document Management Practices			
Reporting and Comm. Structure	+	+	+
Reward Systems		+	+
Slack Time	+	+	+
Reward Development	+		+
Learning and Teaching on-the-job	+		+
Informal Learning and Interaction	+		
Formal Project Management			
Prototyping	+		+
Decision Support Systems		+	+
Knowledge Mapping Activities			
Directory of Internal Expertise		+	+
Electronic Forums for Debate	-		-

KMA use – success

	N=	123	119	122
		Project Time Success	Project Cost Success	Project Specification Success
Use External Research Services	Pearson Correlation	0.38	-0.12	0.15
	Sig. (2-tailed)	0.00	0.20	0.10
Survey/Collect External Information	Pearson Correlation	0.26	0.12	0.26
	Sig. (2-tailed)	0.00	0.20	0.01
Use External NPD Support	Pearson Correlation	0.42	0.30	0.53
	Sig. (2-tailed)	0.00	0.00	0.00
Explore External Opinions	Pearson Correlation	0.21	-0.09	0.16
	Sig. (2-tailed)	0.02	0.35	0.07
Use Information Searches	Pearson Correlation	-0.44	0.20	-0.19
	Sig. (2-tailed)	0.00	0.03	0.04
Attend External TandD	Pearson Correlation	-0.05	0.01	0.10
	Sig. (2-tailed)	0.55	0.96	0.28
Consult Specific Outside Experts	Pearson Correlation	0.45	0.07	0.30
	Sig. (2-tailed)	0.00	0.48	0.00
Participate in Communities of Practice	Pearson Correlation	0.35	0.32	0.39
	Sig. (2-tailed)	0.00	0.00	0.00
Empower Knowledge Brokers in SC	Pearson Correlation	0.45	0.13	0.39
	Sig. (2-tailed)	0.00	0.17	0.00
Empower Knowledge Brokers Sales	Pearson Correlation	-0.20	0.12	-0.24
	Sig. (2-tailed)	0.03	0.20	0.01
Brief Interested Stakeholders	Pearson Correlation	0.11	-0.08	-0.20
	Sig. (2-tailed)	0.23	0.39	0.03
Publish Findings	Pearson Correlation	0.13	0.17	0.36
	Sig. (2-tailed)	0.16	0.06	0.00
Demonstrate Products	Pearson Correlation	-0.03	0.42	0.23

	Sig. (2-tailed)	0.72	0.00	0.01
Discuss NPD Strategically	Pearson Correlation	0.58	0.42	0.51
	Sig. (2-tailed)	0.00	0.00	0.00
Internal Communications	Pearson Correlation	0.24	0.28	0.09
	Sig. (2-tailed)	0.01	0.00	0.32
Document Management Practices	Pearson Correlation	0.17	0.26	0.25
	Sig. (2-tailed)	0.06	0.01	0.01
Reporting and Comm. Structure	Pearson Correlation	0.16	0.55	0.47
	Sig. (2-tailed)	0.09	0.00	0.00
Reward Systems	Pearson Correlation	0.04	0.46	0.28
	Sig. (2-tailed)	0.65	0.00	0.00
Slack Time	Pearson Correlation	0.26	0.61	0.54
	Sig. (2-tailed)	0.00	0.00	0.00
Reward Development	Pearson Correlation	0.44	0.16	0.50
	Sig. (2-tailed)	0.00	0.08	0.00
Learning and Teaching on-the-job	Pearson Correlation	0.11	0.30	0.44
	Sig. (2-tailed)	0.24	0.00	0.00
Informal Learning and Interaction	Pearson Correlation	0.29	0.29	0.41
	Sig. (2-tailed)	0.00	0.00	0.00
Formal Project Management	Pearson Correlation	0.26	0.30	0.30
	Sig. (2-tailed)	0.00	0.00	0.00
Prototyping	Pearson Correlation	0.41	0.26	0.33
	Sig. (2-tailed)	0.00	0.01	0.00
Decision Support Systems	Pearson Correlation	0.09	0.49	0.37
	Sig. (2-tailed)	0.35	0.00	0.00
Knowledge Mapping Activities	Pearson Correlation	-0.03	0.25	0.10
	Sig. (2-tailed)	0.74	0.01	0.30
Directory of Internal Expertise	Pearson Correlation	0.06	0.42	0.35
	Sig. (2-tailed)	0.48	0.00	0.00
Electronic Forums for Debate	Pearson Correlation	-0.44	0.00	-0.23
	Sig. (2-tailed)	0.00	0.98	0.01

N=	123	119	122
	Project *Time* Success	Project *Cost* Success	*Project* Specification *Success*
Use External Research Services	+		
Survey/Collect External Information	+		+
Use External NPD Support	+	+	+
Explore External Opinions	+		
Use Information Searches	-	+	-
Attend External TandD			
Consult Specific Outside Experts	+		
Participate in Communities of Practice	+	+	+
Empower Knowledge Brokers in SC	+		+
Empower Knowledge Brokers Sales	-		-
Brief Interested Stakeholders			-
Publish Findings			+
Demonstrate Products		+	+
Discuss NPD Strategically	+	+	+
Internal Communications	+	+	
Document Management Practices		+	+
Reporting and Comm. Structure		+	+
Reward Systems		+	+
Slack Time	+	+	+
Reward Development	+		+
Learning and Teaching on-the-job		+	+
Informal Learning and Interaction	+	+	+
Formal Project Management	+	+	+
Prototyping	+	+	+
Decision Support Systems		+	+
Knowledge Mapping Activities		+	
Directory of Internal Expertise		+	+
Electronic Forums for Debate	-		-

Regressions – KMAs only

Dependent Variable: Project Time Success	n=	123	R Square	47%
Stepwise model: KMAs only	Unstandardised Coefficient	Standardised Coefficient	Absolute Coefficient	Relative Strength
Discuss NPD Strategically	0.45	0.52	0.45	52%
Use Information Searches	-0.25	-0.28	0.25	-29%
Empower Knowledge Brokers Sales	-0.17	-0.23	0.17	-20%

Dependent Variable: Project Cost Success	n=	119	R Square	51%
Stepwise model: KMAs only	Unstandardised Coefficient	Standardised Coefficient	Absolute Coefficient	Relative Strength
Slack Time	0.59	0.57	0.57	50%
Demonstrate Products	0.31	0.32	0.32	28%
Empower Knowledge Brokers Sales	0.23	0.26	0.26	22%

Dependent Variable: Project Specification Success	n=	122	R Square	57%
Stepwise model: KMAs only	Unstandardised Coefficient	Standardised Coefficient	Absolute Coefficient	Relative Strength
Directory of Internal Expertise	0.32	0.41	0.41	27%
Electronic Forums for Debate	-0.29	-0.39	0.39	-25%
Publish Findings	0.30	0.29	0.29	19%
Use External NPD Support	0.25	0.29	0.29	19%
Reward Development	0.15	0.17	0.17	11%

Regressions – NPDd then KMAs

Dependent Variable: Project Time Success	n=	123	R Square	51%
Enter method NPDd then stepwise method KMAs	Unstandardised Coefficients	Standardised Coefficients	Absolute Coefficient	Relative Strength
Resources available for NPD	0.75	0.54	0.54	44%
Electronic Forums for Debate	-0.26	-0.35	0.35	-29%
Internal Communications	0.32	0.33	0.33	27%

Dependent Variable: Project Cost Success	n=	119	R Square	62%
Enter method NPDd then stepwise method KMAs	Unstandardised Coefficients	Standardised Coefficients	Absolute Coefficient	Relative Strength
Entrepreneurial Climate	0.78	0.56	0.56	34%
Discuss NPD Strategically	0.29	0.27	0.27	17%
Prototyping	0.25	0.25	0.25	15%
Demonstrate Products	0.22	0.22	0.22	13%
Empower Knowledge Brokers Sales	0.17	0.19	0.19	12%
NPD Process Quality	0.34	0.15	0.15	9%

Dependent Variable: Project Specification Success	n=	122	R Square	54%
Enter method NPDd then stepwise method KMAs	Unstandardised Coefficients	Standardised Coefficients	Absolute Coefficient	Relative Strength
NPD Process Quality	0.89	0.46	0.46	40%
Survey/Collect External Information	0.22	0.27	0.27	23%
Resources available for NPD	0.37	0.27	0.27	23%
Informal Learning and Interaction	0.13	0.15	0.15	13%

Appendix J

Appendix K

Knowledge management for new product development

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Abstract

Purpose – *The purpose of this paper is to present a holistic interpretation of the scope of knowledge management processes whose intent is to enhance the effectiveness of new product development (NPD).*

Design/methodology/approach – *The paper reviews key concepts in NPD and knowledge management (KM), leading to propositions about the effective management of NPD-relevant knowledge. It develops a structured, holistic model of organizational KM including practical mechanisms and processes for managing knowledge transfer.*

Findings – *Effective knowledge management needs to: acknowledge the multiple organizational levels at which knowledge is deployed; support the production, elicitation and exchange of tacit knowledge as well as explicit, codified information; hence accommodate and enable both informal and formal, typically IS/IT enabled knowledge processes.*

Practical implications – *KM is work-in-progress, not a one-time search for an idealised state. Computer-enabled information systems are necessary but not sufficient elements of a comprehensive approach to KM. Holistic KM should be integral to the organization, working with not against the grain of its technical, social and cultural processes. Senior managers with titles such as "chief knowledge officer" may be crucial in establishing strategic priorities and change programmes, but all NPD personnel bear responsibility for effective KM.*

Originality/value – *The paper combines propositions about the effective conduct of KM for NPD with a model of holistic KM that involves multi-level flux and constructive knowledge transition. It identifies practical mechanisms, IS/IT enabled and otherwise, in this context. It suggests that new research to identify effective KM practices in NPD is a priority for KM researchers.*

Keywords *Product development, Innovation, Knowledge management, Tacit knowledge, Transition management*

Paper type *Conceptual paper*

Introduction

For over 30 years research has addressed the factors that lead to effective new product development or NPD (e.g. Myers and Marquis, 1969; Booz-Allen and Hamilton, 1982; Cooper and Kleinschmidt, 1987; Zahra, 1993; Cooper *et al.*, 2004). There is now a plausible, broadly convergent list of factors. Since the publication of a very influential book (Nonaka and Takeuchi, 1995), few would doubt that systematic knowledge management (KM) is one important factor. Knowledge work is at the heart of NPD processes. Today therefore, many practitioners are likely to be making decisions about how KM can enable or even orchestrate their companies' NPD activities.

