AN APPROACH TO MANAGING THE COMPLEXITY OF KNOWLEDGE INTENSIVE BUSINESS PROCESSES

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A thesis submitted in partial fulfilment of the requirements of the University of West of England, Bristol for the degree of PhD

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ABSTRACT

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Organisations face ever growing complexity in the business environment and use processes to deliver value in a stable, sustainable and controllable way. However complexity in the business environment is threatening the stability of processes and forcing their continuing evolution in ever shorter time cycles, which then creates significant management challenges. Addressing complexity requires a change in management thinking about processes.

The research explores the nature of complexity, how businesses respond to it, and the consequent impact on process complexity. The research reviews the notion of complexity and its relevance to organisations, business processes and knowledge contexts. The research focuses on knowledge intensive firms, as these exhibit several of the features and allow early application of the approach suggested by this thesis. The research draws upon concepts from several fields including complexity and complex systems, business process management, and knowledge management.

This thesis addresses the question: "How can organisations address the complexity of knowledge intensive business processes?" In answering the question the thesis argues the need to integrate multiple perspectives involved in managing such processes, proposes an approach to complex knowledge intensive business processes that reduces the management challenge, and argues the need to develop an agile shared knowledge context in support of the approach.

This thesis develops a theoretical framework consisting of a set of hypotheses rooted in the literature, and then proposes an approach to addressing complex knowledge intensive business processes based upon these hypotheses. Then,

through a series of QDS investigations and action research cycles, this thesis tests the hypotheses, further develops the approach and examines its application in different problem domains in multiple organisations. This thesis then discusses the process and the outcomes of applying the approach, identifies its limitations, assesses its contribution to knowledge and suggests directions for further research.

Declaration of originality

The researcher declares that this thesis is his own work and has not been submitted in any form for another degree or diploma at any university or other institute of education. Information derived from the published and unpublished work of others has been acknowledged in the text and a list of references is provided[a].

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Acronyms Used

aKC	Agile Knowledge Context
BPM	Business Process Management
CKC	Complex Knowledge Context
cKIBP	Complex Knowledge Intensive Business Process
KC	Knowledge Context
KIBP	Knowledge Intensive Business Process
KM	Knowledge Management
KMS	Knowledge Management System
KYC	Know Your Customer
QDS	Qualitative Data Source
QDSs	Multiple Qualitative Data Sources

Conventions adopted

- Footnotes (available at the foot of the page) follow an alphabetic convention (e.g. a, b, c ...) and provide relevant brief information
- Endnotes (available in Appendix III) follow a numeric convention (e.g. 1, 2, 3 …) and provide relevant detailed information
- Labels are provided for elements of interest in the thesis and are bold faced for readability. These are then referred to in the rest of the thesis.
    - Research questions are labelled with a prefix “Q” followed by a number
    - Research objectives are labelled with a prefix “O” followed by a number
    - Literature review observations are labelled with a prefix “L” followed by a number
    - Hypotheses are labelled with a prefix “H” followed by a number, capabilities with a prefix “C” followed by a number
    - Requirements of the research are labelled with a prefix “R” followed by a number.

Chapter 1: Introduction

Organisations[b] face ever-growing complexity in the business environment (Areta & Giachetti, 2004). Possibly as a consequence, business organisations grow ever more complex and managing such organisations is increasingly challenging. This trend may be driven, among other things, by factors such as globalisation, complex value chains, mass-customisation, complex products among others[c].

Organisations use processes to create and deliver value in a stable, sustainable and controllable way. However, complexity in the environment is threatening the stability of processes and forcing their continuing evolution in ever-shorter time cycles. Toffler (1970) refers to a similar phenomenon as future shock, which is a perception of "too much change in too short a period of time."

A key element of complexity is the notion of relationships between the objects of interest in the organisation. One possible explanation for the growth of organisational complexity is the growth in relationships between internal elements and with external elements that can no longer be isolated or ignored. Organisations must adapt to survive, but the very basis of survival, i.e. the stability of their processes is being threatened. This requires a change in management thinking about processes.

This research addresses one main question and two secondary questions. The main question is:

Q1 How can organisations manage the complexity of their knowledge intensive business processes (KIBP's)?

The question argues for a management strategy to address complex KIBP's (**cKIBP**'s), based upon the hypothesis that the management of cKIBP's will get increasingly more challenging as the rate of evolution, proliferation and integration of the processes being managed keeps increasing.

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[b] The term "organisation" is used in this thesis in the sense of a social entity, existing within an external environment, that is structured and managed to meet needs or to pursue collective goals.

[c] As seen in this statement, the recursive notion of complexity is discussed by Gershenson & Heylighen (2005).

The main question gives rise to two secondary questions:

Q1.a What does "business process complexity" mean?

As the research discovers, it is very difficult to provide a precise definition to the term "complexity" that is acceptable to all disciplines (Richardson K. A., 2005). This is true even when restricted for use in Business Process Management. The term is largely used as a metaphor and that makes it at best a partial description and difficult for traditional management to adopt. What is required is a ***pragmatic***[d] definition that allows discovery, understanding and addressing of cKIBP's.

Q1.b What does it mean to "manage business process complexity"?

As the research discovers, there are many viewpoints as regards management of business processes. Again what is required is a ***pragmatic*** operational strategy to address the management challenge of cKIBP's.

The approach to resolving the question is the development of frameworks that co-evolve in the face of evolution of the processes they manage, and argues the case for agility and integration across process disciplines.

As the research discovers, a key characteristic of cKIBP's is the knowledge of relationships between the objects of interest in the organisation that are relevant to the process (the complex knowledge context). This is particularly relevant in the management of complex business processes that require the maintenance of a shared complex knowledge context while managing sets of multiple concurrent business processes (the process ensemble).

Consequently, as the research argues, any strategy for managing complex business processes requires (a) an organisation wide shared understanding of the necessary objects and relationships, (b) a mechanism to develop and sustain such understanding, and (c) a process that efficiently co-ordinates the growth of such shared understanding. Such a strategy would allow a multi-minded organisation to dynamically integrate multiple perspectives.

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[d] The Merriam-Webster dictionary defines pragmatic as "… practical as opposed to idealistic". It is used here in the sense of pertaining to a practical point of view or practical considerations

There has already been extensive research regarding the nature and impact of complexity on organisations (Lissack, 1999; Stacey R. D., 2001; Burnes, 2005; Richardson K. A., 2005; Lawrimore, 2005). However, there is insufficient research in terms of addressing the management challenges that complexity creates with respect to business processes (Mason, 2007). The research proposes an approach that could help address such management challenges.

The motivation behind this piece of research is to meet the researcher's two objectives:

O1 To understand the nature of complexity as it relates to complex KIBP's (**cKIBP**'s) in order to explain why the current paradigm for managing such processes does not always seem to work**,** and

O2 To provide practicing managers with a pragmatic way of recognising complexity and identifying and addressing cKIBP's

1.1 Justification for research

So long as organisations exist they must be managed. Management has always adapted to challenges in the past and should continue to do so. As Hiett (2001) puts it, "It is clear that we do not have any theoretical handle on why the world is complex, how one should act in such a situation, how to make things less complex, and so on. However, through years of experience and sensitivity to situations, various abilities, techniques, and ideas have been developed that seem to work."

Research into management has noted the growth of complexity in the past and continues to do so (Cilliers P. , 2005). Why attempt to address complexity of business processes separately and directly? In other words, why undertake this piece of research at all? After all, these abilities, techniques and ideas are not particularly the property of complexity science, but of systems people in general, and maybe just of people in general. Again in Hiett's (2001) view, there are many good managers who have never heard of complexity science, but who are very good at managing the complicated situations in which they find themselves.

There are at least three reasons to do so. Firstly, there is increasing recognition among practicing managers (KPMG International, 2011) of the fact that complexity in the business environment is increasing dramatically (Cohen M. , 1999), and this is significantly impacts internal business processes (Perona & Miragliotta, 2004). Secondly, there is a growing management perception that complexity is impacting the success of change interventions (Burnes, 2005). And thirdly, continuing on the current course will make certain kinds of organisation insufficiently agile (Areta & Giachetti, 2004). This is particularly relevant to knowledge-intensive firms (discussed in **3.6.1**), which can be viewed as organizations that use mainly the knowledge of their individuals to develop and trade immaterial responses to customer requirements.