To develop, manage and exploit organizational knowledge requires behaviours we can refer to as knowledge management competencies. They are fundamental to innovation, enabling it to survive competitively and to grow (Kogut and Zander, 1992; Collinson, 2003). The organizational competences crucial for NPD are to know what it knows, tacitly and explicitly, and to be able to recombine and apply what it knows in useful ways. It needs also to know

what it does *not* know and how to close significant knowledge gaps. These actions entail personal and shared cognitions that are generated and articulated both formally and via informal social interactions (e.g. Madhavan and Grover, 1998).

The potential benefits of systematic knowledge diffusion and recombination are now acknowledged to render NPD less *ad hoc*, serendipitous and therefore more effective and efficient. From anecdotal evidence and from the burgeoning literature it is clear that organizations increasingly allocate resources to develop KM information systems, often linked with the appointment of staff to senior roles such as chief knowledge officer to orchestrate these activities (Prusak, 2001). As knowledge management becomes more widespread, conscious, structured and formalised, it becomes – in a sense – knowledge management. Yet, necessary though sophisticated IS/IT support may be, an emphasis on formality may undervalue the contribution of social interactions, despite evidence that these behaviours aid collective knowledge generation and learning (e.g. Nonaka and Takeuchi, 1995; Prusak, 1997; Zhang *et al.*, 2004).

In respect of NPD it must surely be wise to accommodate formal and informal processes in the conduct of knowledge management. But what does this mean in practice? Drawing on recent literature, this paper develops a framework that conceptualises proactive knowledge management in terms of transitions that generate, consolidate, transform, diffuse and apply technical knowledge. These transitions arise at and between various levels within the innovating organization and across its external boundaries. The focus then shifts to the practical implications of the framework for enabling these knowledge transfers in practice.

Knowledge management in support of new product development

For organizations whose long-run competitive advantage and economic success is based on technical (knowledge-intensive) activities, effective NPD processes are crucial (Clark and Fujimoto, 1991). Brown and Eisenhardt (1995) offer three perspectives on these processes that they characterise as exercises in rational planning, in disciplined problem solving, and the enactment of communication webs.

The rational plan perspective endorses deliberate, top-down processes designed to meet clear strategic objectives for product innovation. Processes are proactive, systematic, well structured, and purposefully managed; typically they address major projects for which "the goal is manifestly important and its achievement nearly impossible", a description attributed by Tripsas and Gavetti (2000) to Dr Edwin Land, the founder and former CEO of Polaroid. Though rational planning seems consistent with the second perspective, disciplined problem solving, the latter also acknowledges the emergent, reactive, potentially idiosyncratic and serendipitous nature of NPD, needing strong commitment and initiative from middle and junior levels. Problem solving seems particularly to characterise NPD projects that focus on relatively short-term, near-market solutions. The third, communication web perspective on NPD highlights the importance of human and social dimensions. A variety of factors at both personal and collective levels encompasses goal-directed behaviours, means of formal communication, relationships, social networking activities, and beliefs (possibly local, idiosyncratic) about technical solutions.

Of course, NPD is not a monolithic activity. There is the familiar "stage-gate" model in which NPD is said to proceed in a sequence of as many as thirteen discrete temporal stages punctuated by decision points or "gates" (Booz-Allen and Hamilton, 1982; Cooper and

" The potential benefits of systematic knowledge diffusion and recombination are now acknowledged to render new product development less *ad hoc*, serendipitous and therefore more effective and efficient. "

Kleinschmidt, 1987). Stages carried out concurrently, however, may enhance project co-ordination and reduce overall development times (Takeuchi and Nonaka, 1986; Cooper *et al.*, 2004). Tranfield *et al.* (2003) posit a conceptually simpler model with three, overlapping phases of knowledge activity. These are discovery: knowledge routines that relate to markets and technologies, including environmental scanning, external data capture and the stimulation of internal awareness; realisation: translating acknowledged possibilities into tangible outcomes by applying what is known; and nurture: continuing reflection, learning and subsequent development.

Whatever NPD model is favoured, much of the required organizational knowledge is distributed, rather than centralised; much of it is also tacit, located and possibly locked in the minds of comparatively few, expert staff (Tsoukas, 1996; Alavi and Tiwana, 2002; Kreiner, 2002). Thus, the methods and practices of knowledge management significantly affect how (and how effectively) the organization generates, stores, accesses, recombines and mobilises what it knows about NPD – technically and processually. Knowledge-enabling processes probably cannot and arguably should not be confined to formal, managed mechanisms or standardised "best practices" in the quest for optimal performance. Understandably, though, senior managers may press for a high degree of formality and standardisation, even as their research staff may resist these attempts on the grounds that NPD progress is characteristically uneven and unpredictable, requiring patience, dedication, individual craft and creativity. It may therefore be necessary for opposing views to coexist in a state of tension.

NPD processes are typically organization- and industry-specific: NPD in a semiconductor firm, for instance, will differ in form, pace and cycle time from equivalent processes in, say, a pharmaceutical company or a machinery manufacturer. Knowledge therefore becomes organization-specific; future innovation possibilities become functions of particularised developmental paths or trajectories (Dosi, 1992; Leonard-Barton, 1992; Venzin *et al.*, 1998, p. 32; Stock *et al.*, 2001). Future paths are dictated partly by existing competencies and partly by entrenched belief structures (schema) that tend to inhibit innovative, collective thinking and reduce receptivity to inward knowledge transfers from outside these structures (Dougherty, 1992; Leonard-Barton, 1992; Tripsas and Gavetti, 2000). In short, what an organization already knows (and does not know), constrains what it is practically capable of knowing in the future, determining in effect its learning or absorptive capacity (Cohen and Levinthal, 1990).

These observations may be restated as propositions about the design and application of knowledge management systems and processes relevant for NPD. Thus:

P1. Knowledge management processes for NPD should take due account of both the organizational and the external contexts of innovation.

No single, uniform approach will be appropriate for every organization or likely to enhance all aspects of its NPD activities. Important issues to consider include the competitive business sector context; the organization's current innovative capabilities; its prior and expected future (viable) development paths; product- and technology-specific factors; and the nature of particular NPD activities, whether they be fundamental "front end" research, near-market applications or a combination thereof.

P2. The application of knowledge management processes to enhance NPD effectiveness and efficiency requires practical balance and progressive improvement; it is not the achievement of some notional idealised state.

There are too many novel, complex and confounding factors to expect, let alone achieve perfect KM practices. Approaches to knowledge management, however well founded, are compromises requiring sophistication and flexibility to balance a dynamic set of requirements and priorities that may have contrary implications and imperatives. The desirability of access to deep and comprehensive knowledge has to be balanced against its cost of acquisition (including potential redundancy), timeliness and ease of access. A balance has to be struck between self-sufficiency of knowledge versus reliance on external

sources, and between narrow specialisation versus unfettered diversity of knowledge capture and creation.

Further, a systematic, conceptually sound, centralised approach to knowledge management ought not to inhibit creative, improvised NPD solutions that draw on localised experience and endeavour. Because local knowledge tends to be "owned" by individuals and local teams, there is a balance to be struck between personal and collective ownership. Knowledge processes that seek to externalise, codify and appropriate personal knowledge, for example by forms of knowledge brokering (Burt, 2005), require positive incentives to generate and reward trust between individuals and their employer.

Organizations learn by accumulating and applying knowledge and subsequently reflecting on outcomes. Knowledge within that is not (widely) recognised, applied and developed becomes sidelined and ultimately redundant (Occasio, 1997; Blackler *et al.*, 1999; Davenport and Volpel, 2001). Unfortunately, knowledge does not always flow readily around organizations, creating a variety of problems and barriers to effective innovation (von Hippel, 1998; Hoopes and Postrel, 1999). Organizational knowledge atrophies when static; its true value lies in its flux, its dynamic usage, thus its capacity to stimulate continued learning. An *analogy* is the concept of the economic multiplier: money adds value only through *circulation. Hence:*

P3. Investment *in knowledge accumulation has to be matched* by widespreaed awareness of its existence and utility (effectiveness*) in its application.*

Knowledge banks that sustain no tangible applications are merely costs. Thus the design of KM processes requires mechanisms that monitor the flux of accumulated knowledge with feedback that informs decision makers how the future accumulation of knowledge should proceed appropriately. Drew (1999) distinguishes between what is actually known in an organization (its knowledge base or content) and the collective awareness of what is (and is not) known. These distinctions lead to the matrix of knowledge types shown in Table I.

As a generalisation, collective awareness is linked to explicitness: the codification of what is known. The collective awareness of technically and scientifically specialised knowledge is severely constrained, precisely because it is typically understood and therefore useably accessible only to knowledgeable users and their local peers (Tsoukas, 1996; Madhavan and Grover, 1998; Alavi and Tiwana, 2002). The main exception is non-technical, social and cultural "general knowledge" that permeates an organization irrespective of whether or not it is codified. Much of this general knowledge exists tacitly, stored in the "collective memory" or consciousness (Walsh and Ungson, 1991). Yet this is far from being a reliable depository even of general knowledge.