1.2 Knowledge Intensive Business Processes

Work in knowledge intensive organisations is carried out by means of its business processes (discussed in **3.2**), whose every aspect involves a certain amount of knowledge which may be complex depending on the domain of interest. However, a business process is knowledge intensive if its value can only be created through the fulfilment of the knowledge requirements of each of the process participants (Hofstede, Mecella & Sardina, 2012), and activities in the process require contextual knowledge that cannot be completely managed through stable information sources and the information flows between the activities. This distinction is outlined in Table 1: Regular v/s Knowledge Intensive Business Processes:

Table 1: Regular v/s Knowledge Intensive Business Processes

	Regular Business Processes	**Knowledge Intensive Business Processes**
Distinction	Activities do not require additional contextual knowledge to execute	Activities require additional contextual knowledge to execute
Characteristics	Well Defined Predictable Reproducible Low Creativity / Innovation Stable Structure / Flow	Difficult to define Unpredictable Repeatable High Creativity / Innovation Dynamic Structure / Flow

1.3 Focus of Research

Figure 1: Focus of Research

As will become evident in the review of literature, complexity is a broad subject, with a long pedigree, and cuts across many disciplines. Given the many perspectives and interpretations as to its relevance, it is important to focus the research carefully, in order to maximise the chances of producing credible results. Consequently, this research addresses cKIBP's, in the business environment, as shown in Figure 1. The focus also influences the context of research, the research strategy adopted, content for research, and the opportunities available to carry out the research.

1.4 Organisation of Thesis

This chapter provided the background, motivation and justification for the research, the research questions and the focus of the research.

Chapters 2 and 3 review current literature in relevant areas such as complexity, complex systems, organisations viewed as complex systems, complexity as it relates to business processes, and to business knowledge management, in order to formulate a set of hypotheses and issues to investigate in the Qualitative Data Sources (QDSs). Chapter 4 discusses a research framework that (a) formulates hypotheses relevant to addressing cKIBP's, (b) identifies issues that arise as a result of those hypotheses, (c) identifies capabilities required to address such issues, and (d) proposes an approach to address cKIBP's. It then sets out the requirements that the research must fulfil. Chapter 5 describes the research methodology and methods that are appropriate for fulfilling the research requirements, justifies the choice of that methodology and those methods, and then describes the design of the research as consisting of three phases (1) pilot, (2) development, and (3) validation. It goes on to describe the objectives or each phase, the choice of QDSs and the approach to collecting and analysing the data. The architecture of thesis leading to field research is presented in Table 2.

Chapter 6, 7 and 8 present the field research in the form of QDSs relevant to the pilot, development and validation phases respectively. Each QDS investigation concludes with an analysis of the data collected, presented as findings. Finally, Chapter 9 discusses the findings from the research in the context of the research questions and objectives, identifies limitations of the research, reflects upon the process of research and provides conclusions.

Table 2: Architecture of thesis leading to field research

Research Questions and Objectives	Literature Review	Theoretical Framework	Research Methodology and Design
Questions **Q1:** How can organisations manage the complexity of their knowledge intensive business processes (**KIBP**'s)? **Q1.a**: What does "business process complexity" mean? **Q1.b**: What does it mean to "manage business process complexity"? **Objectives** **O1**: Understand the nature of complexity as it relates to complex KIBP's (**cKIBP**'s)in order to explain why the current paradigm for managing such processes does not always seem to work **O2**: Provide practicing managers with a pragmatic way of recognising complexity and identifying and addressing **cKIBP**'s.	**L1: Concept of complexity** Characteristics Categories of thinking Measuring complexity Limitations **L2: Complex Systems (CS)** Evolution Definitions **L3: Organisations as CS** Modelling organisations as CS Complexity in organisations Managing complexity in organisations **L4: Business Process (BP)** Understanding BP (Defining, Classifying, Analysing, Modelling, Designing, Measuring) Managing BP (Maturity, Agility, Change, Product Management) Complexity and Business Processes **L5: Knowledge Management (KM)** Understanding KM (Defining, Modelling, Social Factors) Managing Business Knowledge (Knowledge Intensive Firms, KIBP's, Integrating KM-KIBP's) Complexity and Knowledge management	**Hypothesis** **H1**: "Complexity" is hard to define in a way that is acceptable to all perspectives and is largely used as a metaphor, which makes it at best a partial description and difficult for traditional management to adopt (**Q1.a, Q1.b, O2, L1, L3**) **H2**: Engaging in complex ecosystems implicitly or explicitly impacts the complexity of the business processes of knowledge intensive organisations and creates significant challenges for them. (**Q1, L3**) **H3**: Management of cKIBP's will get increasingly more challenging as the rate of evolution, proliferation and integration of the processes being managed keeps increasing (**Q1.b, O2, L3**) **H4**: (1) An ensemble of business processes can be regarded as a complex system, but (2) the mechanistic view of business processes does not sufficiently capture the complexity since it obscures the role of relationships (**L2, L3**) **H5**: (1) Complexity arises because of entanglements between processes and (2) addressing complexity requires reduction or removal of such entanglements (**Q1.b, O2, L1, L3**) **H6**: (1) The level of entanglement correlates with the management challenge in managing the process, and, (2) while effective in addressing complicated processes, conventional approaches are less effective in addressing complex processes with knowledge entanglements (**O1, L4**) **H7**: (1) Once knowledge entanglements are reduced or removed, conventional approaches once again become effective on the reorganised process ensemble, and therefore, (2) one indicator of knowledge entanglements is the ineffectiveness of conventional approaches in resolving the problems (**O1, O2, L4**) **H8**: (1) Knowledge sharing entanglements arise when the information flow contains entangled complex knowledge contexts, and (2) can be resolved by reorganising the process ensemble to contribute and consume from a set of integrated knowledge contexts (**Q1.b, O2, L4, L5**) **H9**: While knowledge sharing entanglements can be addressed through a shared knowledge context, creating and managing a complex shared agile knowledge context requires an information framework, processes and tools (**Q1.b, O2, L5**) **Capabilities** **C1**: An **Approach** to addressing cKIBP's (**Q1.b, O2, L4**) **C2**: An **instrument** to assess the management challenge (**Q1.a, Q1.b, O2, L1, L3**) **C3**: An **information framework** to define a shared knowledge contexts, and **processes** and **tools** to manage complex shared agile knowledge contexts (**Q1.a, Q1.b, O2, L4, L5**)	**Requirements** **R1**: Test Hypotheses **R2**: Test **Approach** **R3**: Test Instrument **R4**: Test Information Framework, processes and tools **Methodology** Considerations for selection Action Research QDS Investigations Assuring Rigour **Design** Pilot-Development-Validation Phases Selection of QDSs Selection of participants **Methods** Workshops QDS Investigations Cycles Instrument for assessing management challenge Data Analysis

Chapter 2: Complexity, Complex Systems and Organisations

2.1 Introduction

The last chapter set out the research questions, provided the justification for the research, identified the research focus and showed how the thesis is organised. This chapter sets out the purpose and the context for a review of literature in preparation for undertaking the research, and also describes the structure of the literature review. It then reviews complexity and complex systems to gain insights into aspects applicable to the research.

Given the research questions, one approach to take would be to (1) first identify exemplars where the problem of managing process complexity seemed to have been adequately resolved and distil the essentials elements of the solution; (2) then construct a provisional approach out of those distilled elements and develop that approach over several iterations in solving a specific problem; and finally (3) validate that developed approach by applying it to other problems and testing its success and adequacy. However on closer inspection a number of issues come to light.

In order to identify exemplars it becomes necessary to describe the problem adequately in terms of its complexity characteristics. This requires a much deeper understanding of complexity as a concept and ways to describe and measure it from the point of view of its management in the context of business processes. Further, the researcher would need a consistent theoretical framework in order to assess the exemplars in order to (a) select organisations to study; (b) identify the right participants in the research; (c) select the problem space to study; (d) define the problem and the solution; and (e) measure the impact on managing complexity.

Consequently a necessary preparatory step is to create such a theoretical framework. This in turn requires a review the literature on the subject of complexity, which is wide-ranging. The literature review must therefore carefully select those topics relevant to its research questions. These include complexity and complex systems, organisation and management, business processes and knowledge management, all of which relate to the concept of complexity as illustrated in Figure 2.

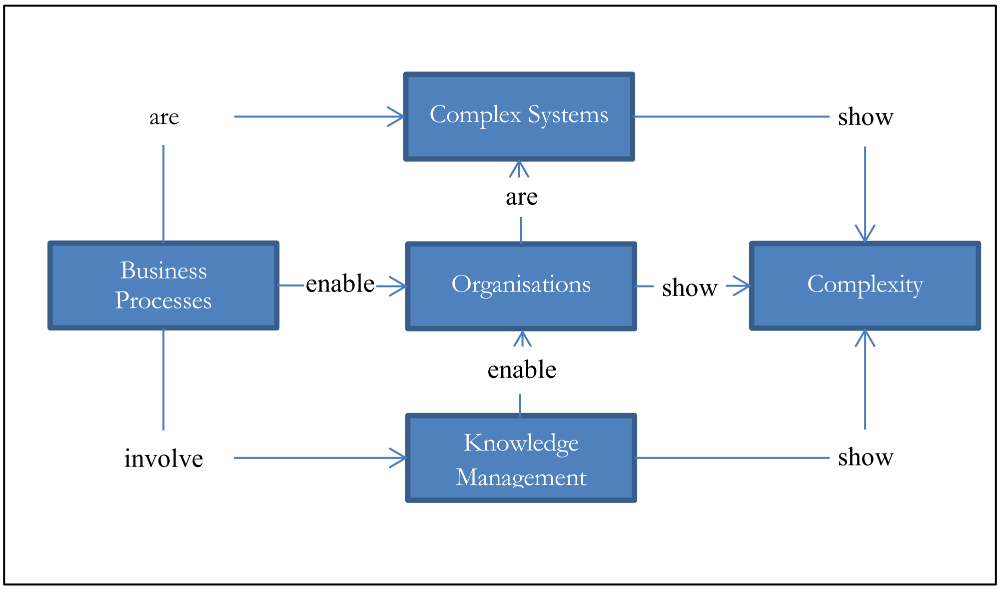

Figure 2: Relationships between topics

However these relationships are intricate and are difficult to appreciate in the absence of a logical flow, and it makes sense to work backwards and downwards, starting with (1) a review of complexity in order to understand the concept of complexity, definitions and measures, kinds of complexity, followed by (2) a review of complex systems in order to understand the evolution of complex systems, definitions and essential concepts, followed by (3) a review of organisations in order to understand how complexity and complex systems relate to organisations, followed by (4) a review of business processes in order to understand the concept of business processes, how business processes are managed and how complexity relates to business processes, culminating in (5) a review of knowledge management in order to understand the concept of knowledge management, how knowledge is managed in organisations and how complexity relates to knowledge management.

Consequently, while the process of literature review is itself organic and driven by the research questions and objectives and the need to support the hypotheses in the theoretical framework, in order to provide a logical flow the literature review is structured as shown in Table 3.

Table 3: Structure of Literature Review

Purpose	Review Focus (Relevance)	Discussed In
Understand the concept of complexity, definitions and measures, kinds of complexity, the evolution of complex systems concepts, definitions and essential elements	Defining Complexity (**Q1**, **H1**) Categorising Complexity (**Q1**, **H1**) Measuring Complexity (**Q1**, **H1**) Evolution of Complex Systems (**Q1.a**, **H2**) Defining complex systems (**Q1.a**, **H2**, **H3**) Conceptualising complex systems (**Q1.a, H4, H5**)	Chapter 2:
Understand how complexity and complex systems relate to organisations	Complex systems and organisations (**Q1.a, H2**) Modelling organisations as complex systems (**Q1.a, H3**) Complexity in organisations (**Q1.a, H2**) Managing complexity in organisations (**Q1.b, H3**)	
Understand the concept, how business processes are managed and how complexity relates to business processes	Understanding business processes (**Q1.a** , **Q1.b**) Managing business processes (**Q1.a** , **Q1.b, H6**) Complexity and business processes (**Q1.a** , **Q1.b, H5, H6, H7**)	Chapter 3:
Understand the concept, how knowledge is managed and how complexity relates to knowledge management	Understanding knowledge management (**Q1**, **Q1.a**, **Q1.b, H7, H8, H9**) Managing business knowledge management (**Q1**, **Q1.a**, **Q1.b, H7, H8, H9**) Complexity and knowledge management (**Q1**, **Q1.a**, **Q1.b, H7, H8, H9**)	

2.2 The Concept of Complexity

The original Latin word "complexus" means "entwined", "twisted together". This may be interpreted to mean that anything that is complex has two or more components, which are joined in such a way that it is difficult to disentangle them. Similarly, the Oxford Dictionary defines something as "complex" if it is "made of (usually several) closely connected parts". In practice, common synonyms for the term complex are difficult, complicated, intricate, involved, tangled, and knotty, amongst many others. (Whitt & Maylor, 2008). This is obviously insufficient as a definition for the purpose of this research. The researcher therefore needed to review relevant literature to obtain a better understanding of the concept.

Several fields have contributed to the understanding of complexity and an exhaustive review of all of these was clearly beyond the scope of the research. While acknowledging the contributions from all of these fields, the research therefore restricted the review to those that were likely to exhibit features of relevance to this research as framed by **Q1,** which relates to (1) complexity, (2) organisations, (3) business processes, and (4) knowledge and its management.

Table 4: Review of complexity as a field of study

Field	Features of interest	Reason for interest	Sources
Systems Theory	Open and closed systems Controlled and uncontrolled systems	Business processes as complex systems	(Boulding, 1956; Bertalanffy, 1968)
Ecological systems theory	Multiple levels of scale and interactions between levels	Perspectives at different levels of management of business processes	(Bronfenbrenner, 1979)
Cybernetics	Regulated and self-regulating systems, feedback loops and external sensors	Regulation of business processes as complex systems	(Kelly, 1994; Pangaro, 2006)
Artificial Intelligence	Complex data structures as networks to support problem solving, deduction and reasoning Computational complexity and descriptive complexity	Modelling activities and information flows in business processes as network structures	(Turing, 1950)
Distributed Neural Networking	Parallel problem solving Distributed decision making	Decision making by actors in the business process	(Anthony & Bartlett, 2009)
Dynamic Systems Theory	Modelling a complex system including feedback loops, complex relationships between elements, delayed response and sensitivity to history	Modelling business processes as complex systems	(Gros, 2008)
Chaos Theory	Extreme sensitivity to initial conditions, making even deterministic systems extremely difficult to predict without perfect knowledge of their original states.	Stability of business processes in response to changes of scale and resourcing	(Thietart & Forgues, 1995)
Complexity Science	Complexity as the order that emerges from a large number of interacting members of a system	Business processes as complex systems	(McDaniel & Driebe, 2001; Cilliers P. , 1998)
Self-Organisation	Simple rules operated by agents in the system lead to a group level behaviour without a central control element Social systems can be thought of as self-organising	Business process change from within	(Capra, 1996; Waldrop, 1993)
Information Theory	Complexity can be measured by the uncertainty in distribution of the system, as well as the shared information of its components.	Information flows within business processes	(Shannon, 1948)

This part of the review is summarised in Table 4, and is restricted to only those fields of study that appeared to the researcher to have features of interest (as identified in the table) relevant to this research. An analysis of the table shows that for features relevant to **Q1.a** and **Q1.b,** (**L1.1**) different fields of study approach complexity from different perspectives, for example, (1) business processes as complex systems (systems theory, dynamic systems theory, complexity science), (2) stability and regulation (cybernetics, chaos theory), (3) modelling processes and information (artificial intelligence, information theory), (4) organisation, management and decision making (ecological systems theory, distributed neural networking, self-organisation).