Knowledge, information and data are conceptually different though, too often, the words are used interchangeably (Nonaka and Takeuchi, 1995, p. 58). For Marchand (1998) information is data provided with context, hence situational relevance. Knowledge derives from *interpreting* the incoming and circulating information flux, leading to descriptive understandings and prescriptive beliefs (whether or not fully justified). Some beliefs are

Table I Extent of knowledge accessibility

	Content	
Awareness	*What the organization knows somewhere within it*	*What the organization does not know*
What the organization is in some sense collectively aware of	Explicit and tacit (probably localised) technical knowledge and generally accessible tacit social and procedural knowledge	Explicit external knowledge of all kinds that can in principle be captured and disseminated throughout the organization
What the organization is collectively unaware of	Tacit knowledge of all kinds that is personal or locally distributed and therefore not widely accessible	Tacit external knowledge that requires access to (external, localised) social networks to capture

Source: Adapted from Drew (1999)

shared, others remain essentially personalised. Thus Newell *et al.* (2002) distinguish individuals' cognitive, information processing from the social construction of knowledge. In fact Marchand confines the term "knowledge" to what is personally known or internalised – hence the property of individuals or at best small teams of NPD actors. The crucial consideration is not the "fact" but the localised and personalised interpretation of that "fact": its perceived significance in a particular context.

Kreiner (2002) notes that because much specialised knowledge is by its nature tacit, control and distribution of it is conceptually distinct from mobilisation. Evidently, the objectives of systematic knowledge management are to:

- provide ways to uncover, spread and mobilise what the organization already knows, explicitly and tacitly;
- enable access to what currently it does not know, but has a collective sense of needing to know, and more problematically; and
- establish what it will need to know *in future*, despite being unaware of this need at present.

Mechanisms and processes that address the first of these appear contentious when they are personally intrusive; the second raises no problems of principle since it addresses knowledge content posited to exist somewhere beyond the organization, although acquisition may prove costly and encounter barriers such as patent protection; while the third presents severe ontological and epistemological challenges. Accordingly:

P4. KM support for NPD processes ideally requires sympathetic consideration and treatment of both tacit knowledge and explicit (codified) information.

Knowledge and information reside at various organization levels and locations that are accessible with varying degrees of difficulty. Some knowledge that will prove necessary, yet whose significance is currently unclear, will also be external to the organization and may remain inaccessible. Explicit, codified information is amenable to computer-based capture, storage and dissemination. IS/IT solutions may perhaps also play a valuable role in the elicitation and dissemination of tacit knowledge, for example via the use of "expert systems" software, as well as communication mechanisms such as e-mail, teleconferencing, and other web-based information systems and intranets. These solutions can play a valuable role in informing individuals, enabling them to enhance and exchange personal stores of knowledge, provided that they have the motivation and time to invest in such activities. This suggests that certain conditions need to be met if these processes are to be effective. For example:

P5. IS/IT enabled knowledge management processes enhance NPD projects and processes most effectively when they: identify or otherwise draw attention to extant codified information that may be relevant to a particular NPD project or activity; support *ad hoc* enquiries by facilitating access to localised as well as centralised information sources, for example via the use of hypertext links; and enable and encourage post-innovation activities that reflect critically on the performance of both completed and in-progress NPD projects.

Unfortunately, IS/IT systems readily overload human beings with information and data, requiring them to respond selectively and perhaps idiosyncratically. Increasing demands for productivity may also limit personal scope to enquire, to read widely, to converse and to reflect. This is significant because it is unclear whether and to what extent IS/IT solutions can enhance the more-or-less tacit interpersonal knowledge transfers that occur in regular or *ad hoc* social encounters.

Also, when an organization seeks to capitalise systematically on these informal and unpredictable social processes, ethical considerations may arise, for example over the legitimate ownership of intellectual property obtained from employees. While this is unlikely to be a significant concern in normal working hours and on company premises, what of tacit knowledge acquired after-hours and via social activities with the character of the bonding sessions attributed particularly to some Japanese corporations. Accordingly:

P6. Knowledge management processes, whether IS/IT mediated or not, are most effective when they: work with, not against the grain of NPD structures, human resource management processes and internal culture; and complement rather than hinder the development of social capital that occurs via interactive networking among members of development teams, including particularly the contribution of boundary-spanning, nodal actors or "knowledge brokers".

Knowledge flux and transitions

The foregoing propositions emphasise that KM processes need to work in accord with organization-specific NPD characteristics in a dynamic yet sensitive fashion. We therefore need to explore the implications in more detail. Following Nonaka and Takeuchi (1995), Marchand (1998) identifies four forms of knowledge flux that constitute collective learning. They are shown in a modified form in Table II, retaining his use of the word "knowledge" to signify what is known by individuals and perhaps by small NPD teams as an entity, rather than more broadly across the organization.

No single KM process based on IS/IT will necessarily contribute effectively to all of four domains of knowledge transfer; indeed, it may be that no formal KM process, whether or not IS/IT based, will enhance tacit-to-tacit transfers. Understandably, given the potency of modern IS/IT, organizations that pursue more effective NPD may be tempted – perhaps wrongly – to focus on scientific and technical information processing, the upper left cell in Table II (explicit to explicit). Moreover, Kreiner's (2002) concern that the attempt to apply IS/IT mechanisms to convert distributed tacit knowledge into explicit information emphasises codification over mobilisation is worth repeating, since it may threaten or devalue the complementary social processes that create knowledge and stimulate innovative behaviours.

Given that information and knowledge span technical and non-technical (social, cultural, procedural) domains, the form of Table II needs expansion. Specifically, it does not acknowledge that information and knowledge exists at – and is often confined to – one of a number of activity levels. Thus Figure 1 elaborates Table II by distinguishing four important levels of exchange and transfer activity that affect NPD within the focal organization.

The collective organizational level needs little comment; NPD activity at this level is limited, with technical information and knowledge here being largely confined to what has already been codified. The primary duty at this level is to upload appropriate information and knowledge to the external world and to download that which exists centrally to the operational sub-levels as and when it is needed.

Table II Process of knowledge conversion

Transition from	*Transition to* Information (explicit knowledge)	*Transition to* Knowledge (tacit knowledge)
Information (explicit knowledge)	(Re)combination and diffusion by acquiring, analysing and organizing documents, files, messages etc. into databases and other forms of accessible repository and publishable report intended for extended access	Internalisation by individuals who read documents and e-mails, attend presentations by others, access databases, and then absorb and reflect on the contents of all of these
Knowledge (tacit knowledge)	Externalisation by articulating the personal knowledge of teams and individuals and creating documents, databases, presentations etc. derived from this knowledge	Socialization among individuals and teams who share knowledge and understanding by articulating, demonstrating, exchanging and negotiating ideas among themselves in a variety of settings (networking, *ad hoc* conversations etc.) without directly codifying what has been shared

Sources: Adapted from Marchand (1998) and Nonaka and Takeuchi (1995)

Figure 1 Information/knowledge transfer among organization levels

	Transition To			
Transition From	External sources	Organization level	Team level (Q)	Individual (Y)
External sources		Download	Download	Download
Organization level	Upload	Circulate	Download	Download
Team level (P)	Upload	Upload	Exchange/ transfer	Download
Individual (X)	Upload	Upload	Upload	Exchange/ transfer

The significant levels of NPD activity are within the project team, or expressed more generically as the innovation unit, and among individual researchers and developers. Among these various levels there are a variety of possible uploads, downloads, lateral exchanges and transfers. Additionally, there is a world of other organizations including suppliers, customers and other stakeholders such as research and development agencies with which the various levels can in principle engage, provided that awareness exists.

Figure 2 extends the conceptualisation of knowledge and information transitions by, in effect, integrating Table II and Figure 1. It accommodates the significant levels posited in Figure 1, while retaining the four-quadrant structure of Table II, together with the feasible knowledge transitions among them. Additionally, it acknowledges transitions from one explicit (codified) state to another (upper left quadrant), and from explicit to tacit (upper right). There can in principle also be knowledge transitions from tacit to explicit (lower left) and from tacit to tacit (lower right).

Some forms of knowledge transition are not germane to this account of NPD. These are the exchanges, whether tacit and explicit, among external agencies signified by the

Figure 2 Possible knowledge and information transitions with respect to the organization

Transition	**To**						
	Codified information retained at the level of:				***Tacit knowledge retained at the level of:***		
From	**External agency/ organization**	**Focal organization**	**NPD Project team Q***	**Individual project team member Y**	**Actors or teams in external agencies**	**NPD Project team Q**	**Individual project team member Y**
Codified information at the level of:							
External agency/ organization		**A: Acquisition or appropriation of information followed by internal diffusion**				**D: Team and personal appropriation of external information as tacit knowledge**	
Focal organization	**C: External publication of organizational information**	**B: Internal recombination, publication and dispersion of organizational information**			**F: External (non-sanctioned?) leakage**	**E: Team and personal appropriation of organizational and localised information as tacit knowledge**	
NPD Project team P							
Individual project team member X							
Tacit knowledge at the level of:							
Teams & actors in *an external agency/* organization		**J: Appropriation, codification and diffusion of *external knowledge* as organizational information**				**G: Team and personal internalisation of external knowledge via networking or collaboration**	
NPD Project team P	**L: Knowledge codification for external purposes (e.g. patenting)**	**K: Codification and diffusion of tacit localised knowledge as organizational information**			**I: Knowledge sharing via JVs or other external collaborations**	**H: Team and personal appropriation of *tacit* localised knowledge via socialisation and networking**	
Individual project team member X							

Note: *Where X and Y may be members of the same team or in different teams

black-shaded cell in Figure 1 and the four black cells in Figure 2. While the primary purpose of NPD is to generate and apply knowledge for internal exploitation, for completeness the figures also acknowledge possible externalisation. These transfers can be officially sanctioned, for example in patenting, licensing (cell L) and in joint ventures (cell I), for authorised publicity and related purposes (cell C) and unofficial, presumably non-sanctioned "leakage" (cell F). Activity in the blanked cells is beyond the scope of this paper, though the security implications need careful note.

Some transitions cannot occur directly, only via an intermediate stage. For example, while tacit technical knowledge can in principle be shared locally among individual researchers and small teams (cell H in Figure 2), before it can become organizationally diffused it has to be codified by the knowledgeable few (cell K). Conversely, well codified and widely diffused information may captured by individuals and small teams for whom it has particular significance (cell B); they subsequently adopt, adapt, internalise and apply it, rendering it as tacit knowledge that takes on a rather different form (cell E).

With these caveats, Figure 2 summarises the gamut of possible knowledge transitions. The upper left quadrant of the figure involves the inwardly-directed transfer and circulation of explicit, codified information. In pursuit of innovative new products the organization, its subunits and individual researchers may acquire information external to their particular levels. They then recombine and apply what is new with what they know already, and may subsequently diffuse the results of these constructive activities.

In cell A, external information is captured for prospective use at various internal levels. In cell B codified information that currently exists in some parts of the organization, but not others is internally transferred and reconfigured. The organization and its subunits can also decide to diffuse information formally to selected other organizations or agencies (cell C). Since these three cells in Figure 2 entail information diffusion and reconfiguration from one explicit state to another, the upper left quadrant contains activities amenable to facilitation by IS/IT processes and mechanisms, hence widely considered to be the proper domain of knowledge management. Even so, these transitions engage complex socio-technical systems in which formal information processing needs to work in harmony with technical human resources for NPD activities to be effective.

In the upper right quadrant of Figure 2 two cells (D and E) involve attempts to capture explicit information and render it into useful, most probably reconfigured tacit knowledge. Because tacit knowledge is essentially localised and personal, it is the *de facto* property of individuals and research teams. Once codified information has been modified, internalised and therefore rendered tacit, it is no longer more widely accessible, a crucial issue given the importance of scientific and technical knowledge for NPD. Knowledge transitions in this quadrant are confined to those project teams and individuals who are competent to share, reconfigure and internalise particular information, irrespective of its source. However, the cognitive and social processes they employ in so doing may benefit to some degree from the support of formal KM processes, particularly those that create or enhance communication networks.

In the lower right quadrant cells G and H are analogous to cells D and E, though the source knowledge is already tacit. To the extent that tacit technical (as opposed to social, cultural and procedural knowledge) can be shared, internalised and reconfigured, these processes occur cognitively and socially at substantially localised levels among individuals and small teams. These exchanges requires contacts among those who know and those who aspire to know, which implies collaboration, networking and informal exchange that may benefit little from the existence of formal KM processes. When employees engage directly with external agents, for example at conferences or in approved business collaborations, corresponding processes may also occur (cell I), though the circumstances where knowledge transitions are considered acceptable are presumably circumscribed for security reasons.

Finally, the lower left quadrant posits taking currently tacit knowledge from one part of the organization, seeking to codify and internally diffuse it as shared information (cells J and K). In these two cells individuals and small teams may benefit from – indeed require – particular

kinds of support, for example the use of enquiry-based software including so-called expert systems as they try to render internalised (personal) tacit knowledge as documented information. In theory these processes could also apply to the codification and export of tacit organizational knowledge (cell L). Legitimate activity of this form requires an intermediate transition via cell K, for example when tacit knowledge is codified for patenting purposes.

The practical implications

Total agreement about the taxonomy of dynamic knowledge-processing activities does not yet exist, though various generic routines have been identified (Table III); these routines are abstractions of tangible mechanisms and processes that are referred to in the following discussion, with particular reference to Figure 2.

The upper left quadrant of Figure 2 involves codified information that is the most obviously amenable to IS/IT enabled knowledge management. Cell A requires the organization to interact continuously with the external environment. Various transfer mechanisms and processes involve systematic scanning allied to the capture of information that actors perceive to be relevant for a particular project and/or domain of innovation. Processes in cell A lead to the accumulation of information that requires collation, recombination and internal dissemination *pari passu* with information generated, recombined and disseminated internally (cell B).

Some cell A processes imply a scope and entail cost that require senior management commitment. Other scanning and knowledge accumulation processes may be feasible for the project team or individual team members to adopt. The following list is necessarily indicative not exhaustive. The elements are presented in a broadly ascending order of cost, scope and level of required commitment, not in order of importance for any particular organization:

1. Perusal of technical journals (papers and via on-line databases).
2. Regular surveys of new patent applications and published patent data.
3. Systematic scanning of generic search engines (e.g. Google Scholar) and specialist technical databases, plus the use of text/data mining software and the provision of staff training in such applications.
4. Systematic, recorded (i.e. not just *ad hoc* and impressionistic) feedback from customers, suppliers and other relevant stakeholders about market trends, interesting new technologies, product usage etc.
5. Systematic attendance at academic and industry conferences, nationally and internationally.
6. Monitoring of competitors' activities and reverse engineering of their new products.
7. Commission of studies by external research agencies into:
   - market needs and trends;
   - technological trends, possibilities and risks; and
   - best practice in technology applications in and beyond the competitive sector.
8. Commission of R&D by external agencies into particular new technologies.
9. Licensing of relevant patents from other innovative organizations.
10. Entering appropriate technological alliances and joint ventures.

Turning to cell B, here the over-riding aim is to enhance the awareness of project teams and individual staff members of the information available to them and to facilitate access and constructive recombination as needs indicate. This aim implies a differing, though complementary set of processes to those in cell A. Some of the previous set will apply, especially in large, innovation-intensive organizations whose R&D facilities are spread around the globe. Additional processes are listed below:

Table III Major knowledge management mechanisms and processes

Knowledge management mechanism	*Exemplar sources*
External (relevant) knowledge search and acquisition	Brockman and Morgan (2003) Darroch (2005) Holsapple and Joshi (2004) Kreiner (2002) Liu *et al.* (2005) Stock *et al.* (2001) Tranfield *et al.* (2003)
Capture, codification and storage	*Alavi and Tiwana(2002)* Davenport and Volpel (2001) Herder *et al.* (2003) Hoegl and Schulze (2005) Kreiner (2002) Liu *et al.* (2005) Tranfield *et al.* (2003)
Tracking, access and retrieval	Davenport and Volpel (2001) Herder *et al.* (2003) Holsapple and Joshi (2004)
Diffusion/dissemination	Brockman and Morgan (2003) Cavusgil *et al.* (2003) Darroch (2005) Davenport and Volpel (2001) Herder *et al.* (2003) Hoegl and Schulze (2005) Holsapple and Joshi (2004) Kreiner (2002) Liu *et al.* (2005) Tranfield *et al.* (2003)
Assimilation/interpretation/signification	Brockman and Morgan (2003) Davenport and Volpel (2001) Herder *et al.* (2003) Hoegl and Schulze (2005) Holsapple and Joshi (2004) Madhavan and Grover (1998) Mylonopoulos and Tsoukas (2003) Stock *et al.* (2001) Tranfield *et al.* (2003) von Krogh *et al.* (2000)
Generation, recombination, mobilization	Alavi and Tiwana (2002) Brockman and Morgan (2003) Burt (2005) Darroch (2005) Davenport and Volpel, 2001) Herder *et al.* (2003) Hoegl and Schulze (2005) Holsapple and Joshi (2004) Kreiner (2002) Liu *et al.* (2005) Madhavan and Grover (1998) Park and Kim (2005) Tranfield *et al.* (2003) von Krogh *et al.* (2000)
Reflection and learning from outcomes	Easterby-Smith *et al.* (1999) Davenport and Prusak (1998) Davenport and Volpel (2001) Tranfield *et al.* (2003)

- enabling mechanisms for teams and individuals to articulate new ideas, draft working papers and summary briefings on technology issues and project applications;
- regular internal reporting systems to communicate the availability of information, best practices and comparative project performance outcomes with respect to technology development and financial indicators;
- organizational reward systems that encourage trust, creativity and proactive knowledge sharing via these internal communication and reporting systems;
- retention of working papers and reports in accessible "libraries" utilising digital document management technologies and/or IT-based repositories with hypertext links and representation systems to facilitate *ad hoc* searches; and
- the integration of NPD decision processes with strategic planning processes.

Many of these options are implementable via appropriate software solutions, of which many commercial packages are available. A significant decision, however, concerns whether the form and implementation of such systems should be centralised or decentralised to business divisions or R&D units with hyperlinks to parallel systems elsewhere in the corporation. Because these processes can no longer be treated as peripheral, optional or "bolt-on" aspects of the organization's approach to NPD, they need to be fully integrated and functional, implying the need for a significant degree of central co-ordination.

External diffusion/dissemination (cell C) presents challenges that to a degree mirror those of internal appropriation. The rationale for dissemination needs to be clear, and clearly understood. External communication processes need careful and secure management control. Use of the corporate website is an option that many medium and large corporations employ to this end. Other processes include:

- regular use and updating of the corporate website(s) to communicate appropriate information to external stakeholders;
- technical reports, data sheets etc. made available to selected external agencies via an on-line "library" with open access or to registered members;
- regular external reporting and communication systems that disseminate appropriate indicators of company performance with respect to product and technology development, where appropriate using public relations agencies;
- active researchers seconded to sales and marketing projects to explain and demonstrate new technology and products to end users;
- papers presented at academic and industry conferences and for journal publication;
- systematic patent applications;
- patent licensing to other appropriate organizations;
- partnerships in the supply chain regarding new product and technology initiatives; and
- other, appropriate technological alliances and joint ventures

In the upper right quadrant of Figure 2, KM processes influence the effectiveness with which individuals and NPD teams internalise already codified information. The priority for the project team is to access the information and knowledge sources available elsewhere in the organization and beyond in a systematic, timely way. Researchers have to combine awareness, access, incentive, motivation and availability of time. The first two requirements are addressed via the processes considered in respect of cells A and B. Linkages between equivalent cells (A to D and B to E) are needed, since acquisition and recombination at the explicit level has to precede internalisation and rendering into tacit knowledge. The other processes require the effective integration and management of human resources with formal knowledge management processes. These include policies and practices that legitimise and enable constructive, curiosity-driven learning, access to

and critical reflection upon disparate information sources and content, all of which require adequate discretionary time.