2.2.1 Characteristics of complexity

In order to address **Q1**, it is first necessary to be able to define complexity. The review of the literature in Table 4 reveals that there have been many attempts to define complexity from various perspectives but none have managed a comprehensive definition. Gershenson and Heylighen (2005) point out that complexity is itself a complex concept as we cannot make an unambiguous distinction between simple and complex systems.

Overall one can say that the complexity of a system increases with the number of distinct components, the number of connections between them, the complexity of the components and the complexity of the connections. This is a recursive definition that is general enough to be applied in different contexts.

However there appear to be characteristics that are indicators of complexity, which prove useful in recognising complexity (**O2**). From among the many approaches in the literature, the researcher summarises those that are relevant to the research in Table 5 and then discusses these further.

Table 5: Characteristics of complexity

Characteristic	Summary Description	Relevance to research
Failure of Newtonian Paradigm	The principle of conservation of distinction does not apply. (Something is lost when a system is decomposed into its component parts	Most models of business processes rely on such decomposition
Incommensurability and Incompressibility	Formal models of complex systems cannot be derived from each other and there is no perfect representation of the system that is smaller than the system itself	Business processes are sometimes repeatable but not reproducible because a complete description is not possible
Distinction and connection	Existence of both variety and interdependency of components in the system	Business processes are usually composed of distinct operations connected by information flows
Symmetry breaking and scale	Symmetry is broken under scale transformations	Not all business processes appear to scale gracefully, and perception of apparent complexity varies with the scale

Failure of the Newtonian Paradigm: Classical science relies upon making as precise as possible distinctions between the different component properties and states of the system under observation which are assumed to be absolute and objective and which are conserved through the evolution of the system. This paradigm, also known as the Cartesian mode of thinking is based upon the principle of distinction conservation and is based upon the assumptions of reductionism, determinism, dualism, correspondence theory of knowledge and rationality. (Gershenson & Heylighen, 2005). From this perspective, the essence of complexity appears to be in the existence of something that is lost as the system is reduced to its parts. Otherwise, the whole is merely the sum of its parts, but the whole may be a more complicated arrangement of the parts[e].

Incommensurability and Incompressibility: Complexity is the property of a real world system that is manifest in the inability of any single formalism being adequate to capture all its properties. It requires that we find distinctly different ways of interacting with systems in the sense that when we make successful models, the formal systems that are needed to describe each distinct aspect, are NOT derivable from each other i.e. they are not *commensurable* with each other. Richardson (2005) implies that this is a way of distinguishing the complicated from the complex and suggests that there exists infinitude of equally valid, non-

[e] This is related to the notion of "non-fragmentable", as discussed in complex systems.

overlapping, potentially contradictory descriptions. This is related to the idea of incompressibility which Cilliers (2005) describes as there being no accurate (or rather, perfect) representation of open systems, which is simpler than the system itself. The analysis of the fields of study in Table 4 leads to the same conclusion.

Distinction and Connection: Heylighen (1999) maintains that the aspects of distinction and connection (differentiation and integration) determine two dimensions characterizing complexity. Distinction corresponds to variety, or heterogeneity, and to the fact that different parts of the complex behave differently. Connection corresponds to constraint, to redundancy, to the fact that different parts are not independent, but that the knowledge of one part allows the determination of features of the other parts. Complexity can only exist if both aspects are present: neither perfect disorder (which can be described statistically through the law of large numbers), nor perfect order (which can be described by traditional deterministic methods) are complex.

Symmetry breaking and Scale: Complexity can be characterized by lack of symmetry (invariance under transformation) or "symmetry breaking", by the fact that no part or aspect of a complex entity can provide sufficient information to actually or statistically predict the properties of the others parts. Havel (1995) maintains that scale is just another dimension characterizing space or time, and that invariance under geometrical transformations, like rotations or translations, can be similarly extended to scale transformations.

From the foregoing discussion one can conclude that (**L1.2**) while complexity has recognisable characteristics, complexity is hard to define.

2.2.2 Categorising complexity thinking

There have been many attempts to categorise the thinking about complexity, but most of these acknowledge that the boundaries between the categories are blurred. Richardson (2005) attempts a classification into philosophy, theory and application but acknowledges that these categories are not independent of each other and defines complexity thinking as the art of maintaining the tension between pretending we know something and knowing we know nothing for sure.

In order to address **Q1.a** and develop hypothesis **H7** in section 4.2**,** the researcher identified some categories relevant to the research and these are summarised in Table 6 and then discussed further.

Table 6: Categories of complexity thinking

Approach	Summary Description	Relevance to research
Apparent and Inherent complexity	Apparent complexity is judged while the inherent complexity can be modelled and verified	Lack of transparency, bad design or implementation may make an inherently simple business process appear apparently complex
Detail and dynamic complexity	Detail complexity is a property of the system while dynamic complexity is a property of its behaviour	Some business processes can be complicated but stable, while others appear to be simpler but unpredictable

Apparent and Inherent Complexity: IEEE Standard Computer Dictionary (1990) defines apparent complexity as the degree to which a system or component has a design or implementation that is difficult to understand and verify. Evans and Marciniak (1987) define inherent complexity as the degree of complication of a system or system component, determined by such factors as the number and intricacy of interfaces, the number and intricacy of conditional branches, the degree of nesting, and the types of data structures.

Detail and Dynamic Complexity: Detail complexity (combinatorial complexity) refers to a system with a complicated structure but possibly simple behaviour, the sort of complexity where there are many variables. Dynamic complexity refers to a system where the structure may be simple, but the behaviour unpredictable (Senge, 1990), situations where cause and effect are subtle, and where the effects over time of interventions are not obvious. Sterman (2000, p. 21) notes that the real leverage in most management situations lies in understanding dynamic complexity, not detail complexity. Chia (1998) distinguishes these in a slightly different way as *taxonomic* complexity, which is, in his view, consistent with classical science and the Platonic view of the world as being composed of "essences", and *dynamic* complexity which recognises that the primary units of analyses are not discrete, isolatable and stabilized entities, but perpetually changing configurations of relations which are continuously transforming themselves.

2.2.3 Measuring complexity

In order to manage complexity one needs to be able to measure it. Therefore, in order to address **Q1,** the next step is to look for ways by which complexity can be measured. There have been several attempts to create measures for complexity. Most of them approach complexity from a specific perspective when defining a measure.

Mitchell (2009) describes approaches to understanding complexity from the perspective of size, entropy, algorithmic content, logical depth, thermodynamic depth, computational capacity, statistical complexity, fractal dimension and the degree of hierarchy. Lloyd (2001) proposes three dimensions along which complexity may be measured for an object or a process in terms of (1) How hard it is to describe, (2) How hard it is to create, and (3) What is its degree of organisation which he divides up into two quantities: (a) Effective Complexity; and (b) Mutual Information

Since business processes must support multiple perspectives, given their cross-functional nature, an inter-subjectively valid measure becomes necessary. Moldoveanu (2005) identifies the problem of achieving an inter-subjectively valid measure that can answer question such as "How would we know a complex phenomenon when we saw it?" and "How can complexity of different phenomena be compared?" He classifies the various definitions of complexity into two classes: (1) Complexity as structural intricacy – The strong objective view; and (2) Complexity as difficulty – the subjective view. He suggests a way of conceptualising a complex phenomenon as follows: "the complexity of a phenomenon is the complexity of the most predictively competent, inter-subjectively agreeable algorithmic representation (or computational simulation) of that phenomenon". In order to address the predictive difficulty in the definition, he proposes breaking it up into two components: informational complexity or informational depth; and computational complexity or computational load. He then makes distinctions in the information space in terms of fathomable and unfathomable phenomena; in the computational space as tractable, intractable and impossible; and finally distinctions based upon interactions between information and computation spaces as simple, complicated and complex. Finally he proposes calling those phenomena as complex "whose representations are informationally deep but computationally light".