As regards tacit-to-tacit transitions in the lower right quadrant of Figure 2, the available processes principally involve networking by individual members of NPD teams in both formal and informal contexts, internally and externally. In some instances these may require *senior management affirmation* of their legitimacy. Externally-oriented processes in cell G *include:*

- questioning of outside experts via interviews, *focus groups (Delphi methods) etc.;*
- participating actively in specialist technical "communities of practice"; and
- enacting boundary-spanning technology roles, knowledge "brokers" and facilitators who are empowered to liaise with regular and *ad hoc* external contacts (end users, clients, suppliers of goods, services and equipment and other significant players).

Similar processes can be encouraged internally within NPD teams and across the boundaries of project teams (cell H). In fact there are many KM processes and HRM policies that can encourage the internal diffusion of "know-how" and "know-who":

- electronic messaging systems; telephone and video conferencing links; groupware/intranets; web-based discussion boards;
- directories of internal expertise;
- Structured job rotation to expose staff to new concepts and encourage learning;
- physical work environments that enable small-group interactions and "corridor conversations";
- a working culture in which the sharing of generative ideas, success narratives and the circulation of searching technical questions is considered normal and legitimate; and
- events and forums inside and outside of normal working hours (e.g. internal "knowledge fairs", "seminars", social events etc.) that encourage the exchange of ideas among staff in conditions where status differences are minimised.

In cell I the emphasis is on the externalisation of tacit knowledge beyond the organization, for example via joint ventures and other forms of external contact and collaboration. When this is the aim there must be person-to-person or team-to-team network contacts across organizational boundaries. Such processes include:

- engagement of active researchers with stakeholders in the supply chain and secondment to other organizations to explore market trends, interesting new technologies etc.;
- presentation of papers and informal networking at academic and industry conferences and forums where other experts attend, and active participation in non-local "communities of practice";
- empowerment of boundary-spanning "brokers" to network externally to promote the companies ideas and strategies as may be appropriate; and
- secondment of active researchers to joint technological alliances and venture projects.

Evidently, activities in cells G and I imply two-way exchanges among these researchers and external actors. The challenge is to ensure that greater benefit accrues to the organization than it concedes externally.

Turning to the lower left quadrant, activities in cells J and K aim to convert tacit knowledge into codified information. In these two cells the tasks are logical complements to those in cells G and H respectively. The specific requirement is to codify reconfigured knowledge gained initially via tacit transfer. Codifying processes include producing reports, presentations, and other forms of structured, explicit content to be communicated to colleagues via processes already referred to. Reward systems therefore need to encourage the writing of succinct internal papers and other communication vehicles. Of course, to render personal knowledge explicit is a challenge – to adapt Polanyi's (1966) observation,

> **"Knowledge-enabling processes probably cannot and arguably should not be confined to formal, managed mechanisms or standardized 'best practices' in the quest for optimal performance."**

"we know more than we can readily say". Thus activities in cells J and K may benefit from the use of specialised software to elicit and codify what is presently tacit, such as so-called expert systems software, software for decision support, simulation modelling, knowledge mapping and so on.

Finally, there is cell L, where activities aim to elicit and codify tacit knowledge from various levels in the organization for the purpose of external diffusion. As such there are required links with cells J and K. As noted, the appropriate circumstances may be heavily circumscribed, most obviously to facilitate patent applications and to enable technology collaborations.

Conclusions: linking knowledge management processes with NPD effectiveness

For organizations whose economic success derives from technological advantage achieved through NPD, the ability to capture, embed, reconfigure, apply and diffuse knowledge has always been significant. New possibilities arising from IS/IT enabled knowledge management processes are timely as the pace of change accelerates and knowledge flux becomes increasingly dynamic.

This article has attempted to outline an integrative view of knowledge management: one that is not only about manipulating data and information, but entails knowledge mechanisms and social processes that are consistent with and fully integrated into the warp and weft of the organization's fabric. The model as presented highlights the need to consider exchanges and reconfigurations involving both tacit and explicit states of knowledge within and among organizational levels. A complication that needs also to be considered is that some forms of transition can occur only indirectly, as previously discussed.

These arguments will be controversial for those who see knowledge management largely or exclusively in terms of codified information, captured and disseminated via sophisticated information technology. Due account must also be taken of complementary, informal knowledge processes, often affected significantly by the human resource management policies and practices in place. A knowledge strategy for NPD should accommodate and integrate human processes with technical processes in the complex socio-technical system that is NPD and where necessary encourage structural change in order to enhance productive knowledge flows (Miles *et al.*, 1997; Collinson, 2003; Hansen *et al.*, 1999). The key argument here is that it is helpful to operationalise this approach in terms of identifiable knowledge transitions and how they can be enabled in practice. In other words, to construct a bridge between the conceptual level of KM thinking and its integration and application into organizational structures appropriate for new product development activity.

The challenge for specialist "knowledge managers" is to underpin the processes that are necessary for NPD by enabling information and knowledge flows that aid knowledge creation and recombination, via enhanced communication, both formal and informal. This is a holistic, integrative conception of knowledge management. If implemented effectively, it can have a positive impact on the effectiveness of NPD processes. The role of knowledge manager is necessarily a strategic one. It involves intervention, challenge to the *status quo*, co-ordination and even the promotion of necessary structural organization change, recognising that KM for NPD is fundamentally a dynamic, learning process, not a set of tools to be designed and applied once-for-all-time. Continuing enhancement of extant

approaches and systems is therefore a necessity, which requires thoughtful reflection on what has worked and what has not.

There are *many con*textual influences on NPD in practice, so the relationship between KM and NPD is complex. Innovation takes *many forms, even* within what is conventionally considered NPD, ranging from fundamental research to near-market *product development*. Particular knowledge management processes will have different degrees of relevance and effectiveness for each set of circumstances and stages of development. Since proprietary KM software packages are commercially available and very probably utilised by the leading industry competitors, the differential effectiveness of their NPD processes must in part derive also from constructive, less formal KM processes involving (sometimes idiosyncratic) human behaviours such as effective technology championing, and knowledge brokering across organizational boundaries.

While expectations about the positive benefits of knowledge management on NPD may have been elevated too high, too soon, the research to date suggests that technological innovation workers do consider proactive KM a significant factor in day-to-day practice. However, with some notable exceptions (e.g. Suhet *et al.*, 2004; Darroch, 2005) there has to date been comparatively few systematic, published reports into the relative effectiveness of various processes. Though much of the variance in the effectiveness of observed NPD processes has been explained, a substantial residue of unexplained variance remains that one would predict to be caused at least partially by differences in KM practices and how they are implemented. Further research is needed to put this hypothesis to the test. Not only is there scope for large-scale statistical studies that introduce explicit KM variables, but also for smaller scale "fine grained" and action research studies in organizations that manifest qualitatively different approaches to NPD within sector and across a variety of different sectors.

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Proactive knowledge management: an independent enabler of New Product Development success?

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Abstract: This paper investigates the claim that Knowledge Management Activities (KMAs) are an independent influence on New Product Development (NPD) process success. The literature indicates that while well-known New Product Development drivers (NPDd) account for much of the variance in NPD process success, KMAs should also have a significant effect. To study this phenomenon data was collected in 2006 from a sample of 124 UK-based NPD projects. Analysis of the results provides evidence to suggest some KMAs have an independent effect on NPD process success. The study provides three new variables (*knowledge benchmarking, sharing and embedding*) to the academic model of NPDd; and for practitioners suggests nine KMAs that may enhance NPD process success in their organisation.

Keywords: knowledge management; NPD; new product development; project management; innovation.

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1 Introduction

Since the 1970s a large body of research has addressed the question: 'What factors impact the effectiveness of the New Product Development (NPD) process?' (Booz-Allen and Hamilton, 1982; Cooper and Kleinschmidt, 1987, 1995; Cooper et al., 2004; Myers and Marquis, 1969; Zahra, 1993.) The outcome has been a plausible, if not entirely convergent, list of significant factors (Brown and Eisenhardt, 1995; Henard and Szymanski, 2001; Montoya-Weiss and Calantone, 1994). These factors can be loosely termed New Product Development drivers (NPDd).

Following the publication of 'The Knowledge-Creating Company' (Nonaka and Takeuchi, 1995), few people would doubt the potential of systematic Knowledge Management (KM) to enhance the processes of NPD. Although, recently there has been a drive within the KM field to empirically support claims that KM activities (KMAs) have a distinguishable effect on 'the bottom line'. While this research is not yet as established as the NPD literature, many would argue that there is sufficient evidence to suggest that KM competency is factor in NPD success (Darroch, 2005; Hoegl and Shulze, 2005; Liu et al., 2005, and Tranfield et al., 2003).

Consequently there is a problem for NPD project managers. NPDd predate KMAs, and arguably must already support the application and embedding of knowledge into goods. Conversely, in 2003 KMAs are increasingly recommended to achieve this end. Both claim to affect the success of the NPD process, but as yet the two groups of drivers remain mutually exclusive in the literature available. Is this 'academic logic' a practitioner might reasonably ask?

This paper argues that an organisation's conscious and proactive knowledge management activities are an independent influence on NPD process success. *Further, it* reports on the results of a small-scale empirical investigation examining the use of KMAs and NPDd within 124 UK-based NPD projects.

For the practitioner, if KMAs are indeed independent drivers of NPD success, then they are surely worthy of uptake by project teams already competent at known NPDd. Furthermore, such KMAs may also be significant to project teams who are looking for an alternative driver of development when resources, time, or management support does not allow well-known NPDd to be in place.

This paper begins with a critical review of the two bodies of academic literature that inform the debate. Next it engages with the notion that drivers recommended by these two bodies of literature are not mutually exclusive, but rather can be usefully combined to give a more complete model of NPD success. Following this, the results of a small-scale empirical investigation of the hypothesised model are described, with statistical analysis appended. These results are discussed, used to understand the implications, and to draw conclusions for both academics and practitioners in the field.