Moldoveanu's analysis provides a key insight in terms of the distinction between the complexity of a process and difficulty in managing it. If one can consider a business process as an inter-subjectively agreed algorithm, then its informational depth would be characterised by the information structures and flows affecting the process, and computational load by orchestration and execution needs, and therefore (**L1.3**) the process could be viewed from the perspective of complexity as structural intricacy while the management of it could be viewed from the perspective of complexity as difficulty. Consequently this analysis is used to support the development of hypotheses **H4**, **H5** and **H6** in section 4.2 to meet objective **O2** of this research

2.2.4 Limitations of Complexity thinking

While much good and detailed work has been done in this field, the researcher discovered that a number of authors express doubts about complexity and the concepts therein, and this does have a bearing on how much reliance can be placed on the concepts discussed for the purpose of the research.

Rosen (1985; 1991) and Cariani (1989) express doubts about the concept of emergence. Rosen (1991) demonstrates that complexity science must effectively satisfy two contradictory conditions: (1) the models of analytic science are (ideally) complete with respect to causation, and (2) the models of analytic science are clearly not complete with respect to causation, since there are further things to explain, which equates to further causes being needed.

Sardar and Ravetz (1994) also wonder if complexity science is only a fad. Richardson, Cilliers, and Lissack (2000) express concern over the hype around complexity science, and suggest that complexity science has "some affinity with sceptical postmodernism" in that it tends to undermine all attempts to fully characterize the world, including its own attempts. Hiett (2001) suggests that it is therefore a "grey" rather than a "black and white" science. In Cohen's (1999) view, we do not yet have a unified, theoretically coherent account of complexity, only a rapidly growing collection of results, models, and methods. Horgan (1995) describes this state of affairs as perplexity in another guise.

The researcher acknowledges the doubts raised by these authors. However, the purpose of the research is to develop an approach to managing complexity of business processes. Consequently, (**L1.4**) the researcher is of the view that, whilst not perfect, the thinking around complexity could still serve as a lens through which to understand business processes.

2.3 Complex Systems

While generally modelled as systems, in the researcher's experience, organisations and business processes, particularly knowledge intensive ones, often display some of the characteristics of complexity. Therefore it is necessary to review the literature on complex systems, in terms of the evolution of thinking, definitions and concepts, in order to understand whether those concepts could be applied to organisations and business processes, and gain insights and identify impacts upon the research.

Complexity is often used as shorthand for "complex systems" (sometimes called complex adaptive systems or CAS). The field of complex systems draws upon work in various fields including Non-linear dynamics, Systems theory, Pattern formation, Evolution and adaptation, Networks, Collective behaviour and Game theory. In the early part of the 20th century, and based on the revolution in science begun by Einstein, physicists in quantum theory and the subatomic world of protons, neutrons, and electrons, advanced science beyond the earlier emphasis on reductionism (Capra, 1982). While the science of systems thinking has contributed considerably to the recognition that (**L2.1**) we need to acknowledge the complexity of the systems that we deal with, to take account of the kinds of complexity found in complex systems, (**L2.2**) it is the availability of computers and computational capability that allow us to build complex representations of reality and explore complex behaviours. This is further advanced by research around "systems based methodologies for real-world problem solving" (Checkland P. B., 1972). This has been extended in the 1980's with analytical frameworks such as "soft system methodology" (Checkland P. B., 1981). The 1990's saw further developments in terms of analytic frameworks (Jackson & Keys, 1984; Flood R. L., 1995) that explicitly acknowledged the subjectivity and uniqueness of experiencing complexity, a shift that acknowledged that (**L2.3**) application of method cannot remove subjectivity which must be addressed explicitly. A biological perspective (Cilliers P. , 1998) began to emerge as did the concept of non-linear relationships, particularly in chaos theory, where seemingly small changes in the initial characteristics of an active system can dramatically affect the long-term behaviour of that system[f] (Haigh, 2002). While weather is the classic example of the non-linear world, other examples of non-linearity abound: ecosystems, economic entities, developing embryos, the human brain: 'each is an example of complex dynamics that defy mathematical analysis…' (Lewin R. , 1999, p. 11)

2.3.1 Defining complex systems

In order to make the connection between complex systems and organisations, it is necessary to review definitions and properties of complex systems in the literature. Simon (1996) defines a complex system as one that is made up of a large number of parts that have many interactions. Plsek & Greenhalgh (2001) define complex adaptive systems as a collection of individual agents with freedom to act in ways that are not always totally predictable, and whose actions are interconnected so that one agent's action changes the context for other agents. Complexity, then, could be construed as a measure of the inherent difficulty to achieve the desired understanding of a complex system. Or

[f] This is often referred to as the 'butterfly effect' - If a butterfly flaps its wings somewhere in the world today, there will be a hurricane somewhere else at some future point

alternatively stated it is the amount of information necessary to describe a complex system (Bar-Yam, 2003).

But complexity is a systemic property, and, according to Walker and Avant (1995), a critical component of a conceptual analysis is the identification of defining attributes. Even though there is no sound definition for complexity, there have been efforts to define properties of a complex system. Casti (2003) mentions instability, non-reducibility, adaptation and emergence; Levin (2003) identifies the heterogeneity and uniqueness of components, local interaction between the components, and an autonomous process that uses the outcomes of that interaction to select a group of those components in order to refine and copy them. Holland (1995) states seven characteristics, namely aggregation, non-linearity, flows, diversity, internal models, building blocks and tagging.

Cilliers (1998, pp. 3-5) summarises general characteristics of complex systems and states that certain systems may display some of these characteristics more prominently than others. He emphasizes that "these characteristics are not offered as a definition of complexity, but rather as a low level qualitative description". The characteristics (Cilliers P. , 2005) of a complex adaptive system are elucidated to include the following: (1) large number of elements interact in a dynamic way with much exchange of information, (2) interactions are rich, non-linear, and have a limited range because there is no over-arching framework that controls the flow of information, (3) open, with feedback loops, both, enhancing, stimulating (positive) or detracting, inhibiting (negative), (4) operating under conditions far from equilibrium, which means there is continual change and response to the constant flow of energy into the system, (5) embedded in the context of their own histories, and no single element or agent can know, comprehend, or predict actions and effects that are operating within the system as a whole, (6) complexity in the system is a result of the patterns of interaction between the elements. Some authors suggest that complex systems may be divided up to complex adaptive systems and complex deterministic systems (Roos & Oliver, 1997).

Based upon the review of literature the researcher identified (**L2.4**) characteristics of complex systems that would be relevant to business processes. These characteristics are further discussed below.

Components and Interactions: A complex system consists of real components that are distinct from its parts. Cilliers (2005) calls these "elements". These functional components are defined by the system and have their ontology dependent on the context of the system. If they are "removed" from the system in any way the system loses its original identity as a whole system. The basic building blocks are the characteristics and activities of the individual components (agents) in the environment under study that are heterogeneous, i.e. differ in important characteristics. The elements interact dynamically by exchanging energy or information, and the effects of these interactions are propagated throughout the system (Cilliers P. , 2005).

Non Fragment-able: Complex systems are often capable of being reduced to parts, but any such reduction destroys important system characteristics irreversibly. If a complex system were fragment-able it would be a machine fitting the Newtonian paradigm. This relates also to the incompressible and incommensurable properties of complexity discussed earlier.

Model-able: These models may be analytic or synthetic models. The analytic models differ from the synthetic. This must be so for consistency with the requirement for non-fragmentability[g]. There can be no "largest model"[h]. The system falls outside the Newtonian paradigm in some important ways (Gershenson & Heylighen, 2005). If it could be described by the Newtonian Paradigm it would have a largest model from which all others could be derived. Problem solving in the context of complex systems requires continual translation between the state and process descriptions of the same complex reality (Simon H. A., 1962).

Emergence: What distinguishes a complex system from a merely complicated one is that some behaviours and patterns emerge in complex systems as a result

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[g] When synthetic models can replace analytic models, the system is fragment-able and is therefore a machine.

[h] If there were a largest model, all other models could be derived from it and fragment-ability would result.

of the patterns of relationship between the elements. Cilliers (2005) maintains that the behaviour of the system is determined by the nature of the interactions, not by what is contained within the components. Since the interactions are rich, dynamic, fed back, and above all non-linear, the behaviour of the system as a whole cannot be predicted from an inspection of its components which leads to the notion of emergence. The presence of emergent properties does not provide an argument against causality, only against purely deterministic forms of prediction.

Relationships: These are short-range and non-linear with direct and indirect feedback loops (Cilliers P. , 2005). Thus information is normally received from near neighbours. The richness of the connections means that communications will pass across the system but will probably be modified on the way. There are rarely simple cause and effect relationships between elements. A small stimulus may cause a large effect or no effect at all. Both negative (damping) and positive (amplifying) feedback are key ingredients of complex systems. This set of constantly adapting nonlinear relationships is at the heart of what makes a complex system special.

Openness: Complex systems are open systems - that is, energy and information are constantly being imported and exported across system boundaries. Because of this, complex systems are usually far from equilibrium (Cilliers P. , 2005) but there is also the appearance of stability. Boundaries are difficult to determine, and the decision is usually based on the observer's needs and prejudices rather than any intrinsic property of the system itself. Free-market economies are cited as classic examples of complex adaptive systems (Cilliers P. , 1998; Rouse, 2000).

Dynamic: Complex systems are adaptive in the sense that they can reorganise their internal structure without intervention of an external agent (Cilliers P. , 2005). The characteristics of the systems change over time, as the elements adapt to their environment, learn from their experiences, or experience natural selection in the regeneration process. The dynamics that describe how the system changes over time are usually nonlinear, sometimes even chaotic. The system is rarely in any long run equilibrium.

For the purpose of the research, a complex system can thus be defined as a phenomenon that has a significant number of these characteristics. However, Cohen (1999) points out the problems of definition that would apply to this definition as well. (**L2.5**) Should (1) "complex" mean the same as "complicated," or (2) should the former denote nonlinear dynamic properties and the latter mere multiplicity of moving parts? For this research the second meaning is adopted as doing so distinguishes "complex" models of business processes "complicated" ones. (**L2.6**) Should "adaptive" denote changes that are improvements as measured on some standard, and if so, on a standard internal or external to the system? Or can "adaptation" be merely change in response to change? Again for this research, the latter meaning is adopted as it denotes the process' response to change in meeting its goals.

The key insight from this review is that while most knowledge intensive business processes do exhibit most of these characteristics, current modelling practices tend to ignore most of them (see section 3.2.3). Consequently, the resulting design tends towards the Newtonian paradigm, that of a complicated machine, rather than a complex system. This insight leads to the development of **H4** in section 4.2, which is tested in the course of the research.

2.4 Organisations as Complex Systems

Is organisation, then, a complex system, and if so what is the role of complexity in organisation theory? Gershenson & Heylighen (2005) define organisation as structure with a function. Complexity implies structure as the combination of distinction (differentiation) and connection (integration). Function means the structure is developed to achieve some goal or purpose.

Simon (1996) defines a complex system as one which is made up of a large number of parts that have many interactions. Thompson describes a complex organization as a set of interdependent parts, which together make up a whole that is interdependent with some larger environment (Thompson, 1967). These descriptions appear consistent with each other. According to Lewin (1999), this notion allows us to learn something about business on the basis of the previous knowledge of similar systems in nature and in computer simulations.

Other authors make more explicit connections. Veliyath and Sathian (2005) identify properties of complex systems that are applicable to organisation as: large number of dynamically interacting elements resulting in complex processes and unpredictable outcomes; complexity increasing exponentially with the number of elements, the complexity of each, the number of interactions and the complexity of each interaction; non-linear interaction with many direct and indirect feedback loops; open systems, i.e. open to the external environment; unpredictable causality; and self-organisation.

Cilliers (2005) maintains that complexity theory has important implications for the general framework we use to understand complex organisations and makes the following observations: (1) relationships are vital since the nature of a complex organisation is determined by its members, (2) complex organisations are open systems which means that a lot of energy and information flow through them and that an invariable state is not desirable, (3) along with its context an organisation co-determines its nature which means that two similar looking organisations with different histories are not the same, (4) unpredictable and novel characteristics may emerge from an organisation which may or may not be desirable, but they are not per definition an indication of malfunctioning, (5) because of the non-linearity of the interactions, small causes can have large effects and the reverse is also true, (6) the organisation will self-organise to be critically sensitive to specific issues in the environment that may affect its well-being, and (7) Complex organisations cannot thrive when there is too much central control (as opposed to distributed control) and work best with shallow structures

With the advent of the open-systems view of organizations in the 1960s, complexity has been a central construct in the vocabulary of organization scientists. Open systems are open because they exchange resources with the environment, and they are systems because they consist of interconnected components that work together (Anderson, 1999). But there are a number of contemporary trends that seem to be contributing to the growth of interest in complex systems theories and in noting three of these Cohen (1999) argues that there are grounds for organizational researchers and practitioners to be intrigued with complex systems. But, human-based systems differ from systems in nature and in computer simulations. Cohen (1999) rightly advocates the sharpening of appraisal of the promise and limitations of complex systems theories in the study of organizations.

Organization theory has often treated complexity as a structural variable that characterizes both organizations and their environments. Daft (1992) equates complexity in organizations with the number of activities or subsystems within the organization, noting that it can be measured along three dimensions: Vertical complexity is the number of levels in an organizational hierarchy, horizontal complexity is the number of job titles or departments across the organization, and spatial complexity is the number of geographical locations. With respect to environments, Scott (1992) equates complexity with the number of different items or elements that must be dealt with simultaneously by the organization. This means that organization design is then the process of matching the complexity of an organization's structure with the complexity of its environment and technology (Galbraith, 1982).

The observations above help develop hypotheses **H2** and **H3** in section 4.2.

2.4.1 Modelling organisations as complex systems

If, from the foregoing discussion, organisations can indeed be perceived as complex systems, then, in order to develop an approach **C1** to meet the research objective **O2,** it is necessary to understand the ways in which organisations are so perceived, the ways in which organisations could be modelled as complex systems, and the limitations of such approaches.

Organisations can be perceived in different ways when viewed with the complex systems lens. While authors such as Mitleton-Kelly (1998) and Anderson (1999) argue that one of the major insights that complexity theory brings is that the organization can be viewed as a non-equilibrium system, moving from one stable state to another as a result of change, Houchin & MacLean (2005) propose an alternate view that in social systems, equilibrium-seeking behaviour is the norm; such systems can self-organize into hierarchy; disequilibrium is anxiety; organization is a defence against anxiety, and organizations thus tend towards stability.

Yet another way of perceiving organisation can be as a co-ordination between components of the system to maximise their synergy. Self-organisation then is the spontaneous co-ordination of such components. Since each component will perceive different aspects of a situation, this requires both propagation and processing of information as well as integration of information towards a shared goal. According to Hutchins (1995), this process is characterised by distributed cognition with different components participating in different ways to the overall gathering and processing of information, thus collectively solving the problems posed by any perceived deviation between the present situation and the desired situation. The key point is that these components may be a mix of intelligent, cognitive agents such as human beings and purely physical ones, but from the cybernetic perspective, there is no strict boundary between the two.

Is organisation then a form of "mind"? Gershenson and Heylighen (2005) make the point that a fundamental insight of cybernetics is that goal directedness can be understood as a type of negative feedback loop and that the concept of information allows us to model this as a system.

Noting that while scientists have studied complex organizations for many years, complex organizations can exhibit surprising, nonlinear behaviour, and a developing set of conceptual and computational tools makes possible new approaches to modelling nonlinear interactions within and between organizations, Anderson (1999) claims that complex adaptive system models represent a genuinely new way of simplifying the complex.