2 Frame of reference and hypotheses

At the outset it must be recognised that knowledge work is at the heart of the NPD process. The ability of an organisation to know what it knows and apply what it knows in useful and innovative ways is its route to competitive survival and growth (Kogut and Zander, 1992). Therefore, to develop, manage, and exploit organisational knowledge is fundamental to NPD and always has been. However, it is also known from the

burgeoning literature that knowledge management activities have become a widespread, conscious and increasingly formalised aspect of business processes, including NPD.

One element that adds complexity to the investigation of NPD is that the knowledge that is embodied in the final product is inherently distributed, rather than centralised and much of it is tacit, residing in the minds of its expert employees (Alavi and Tiwana, 2002; Tsoukas, 1996). Activities that involve the collation, storage, and dissemination of data and information can have a significant impact on NPD processes, but the ways in which knowledge is accessed, mobilised and exploited is not confined to formal mechanisms. Accordingly, there may be tensions between the desires of senior managers, who wish to implement standardised 'best practice' NPD processes, and researchers, who perceive NPD processes to be inherently unpredictable. Indeed, researchers may see formal processes as simply another attempt to tighten managerial control of NPD.

Nonetheless, a variety of tasks has been argued empirically and normatively to be necessary for effective NPD. Cooper and Kleinschmidt (also see Cooper, 1979; Cooper and Kleinschmidt 1987, 1993, 1995; Cooper, et al., 2004) are the recognised field leaders in tracking the success and failure of NPD. In their research (in this case we highlight Cooper and Kleinschmidt, 1995) they argue that the presence of the following nine NPDd has the greatest correlation with process success:

- a high quality new-product process
- a clear, well-communicated new product strategy
- adequate resources for new products
- senior management commitment to new products
- an entrepreneurial climate for product innovation
- senior management accountability
- strategic focus and synergy
- high-quality development teams
- cross-functional teams.

It is also important to point out that while empirical measuring of success factors has become a very popular in the major NPD journals, it has also drawn its fair share of criticism, some of that from the authors themselves. Cooper and Kleinschmidt (1995) state: 'while large sample sizes yield a convergent list of factors that have both correlation and causation with NPD success, it is also known that on a case by case basis many other factors influence success, and some of the major influences listed in our research may be shown to have no impact at all.'

This paper acknowledges that a very large percentage of variance in NPD success can be accounted for by known success factors such as resource availability, managerial commitment, and process quality. Of course it is also important to have some empirical indication that any sample of NPD projects examined in relation to KMA is fairly similar to that measured in existing studies. Thus a useful first hypothesis is:

H1: A project team's NPDd capability is positively related to NPD project success.

Reviewing the literature it is clear that KM and KMA have a strong theoretical association with organisations in the business of innovation. The concept of KM as the facilitation of organisational knowing and learning through strategy and process includes investigation of methods for leading innovation processes (Translield et al., 2003; Takeya et al., 2003), knowledge coordination (Faraj and Sproull, 2000; Silva and Agrasi-Cullel, 2003), focusing on innovation (Ribie're and Sitar, 2003) and open vs. closed sharing strategies (von Hippel, 2001; Munsch, 2004). KMA can be viewed as the implementation of institutional mechanisms, tools, and technology for information management, includes research into leadership, management and line roles (Bonds, 2001; Lang, 2001; Ribie're and Sitar, 2003). ICT Tools such as KM software, databases, shareware, networks, and telecommunications, internal sharing mechanisms (Hansen, 2002) and Alignment of HR etc to KM (Robertson and Hammersley, 2000).

This study takes its base definition of KM from Holsapple and Joshi (2004):

> "An entity's systematic and deliberate efforts to expand, cultivate, and apply available knowledge in ways that add value" (a list of study specific KMAs follows on the next page).

More recently, Darroch (2005) has argued that KMA has a measurable relationship with firms who have a strong ability to deliver incremental product innovation. Darroch surmises:

> "having access to knowledge supports any decision making about resources ... a capability in knowledge management enables a firm to leverage the most service from knowledge and other resources." Darroch (2005)

The measurement of KMAs in the NPD process is further explored by Liu et al who state that:

> "Knowledge has become the main manufacturing resource and a prerequisite for success in the production environment ... [their statistics support the claim that] the stronger the knowledge management method, the more complete the new product development." Liu et al (2005)

Thus there is a growing body of academic support for the (second) hypothesis that:

H2: A project team's KM capability is positively related to NPD project success.

It is important to note, though, that KM and KMA may also have several potential drawbacks for firms in the business of innovation. Drawbacks include: best practice posing a barrier to radical ideas (Leonard-Barton, 1992; Hoibe, 2001); that KM may lose good ideas in the mass of data collected; that KM can slow uptake or approval of innovation (Leonard-Barton, 1992); that employees may focus only on activities related to KM processes if this is the sole measure of performance; KM often focuses on efficiency when quality or the need for slack time is more important (Nohria and Gulati, 1996); that knowledge only constitutes capacity not motivation (Hoibe, 2001); that KM does not lead to cultural changes needed for success (Chandler et al., 2000; Hoibe, 2001); that employees may not wish to share (Scarbrough, 2003), and that KM does not lead to commitment and may reduce this as it is seen as a burden or interference (Waters, 2000; Hoibe, 2001).

This being said, the independent variables NPDd and KMA, and the dependant variable 'success' are clearly measurable within most innovation projects. Thus, an additional consideration is how to reduce other contextual influences on NPD success.

Looking to project success literature as a guide, it is useful to note the theoretical contribution of the 'Iron Triangle.' This project measurement technique considers success to be equal to conformance to internally specified time, cost, and specification criteria. While any population may have an infinitely wide range of NPD projects, resources, and operating practices, the Iron Triangle remains a constant benchmark as the desire of conformance to expectations is a fairly universal management goal. Thus the dependent variables are conformance to:

- percentage over or under Time allocated to complete the project
- percentage over or under Cost (spend) allocated to complete the project
- percentage of features over or under those required by the budgeted specification

But to be measured with any degree of usefulness to NPD project teams it is important to identify specific KMAs, and furthermore to expand H1 by hypothesising whether the relationship these KMAs have with success might be independent of the influence of NPDd. The following details a list of potentially independent KMAs derived from the literature. Each of the KMAs is located within the existing body of knowledge and their theoretical relationship to the three dependent variables is posited. These nine compound variables (H3a-i) provide the justification for H3 (below).

In the literature the KMA *Scanning and collecting information* is said to aid in the transfer of explicit knowledge from outside to inside a NPD project team. This should increase a team's ability to develop a clear NPD strategy (Liu et al., 2005) and provide adequate information resources (Darroch, 2005) for new products while also providing the external information necessary to reduce replication (and thus time spent) of development already available from the marketplace.

H3a: The ability of a project team to scan and collect information will make an independent contribution to project time success.

In the literature the KMA *enhancing staff (external) knowledge* is said to contribute to the explicit knowledge base of individuals inside the project, but notably this takes more time than internal knowledge transfers. The team would have access to the key information resources (Darroch, 2005) needed to develop new products, while also being provided with the external market information necessary to understand how to develop a high specification end product.

H3b: The extent to which staff are aware of (external) knowledge will make an independent contribution to project specification success, but will reduce projected time success.

In the literature the KMA *networking* is argued to give project team members the ability to learn tacit knowledge known by others outside of the organization. This should increase the chance that they may participate constructively in developing a clear NPD strategy (Liu et al., 2005). The team could have access to current and context specific information resources (Darroch, 2005) needed to develop new products. Having this shared knowledge of outside information, and in turn discussing and internalising this knowledge within a work related context, it can be argued that these team members would be more likely to develop a high specification end product.

H3c: The relative ability of a project team to network will make an independent contribution to project specification success.

In the literature the KMA *external communications* is said to be significant as key users often shape development trajectories (von Hippel, 2001). External communications are also important in accessing resources (Allen, 1971; Darroch, 2005). Hansen (2002) argues that this KMA is key to knowledge sharing across multiple units in a single company. So it is possible that *external communications* aid the project communicating its purpose to external stakeholders, users, and those involved in company strategy. This should reduce the time taken to develop the product through reduction of barriers, gaining access to resources, attracting user support, and receiving appropriate feedback from interested stakeholders.

H3d: Participation in appropriate external communication will make an independent contribution to project time success.

In the literature the KMA *enhancing the extent of staff information from internal sources* is said to positively affect the ability of the project team to respond to changes in knowledge (Darroch, 2005). Effective internal communication is *the* key driver of project success for many innovation field authors (Allen, 1971). So it is reasonable to argue that *enhancing the extent of staff information from internal sources* will reduce the cost of duplicated effort, as a result of effective communication across departments and functions.

H3e: The extent to which project members are informed of information from internal sources will make an independent contribution to project cost success.

In the literature the KMA *personal learning and development* is said to "be at the very core of organisation theory" (Nobria and Gulati, 1995). Rewarding development is a key part of developing an innovative culture, especially in the western tradition of personal rewards and professionalism. So it can be asserted that in an environment where much of the value of a product can come from the unique and discretionary contribution of a few key developers, it is important to have mechanisms that increase the skill of those developers. When effective, *personal learning and development* should reduce project development time and save wasted expense.

H3f: The opportunities that project team members have for personal learning and development will make an independent contribution to project time and cost success.

Senge (1990) argues that the KMA *organisational learning* will render all people and processes more informed and effective. Orr (1990) highlights that only through learning and teaching on the job can solutions to new technical problems be both effectively developed and tacitly shared. Hoegl and Schulze's (2005) study rates informal events and experience reports (both forms of *organisational learning*) as among the top three best known and deployed of KM methods in innovative organisations; arguing that they create new insights, increase technical ability, and increase the knowledge resource base. So a project that has mechanisms that aid *organisational learning* should develop projects with higher specification.

H3g: Project team members' enhancement in organisational learning and development will make an independent contribution to project specification success.