The review identified two approaches to modelling organisations: (1) as non-linear feedback systems; and (2) as an encoding from a natural to a formal system. Stacey (1995) describes organisations as non-linear feedback systems, where agents are free to change or ignore the accepted decision rules and behavioural scripts. However, according to Simon (1996) the central task of a natural science is to show that complexity, correctly viewed, is only a mask for simplicity. Both social scientists and people in organizations reduce a complex description of a system to a simpler one by a process of abstracting out that which is unnecessary or minor. Building a model is therefore a process of encoding a natural system into a formal system, thus compressing a longer description into a shorter one that is easier to grasp. (Anderson, 1999). While acknowledging the former, the latter approach is more pertinent to the research question **Q1**, and the research objective **O2**.

However, there is need for caution in applying these concepts. With complexity being a property of a system, it is natural that complexity theories have arisen on the basis of system theory. However, there are certain differences between these two areas of knowledge. In contrast to system theorists, complexity theory tends to focus more on explanatory analysis, to use agent-based modelling and to consider that complexity to arise from the interaction of agents that use simple rules (Phelan, 1998). But, exploitation of either system theory or complexity theory requires recognition of a system in an organisation or organisation population. If a system is considered to be a combination of interlinked agents, an organisational system may be almost anything varying from a team to a network of organisations. The definition of system depends on the phenomena under study. (**L3.1**) Choosing the agents and defining the boundary of a certain system is a task the results of which vary according to the observer. This observation has implications on the design of the approach (in terms of defining the boundary) and the choice of the participants in the research (in terms of representing implicated interests in the system).

Defining a system often necessitates making simplifications and conceptualising thing because it brings out the essential and leaves unnecessary details out. In fact, (**L3.2**) systems consisting of organisations or their parts may be easier to model than a system consisting of individuals. Andrews (2003) states that "firms can be thought of as contractually linked aggregations of individuals, and in following society's laws they exhibit a relatively narrow range of behaviours" whereas an individual has got an almost infinite range of possible behaviours. However, a system consisting of those individuals does not inherit all that range to the system level, and thus the dynamic complexity does not increase in a similar way as detail complexity increases. This adds support to the rationale for not including the political dimension for the purpose of this research.

2.4.2 Complexity in organisations

Organisations and organisation populations are complex both in their structure and in their behaviour. The researcher therefore reviewed those features of complex systems, such as self-organisation, emergence, innovation, co-evolution and adaptation, three related behaviours which might apply to organisations and organisation populations.

Complexity theory views organizations as "complex adaptive systems" that coevolve with the environment through the self-organizing behaviour of agents navigating fitness landscapes (Kauffman, 1995) of market opportunities and competitive dynamics, and suggests that self-organization is the natural "default" behaviour, while organization studies recognize barriers to such freedom in bureaucratic structure. Self-organisation is basically spontaneous order (Mitleton-Kelly, 2003). According to Deguchi (2004, p. 14), in social sciences "self-organization is explained as an emergence of a new equilibrium pattern of a dynamical system as a time and spatial order through a change of structural parameters."

Self-organisation is thus a process that produces order bottom-up and takes place if there is "a system of distributed elements which all have random behaviour in the equilibrium state. The system is then brought out of equilibrium, which is usually by the supply of energy in physical systems. A positive feedback loop becomes active, enforcing local fluctuations into coherent global behaviour." (Steels, 2003, p. 131)

Gershenson & Heylighen (2005) see the manifestation of self-organisation as the (**L3.3**) evolution towards a stable configuration of states limiting their interactions to those that allow the collective configuration to endure. This is in essence what the proposed approach and framework hope to achieve.

Besides self-organisation, emergence is considered to be a process that creates new order. Emergent features of a system may be properties, qualities, patterns or structures that arise from the interaction of individual elements (Mitleton-Kelly, 2003). Because an emergent feature may be a structure arising bottom-up, emergence may be sometimes another name for self-organisation. It is linked also to co-evolution, which is interaction between individual elements. In addressing **Q1**, it is possible then to construe the proposed approach as an innovation, a structure that arises from the existing processes in order to reduce the management challenge.

Emergent properties are basically those that are visible on the system level but are not easily predicted by studying the individual elements (Mitleton-Kelly, 2003). Casti (1997, p. 91) considers emergence to be "a process, where complex systems produce unexpected behaviour and properties, which cannot be anticipated on the basis of studying the separate parts of the system". Thus, emergence is one of those processes that make complex systems non-linear and their development irreversible and path-dependent. Emergent phenomena are difficult to anticipate or predict and may seem to be chaotic or random, and thus puzzle managers and researchers (Houchin & MacLean, 2005).

Innovation is conceived as a means of changing an organization, either as a response to changes in the external environment or as a pre-emptive action to influence the environment. Damanpour (1996) defines innovation at the organizational level, as the adoption of an idea or behaviour new to the adopting organization and the adoption of innovation is conceived as a process that includes the generation, development, and implementation of new ideas or behaviours. The most productive applications of (**L3.4**) complexity insights have to do with new possibilities for innovation in organizations, but these possibilities require new ways of thinking, and old models of thinking persist long after they are productive (Lissack, 1999).

Complexity creates organizational constraints on incremental innovation because complexity has path-dependent effects over time[1]. Therefore, over time, the knowledge about interdependencies becomes embedded and obscured in organizational processes and such obscured interdependencies make it more difficult to effect change when needed. (Ethiraj, Ramababu, & Krishnan, 2012). This observation relates to the resistance encountered in the implementation of the proposed approach.

Emergence may also be a result of other complex processes, like self-organisation or co-evolution. Co-evolution has been defined to happen when "the evolution of one domain or entity is partially dependent on the evolution of other related domains or entities.—or that one domain or entity changes in the context of the other(s)." (Mitleton-Kelly, 2003, p. 29). In the business context a common example is the development of microprocessors and software (Baskin, 1998). In general, coevolution is visible in technological development, where companies collaborate to develop a technology or when the development of a technology enables other technologies to develop.

Adaptation resembles co-evolution to some extent. Holland (1995) extends the biological definition of adaptation that is the process whereby an organism fits itself to its environment, to include learning and related processes. Adaptation describes a case, where one unit changes its behaviour and the other unit(s) stays unchanged, and after that process the changed unit is considered to fit better to its environment. This kind of unilateral relationship where no co-evolution seems to take place may exist e.g. between a company and a government body. Adaptation may also be considered to happen against a stable environment. Thus (**L3.5**) adaptation seems to happen between a system and its surroundings whereas co-evolution takes place inside the system. Whether a process is co-evolution or adaptation thereby depends on the definition of a certain system.

The proposed approach may be considered to encourage co-evolution within the business process addressed and adaptation to its environment.

2.4.3 Managing complexity in organisations

Having established that organisations can be modelled as complex systems and reviewed features of complexity in the context of organisations, the next step was to review the literature from the perspective of *managing* complexity in organisations (Lawrimore, 2005).

Salthe (2005) defines management as "efficient action at the personnel level, deployed so as to arrange material causes at the workplace in order to mediate input into growth and profit, by harnessing a firm's formal procedures at the workplaces to the final goals of growth and profit at the level of the firm …"

Complexity has been studied in the context of organisations for some considerable time. Complexity theories are increasingly being seen by academics and practitioners as a way of understanding and changing organizations (Burnes, 2005; Lissack, 1999). Since businesses and markets are complex adaptive systems, using complexity theory to increase understanding of how to cope in complex and turbulent environments is necessary, but has not been widely researched (Mason, 2007). However, as Lissack (1999) points out, the recognition of organisations as complex systems allows managers to understand complex phenomena like self-organisation and emergence, and thus seeing things below the surface.

Richardson (2005) identifies (**L3.6**) three different schools of thinking within the complexity movement as: (1) the neo-reductionist school, based upon the idea that better models and powerful computers can help scientists root out the simple rules underlying complex phenomena in the world; (2) the metaphorical school, which believes that the theories of complexity (which have been developed primarily through examining natural systems) are less directly applicable to social systems, although the complexity perspective and its associated language provides a powerful lens to gain insights into organisations; and (3) the critical pluralist school on the other hand recognises that any perspective has the potential to shed light on complexity, but not every perspective is equally valid and therefore advocates the right attitude towards models rather than privileging any one model over others. This research adopts (3) in developing and approach to address **Q1**.