In the literature the KMA *engineered work processes for codification of knowledge* is said to be the backbone of the technocratic school (Earl, 2001). As such they formalise the knowledge creation process and ensure retention of this knowledge embedded in the system (Blacker, 1995). Hansen et al. (1999) refer to this as a 'codification' strategy and note this has clear cost saving advantages. Furthermore, Blumentritt and Johnston (1999) argue that explicitly addressing development of mechanisms at the knowledge-information interface is the most important goal of formal KM. So, there is reasonable support to suggest *engineered work processes for codification of knowledge* will reduce the cost of lost information and increase the resource base from which contributions to specification are made.

H3h: The use of engineered work processes for codification of knowledge will make an independent contribution to project cost and specification success.

In the literature the KMA *sharing of expert knowledge* is said to underpin a 'personalisation' strategy (Hansen et al., 1999) and the behavioural KM school (Earl, 2001). Sharing knowledge is key to innovation in the well-respected learning model of Nonaka (1994). On the other hand the use of knowledge sharing will increase the time taken to develop a product, something practitioners might argue is a 'necessary expense'.

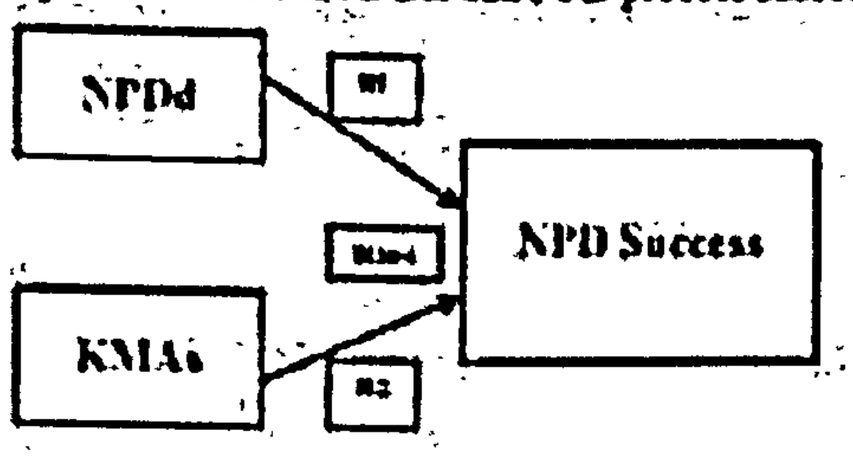
H3l: The sharing of expert knowledge will make an independent contribution to project specification success but will reduce projected time success.

This drawbacks notwithstanding, if as is suggested KMA moderates the flow of information, enhances communication, aids knowledge creation through recombination and a host of other processes that are arguably at the core of NPD, then it seems reasonable to suppose that their presence will generally have a positive impact on the effectiveness of the NPD process. If, as is argued above, specific KMAs play a significant, and often unique, role in the embedding of knowledge into new products it seems reasonable to argue that:

H3: The contributions that KMAs make to project success are independent of those made by NPDd.

These relationships are usefully modelled in Figure 1:

Figure 1 The relationship between NPDd, KMAs and NPD process success



3 Research method

In September 2006, a sample of 180 projects was generated through telephone interviews with UK based NPD project managers across multiple industrial sectors. The projects were chosen on the basis that each resulted in the development of a distinct product, where each had identifiable team members, resources, and a date of completion in 2005. Of note, the study sample (a projects) was drawn from organisations in the (UK) Department of Trade and Industry's Research and Development Index 2004. Within this sample individuals were identified, including engineers, project managers, and executives. Each respondent was asked to report on distinct and specific NPD projects that they had worked on over the previous twelve months (the year 2005). The respondents were asked to reflect on the tools, practices, processes, and support that "helped get the job done". All respondents were sent a pilot version of a questionnaire detailing NPDd, KMAs, and measures of success. The terminology used was reviewed, edited, and added to on the basis of the respondent's familiarity. Each then completed a final version of the survey tool between January and March 2006. The results were coded into SPSS. In all, the survey collected data on 124 projects (a response rate of 69%), each reflecting the relationship between one project's success (time, cost, specification) and the mix of NPDd and KMAs used during the development process.

4 Statistical preparation

4.1 *Exploratory factor analysis*

The first stage in the analysis was to run an exploratory factor analysis (see Table 1) on the nine KMA variables. This is to test whether there are nine independent themes within knowledge management as generated through the literature, or if these can be reduced to fewer factors. Principle components analysis with varimax rotation was used, followed by using Jolliffe's criterion (1972, as cited in Field, 2005) of keeping factors with eigenvalues of > 0.7, giving three factors (see Table 2). This agrees with Cattell's method (1966, as cited in Field, 2005) of using the point of inflection in the scree plot as the cut-off point and also means that each of the KMAs has a high loading on a factor.

Table 1 Exploratory factor analysis of KMAs

	Component		
Rotated component matrix (a)	1	2	3
Scanning and collecting information	*0.7078*	0.3196	0.2503
Enhancing staff (external) knowledge	*0.9013*	0.2632	−0.0963
Networking	*0.7774*	0.3428	0.2004
Externally facing communication	0.1291	*0.8565*	0.1417
Enhancing staff (internal) knowledge	−0.0432	*0.7430*	0.4165
Personal learning and teaching	0.1763	0.2727	*0.8919*
Organisational learning	0.0978	*0.7682*	0.2556
Engineered work processes for codification	0.0003	0.3318	*0.7302*
Sharing expert knowledge	*0.7842*	−0.0001	0.4137

Table 2 Exploratory factor analysis eigenvalues

Total variance explained									
	Initial eigenvalues			*Extraction sums of squared loadings*			*Rotation sums of squared loadings*		
Component	*Total*	*Percentage of variance*	*Cumulative percentage*	*Total*	*Percentage of variance*	*Cumulative percentage*	*Total*	*Percentage of variance*	*Cumulative percentage*
1	3.71	41.20	41.20	3.71	41.20	41.20	2.59	28.80	28.80
2	2.34	25.97	67.17	2.34	25.97	67.17	2.43	26.97	55.76
3	0.89	9.86	77.03	0.89	9.86	77.03	1.91	21.27	77.03

4.2 Discussion of factors

Using a rotated component matrix the nine KMAs taken from the literature give three factors in the EFA.

The first factor is made up of *scanning and collecting information*, *networking*, *enhancing staff (external) knowledge* and *sharing expert knowledge*. This paper argues that each of these components is likely used when a project team is attempting to attract and retain disperse knowledge. Thus, for the purpose of the analysis to follow factor one is named *knowledge benchmarking*. It is important to note that *enhancing staff (external) knowledge* and *sharing expert knowledge* are negative components of the factor, so are generally not present when the KMAs *scanning and collecting information* and *networking* are used within a project. The statistical generation of the *knowledge benchmarking* factor suggests a synthesis of the hypothesised relationships H3a, H3b, H3c, and H3i. Thus it can be expected that the use of the two positively loaded KMAs for *knowledge benchmarking* will result in increased project specification success and that use of the two negatively loaded KMAs will result in decreased project specification success. *knowledge benchmarking* (i.e., use of *scanning and collecting information* and *networking* rather than *enhancing staff (external) knowledge* and *sharing expert knowledge*) should also have a positive effect on time success.

The second factor is made up of *externally facing communication*, *enhancing staff (internal) knowledge*, *and organizational learning*, all with a positive loading. Each of these components is arguably an attempt to distribute knowledge to appropriate project stakeholders, so for the purposes of the analysis to follow factor two is named *knowledge sharing*. The statistical generation of the *knowledge sharing* factor suggests the synthesis of the hypothesised relationships H3d, H3e, and H3g. Thus it can be expected that the use of KMAs for *knowledge sharing* will result in increased project time, cost, and specification success.

The third factor is made up of *personal learning and teaching* and *engineered work processes for codification*. Given that these two components describe the activities project teams use to try and render knowledge more usable, for the purposes of the analysis to follow factor three is named *knowledge embedding*. The statistical generation of the *knowledge embedding* factor suggests the synthesis of the hypothesised relationships H3f and H3h. Thus it can be expected that the use of KMAs for *knowledge embedding* will result in increased project time, cost, and specification success.

4.3 Reliability

The last step was to run reliability tests on the factors found. The Cronbach's Alpha statistic was obtained for each factor. *Knowledge benchmarking* has a Cronbach's Alpha value of 0.80, a lowest item-item correlation of 0.26 and a lowest item-total correlation of 0.53. *Knowledge sharing* has a Cronbach's Alpha value of 0.79, a lowest item-item correlation of 0.54 and a lowest item-total correlation of 0.63. *Knowledge embedding* has a Cronbach's Alpha value of 0.78, a lowest item-item correlation of 0.65 and a lowest item-total correlation of 0.66. As all factors have an Alpha value greater than 0.7 they can be said to be reliable measures, and all item-item and item-total correlations are statistically significant.

5 Findings

The results of the statistical analysis (below) provide evidence to support hypotheses H1–H3 follows:

Table 3 Correlations of NPDd with success

n =	*123*	*119*	*122*
	Project time success	*Project cost success*	*Project specification success*
NPD Process Quality	*0.312**	*0.430**	*0.384**
NPD Strategy Quality	*0.277**	0.163	*0.435**
Resources available for NPD	*0.502**	*0.191**	*0.540**
Snr. Mgt. Commitment	−0.177	*0.311**	0.151
Entrepreneurial Climate	−0.173	*0.463**	0.125
Top People Accountable for NPD	*0.225**	*0.318**	*0.381**
NPD takes advantage of Synergy	*0.300**	*0.430**	*0.479**
NPD teams are high quality	−0.160	*0.435**	0.165
Teams are cross-functional	−0.070	*0.480**	*0.313**

*Correlation is significant at the 99% level

In the first instance H1 is corroborated, with all 9 NPDd positively correlated with at least one of the success factors (see Table 3). This provides two important insights: First, that covariance between success and NPDd in the sample population tends to be similar to other NPD project populations; Second, that in the sample the use of differing 'mixes' of NPDd will likely result in differing project success.

The analysis also corroborates H2, with eight of the nine KMAs and all three of the KMA factors positively correlated with at least one aspect of success (see Table 4). This provides two important insights: First, that covariance between success and KMA in the sample population tends to be similar to other NPD project populations. Second, that in the sample the use of differing 'mixes' of KMA factors will likely result in differing project success.

Table 4 Correlations of KMAs and KMA factors with success

	Project time success	Project cost success	Project specification success
Scanning and collecting information	0.422*	0.035	0.353*
Enhancing staff (external) knowledge	-0.307*	0.123	-0.058
Networking	0.412*	0.244*	0.312*
Externally facing communication	0.370*	0.443*	0.399*
Enhancing staff (internal) knowledge	0.220*	0.001*	0.423*
Personal learning and teaching	0.438*	0.424*	0.654*
Organizational learning	0.233*	0.343*	0.499*
Engineered work processes for codification	0.305*	0.526*	0.452*
Sharing expert knowledge	-0.225*	0.245*	0.063
Knowledge benchmarking	0.305*	-0.054	0.148
Knowledge sharing	0.229*	0.410*	0.363*
Knowledge embedding	0.289*	0.446*	0.307*

*Correlation is significant at the 95% level.

To investigate H3 the data was analysed using ordinary least squares linear regression, using forward stepwise methods to find the variables which could explain the most variation in the dependent variables: cost, time and specification success. First, this was done for each of the dependent variables looking at NPDd and KMAs separately. This was to enable the separate contributions of NPDd and KMAs towards success to be found. The next step was to run a regression model for each of the success variables including both the KMA factors and NPDd which were significant in the first step of the regression analysis, using enter method. The significance of the KMA factors and NPDd in the combined model shows whether these factors are independent of one another in their contribution towards success. The increase in adjusted r^2 of the second step models over those of the first step will show how much additional variation is explained by including both KMAs and NPDd in the models. The stepwise regressions were run using a 95% significance test when deciding whether to add each variable to the model. A 90% significance level was used to determine whether variables were still significant in the combined (enter method) models, as would be used as the level at which to remove variables in a stepwise procedure.

The following stepwise regression analysis shows the independent contributions of those KMA factors and NPDd that are related to project time, cost, and specification success:

The regression analysis for project time success (Table 5) shows NPDd and KMA factors independently, before combining these into a single model. These steps show that all three KMA factors are still significant after their addition to the model, and so are predictors of success independent of the resources available for NPD.

In the case of all three models of success there is an increase in adjusted r^2 when NPDd *and* KMA factors are included in the same model over when they are included separately, showing that use of KMAs is a predictor of success beyond that which can be predicted from the use of NPDd alone. The analysis corroborates H3.

with all three KMA factors making a contribution to at least one aspect of NPD success independent of the effect of NPDd

Table 5 (Regression) Dependent variable: project time success ($n = 123$)

Independent variables: NPDd					
	B	*Std error*	*Beta*	*t*	*Sig*
Adjusted R Square	25%				
Resources available for NPD	0.7105	0.1092	0.5090	6.5047	0.0000
Independent variables: KMA factors					
Adjusted R Square	27%				
Knowledge benchmarking	0.5653	0.1102	0.3962	5.1301	0.0000
Knowledge embedding	0.4124	0.1102	0.2890	3.7428	0.0003
Knowledge sharing	0.3185	0.1102	0.2232	2.8902	0.0045
Independent variables: NPDd and KMA factors					
Adjusted R Square	38%				
Resources available for NPD	0.5185	0.1109	0.3715	4.6764	0.0000
Knowledge benchmarking	0.4830	0.1032	0.3385	4.6823	0.0000
Knowledge sharing	0.2183	0.1039	0.1531	2.1037	0.0375
Knowledge embedding	0.2168	0.1099	0.1519	1.9721	0.0509

Table 6 (Regression) Dependent variable: project cost success ($n = 119$)

Independent variables: NPDd					
	B	*Std error*	*Beta*	*t*	*Sig*
Adjusted R Square	32%				
NPD Process Quality	0.8559	0.1858	0.3717	4.3780	0.0000
Entrepreneurial Climate	0.4531	0.1143	0.3291	4.0329	0.0001
Independent variables: KMA factors					
Adjusted R Square	37%				
Knowledge embedding	0.8039	0.1257	0.4655	6.3945	0.0000
Knowledge sharing	0.5037	0.1251	0.4094	5.6239	0.0000
Independent variables: NPDd and KMA factors					
Adjusted R Square	50%				
Knowledge sharing	0.6767	0.1162	0.3937	5.8226	0.0000
Knowledge embedding	0.3364	0.1382	0.3106	3.8799	0.0002
Entrepreneurial Climate	0.4554	0.0939	0.3471	4.9365	0.0000
NPD Process Quality	0.2435	0.1956	0.1042	1.2262	0.2225

Table 7 (Regression) Dependent variable: project specification success (n = 122)

Independent variables: NPDd	*B*	*Std. error*	*Beta*	*t*	*Sig.*
Adjusted R Square	43%				
NPD Process Quality	0.8322	0.1455	0.4325	5.7204	0.0000
Resources available for NPD	0.4963	0.1038	0.3549	4.6539	0.0000
Independent variables: KMA factors					
Adjusted R Square	39%				
Knowledge embedding	0.7249	0.1011	0.5069	7.1673	0.0000
Knowledge sharing	0.5194	0.1015	0.3618	5.1153	0.0000
Knowledge benchmarking	0.2089	0.1015	0.1456	2.0582	0.0418
Independent variables: NPDd and KMA factors					
Adjusted R Square	53%				
NPD Process Quality	0.5634	0.1591	0.2934	3.5726	0.0005
Knowledge sharing	0.3642	0.0938	0.2537	3.8839	0.0002
Resources available for NPD	0.3574	0.1015	0.2555	3.5221	0.0006
Knowledge embedding	0.3466	0.1128	0.2423	3.0724	0.0026
Knowledge benchmarking	0.1897	0.0924	0.1322	2.0528	0.0423

5.1 Limitations

Some limitations with these data and analysis result from the small sample size achieved. In the models where NPDd and KMAs were included together, the significance of some variables decreased, in one case so that it was no longer significant. With a larger sample size these results would be more reliable. It is also possible that with a larger sample size the study would find that more of the NPDd and KMAs had an independent contribution towards success. Furthermore, the small sample size relative to the variety of contextual variables (which might influence project success and/or use of NPDd and KMAs) included in the data meant that it was not possible to perform t-tests or ANOVA tests to verify whether projects from different companies or different industries might have differing relationships.

6 Discussion

The findings provide evidence to support the inclusion of KM as a significant influence in NPD success, as was suggested to be the case by Darroch (2005) among others. Furthermore this study provides empirical support for a revised theoretical model of NPD process success with the inclusion of *knowledge benchmarking, sharing and embedding* to the nine NPDd of Cooper and Kleinschmidt (1995). While the nine "known" NPDd make a considerable contribution to NPD process success in the sample, it is notable that

(statistically speaking) they do not account for the value added by proactive knowledge management.

Beyond the theoretical contribution, this paper suggests that managers who have a choice over the tools and practices used in the NPD process need to consider a more diverse pool of options prior to selection. This study suggests that actively pursuing any of the nine KMAs listed (*scanning and collecting information, enhancing staff external knowledge, networking, external communications, enhancing staff internal knowledge, personal learning and development, organisational learning, engineered work processes for codification of knowledge, and sharing of expert knowledge*) should make a positive contribution to NPD process success. Asserting the usefulness of these practices is surely nothing radical given their frequency in the population, and popularity in practitioner literature, but this study provides the some of the first empirical support that this is the case.

Two related considerations: to what extent is a project team already competent in the nine, and, do they use the (positive) KMAs prescribed by this study? In the first instance this study has shown that increased proficiency in the NPDd leads to increased process success. Organisations deficient in the nine NPDd might do well to concentrate efforts in what have become industry standard practices (at least among larger organisations). Secondly, if already proficient at the nine NPDd, then (considering context) they should focus effort on the acquisition and use of KMAs. In this study KMAs are shown to increase process performance at the project level above and beyond that which can be achieved by ability in the NPDd alone.

While it is possible to make such simple suggestions based on the statistical averages provided by the study, the simple addition of the KMAs to a well-rounded NPD firm is unlikely to create true competitive advantage. Thus this study underscores the principles from the literature: there is a need for organisations that rely on NPD to generate economic returns to track and evaluate their knowledge embedding process (Blackler, 1995). Unfortunately the KMAs recommended in the findings section are not specific enough to enable their immediate use, so the broader task for senior managers is to consider the extent to which the entire process embeds knowledge. The challenge is an ongoing one, and does not end at the addition of a single new system or recognition of best practice.

7 Conclusion

This study provides three new variables (knowledge benchmarking, sharing and embedding) to the existing academic model of NPDd, and for practitioners suggests nine KMAs (scanning and collecting information, enhancing staff external knowledge, networking, external communications, enhancing staff internal knowledge, personal learning and development, organisational learning, engineered work processes for codification of knowledge, and sharing of expert knowledge) that may enhance NPD process success in their organisation.

If it is accepted that current attempts towards KM are based on a desire for the systematic, then only through a more detailed consideration of the diverse practices within NPD can organisations fully integrate KM with NPD and achieve economic returns. For managers a starting point to this end is the proactive use of one or more of the nine KMAs. This should, in theory, generate greater success in many cases than if the

project team were to have specific competencies in Cooper and Kleinschmidt's (1995) nine NPDd alone.

In future work in the field the authors argue that NPDd and KMAs can no longer be discussed in separation. This work contributes to a growing body of evidence that the conscious management of knowledge (regardless of the names used to categorise its modes, methods and practices) plays a measurable role in the development of new products. So, while organisations consider their 'mix' of knowledge embedding activities, it is up to the academic community to extend the work presented in this study and provide a cross-disciplinary view of the factors (both content and contextual) which influence NPD success.

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