2.4.3.1 Using Complexity as a metaphor

In order to address **Q1.a**, it is necessary to understand how the concept of complexity is used by managers in organisations.

Complexity theory research has allowed for new insights into many phenomena and for the development of new manners of discussing issues regarding management and organizations and the use of complexity theory metaphors can change the way in which managers think about the problems they face (Lissack, 1999). However, in showing how perspectives on organizational change have altered over the last 20 years, Burnes (2005) argues that, even in the natural sciences, the complexity approach is not fully developed or unchallenged, and that, (**L3.7**) as yet, organization theorists do not appear to have moved beyond the stage of using it as metaphor rather than as a mathematical way of analysing and managing organizations

Various metaphors of organisation allow for or deny the role or presence of complexity in various ways. As individuals in organisations employ different metaphors do describe their organisation (Morgan, 1997), their attitudes to complexity also tend to differ. One metaphor of organisations is that of a complex system. There have been many approaches to understanding organisations using this metaphor and applying results from the study of complex systems in other disciplines (Stacey R. D., 2001).

Lissack (1999) points out that the emerging theory of complex systems research has resulted in a growing movement to reinvigorate management, and that theory, research, practice, and education can all benefit by adopting a more dynamic, systemic, cognitive, and holistic approach to the management process.

But are managers equipped to conceive of management this way? Axley & McMahon (2006) critique the mechanistic grounding of traditional management education and propose complexity science as a fitting explanatory model for an age of complexity, contributing timely and important educational content and instructional processes to management education and suggest the value in harnessing natural tendencies of systems by working in harmony with them.

The foregoing discussion on the use of complexity as a metaphor leads to the development of hypothesis **H1** in section 4.2.

2.4.3.2 Corporate strategy, leadership and complexity

From the perspective of this research it is necessary to understand how complexity relates to corporate strategy and leadership as they influence the definition and evolution of business process goals and thus impacts **Q1.a** and **Q1.b**.

Applying complex adaptive systems models to organisations has implications on strategic management. As Anderson notes, this leads to an emphasis on building systems that can rapidly evolve effective adaptive solutions, since managers influence strategic behaviour by altering the fitness landscape for local agents and reconfiguring the organizational architecture within which agents adapt (Anderson, 1999)

While exploring the influence of the external environment on the choice of strategic management activities, from a chaos and complexity perspective, Mason finds that more successful companies in turbulent environments would use radical, fast and disruptive strategies, and that such strategy making should be a democratic, bottom-up process and should be organic, self-organising, adaptive and emergent (Mason, 2007).

Caldart and Ricart (2004) propose a framework for corporate strategy that approaches the field from the theoretical perspective provided by complexity theory. They conceive corporate strategy as the decision level that 'drives', 'paces' and 'frames' corporate wide evolution through the choice, at the corporate level of the firm, of a particular equilibrium configuration of cognition-evolution pattern-architectural design.

There are implications of the complexity perspective as regards leadership and decision making in organisations.

Fitzgerald (1945) notes that the test of a first-rate intelligence is the ability to hold two opposed ideas in the mind at the same time and still retain the ability to function. While leadership models of the last century which are products of top-down, bureaucratic paradigms, are eminently effective for an economy premised on physical production they are not as effective for a more knowledge-oriented economy. Complexity science suggests a different paradigm for leadership. It frames leadership as a complex interactive dynamic from which adaptive outcomes (e.g., learning, innovation, and adaptability) emerge (Uhl-Bien, Marion, & McKelvey, 2007).

Uhl-Bien et al. (2007) develop an overarching framework for the study of Complexity Leadership Theory, a leadership paradigm that focuses on enabling the learning, creative, and adaptive capacity of complex adaptive systems (CAS) within a context of knowledge-producing organizations. Their conceptual framework includes three entangled leadership roles (i.e., adaptive leadership, administrative leadership, and enabling leadership) that reflect a dynamic relationship between the bureaucratic, administrative functions of the organization and the emergent, informal dynamics of complex adaptive systems (CAS).

McKelvey (2003) discusses the concept of entanglement in explaining order in firms. With the perspective of organisations as complex adaptive systems, Uhl-Bien et al (2007) propose a leadership framework that envisions three leadership functions, adaptive, administrative, and enabling. Klijn (2007) notes that modern decision-making is highly complex, and tracks the sources of complexity in three dimensions and identifies a few stabilising factors including the interdependencies, interaction patterns, rules and trust relationships in a network.

Thus (**L3.8**) corporate strategy and leadership are complex processes exhibiting entanglement and would impact business processes in complex ways. This has implications on the selection of participants in the research as the perspectives of strategy and leadership would need to be represented.

2.4.3.3 Reservations about the complexity perspective

Despite the support for the use of the complexity perspective as related to organisations, the review uncovered several doubts, anxieties and paradoxes.

Discussing the role and practice of accounting in dynamic and complex business networks, Thrane (2007) conceptualises change in complex inter-organisational systems as a process where various perturbations from the environment or installation of management accounting affect the system, and concludes that the inter-organisational system is therefore schizophrenic in a sense, since it can shift between fundamentally different behaviours and orders within a short span of time. Management accounting in this complex evolving inter-organisational system is a source of instability rather than stability, a source of emergent, unintended order rather than planned or institutionalised change.

Richardson (2005) makes the point that if we consider organisations as social systems then, as these change and evolve, the boundaries and patterns that describe such systems continuously change and emerge. To apply science one is forced to reduce the system of interest to an idealized caricature that remains steady over time. This raises the question whether the "science of management" is meaningful at all?

Ethiraj et al. (2012) assert that, even in customer focussed firms, complexity creates organizational constraints that will alter firms' incentive to be customer-focused. Cohen (1999) points out the difficulty that plagues work on "learning," both at the individual and organizational levels. Some writers take the word to imply improved performance; others do not. Burnes (2005) concludes that, though complexity theories may be bringing about a fundamental re-evaluation of how we view the natural world, it is difficult to support the claim that they also have the potential to bring about the same sort of fundamental re-evaluation of the nature, purpose and operation of organizations.

Burnes (2005) points out that if organizations are to be re-conceptualised as dynamic non-linear systems capable of continuous transformation through self-organization, (**L3.9**) advocates of this approach will need to show either that it is more than just a metaphorical device, or that even as such it is able to resolve the problems of managing and changing organizations more effectively than other approaches that are on offer. This has implications regarding the success criterion for the proposed approach.

2.5 Implications for research

Several points for consideration arose in addressing the requirements and developing the theoretical framework from the review. These are assessed in terms of observations and their implications for this research in Table 7.

Table 7: Organisations as Complex Systems – Implications for research

Observations	**Implications for this research**
(**L1.1**) fields of study approach complexity from different perspectives on features relevant to **Q1.a** and **Q1.b** (**L1.2**) while complexity has recognisable characteristics, complexity is hard to define (**L1.4**) whilst not perfect, the thinking around complexity could still serve as a lens through which to understand business processes	The research would need to address apparent rather than inherent complexity as the latter could be masked by design, implementation and documentation difficulties and therefore difficult to ascertain.
(**L1.3**) The process could be viewed from the perspective of complexity as structural intricacy while the management of it could be viewed from the perspective of complexity as difficulty (**L3.3**) evolution towards a stable configuration of states limiting their interactions to those that allows the collective configuration to endure	If the knowledge managed by the business process could be considered a state description of the process, then one approach to reducing the management difficulty would be to attempt to transfer the complexity from the process description to the state description. Consequently this analysis is used to support the development of hypotheses **H4**, **H5** and **H6** in meeting objective **O2** of this research and L3.3 is in essence what the proposed approach and framework hope to achieve.
(**L2.1**) we need to acknowledge the complexity of the systems that we deal with, to take account of the kinds of complexity found in complex systems (**L2.4**) characteristics of complex systems that would be relevant to business processes are components and interactions, non-fragment-able, model-able, emergence, relationships, openness and dynamic (**L2.2**) it is the availability of computers and computational capability that allow us to build complex representations of reality and explore complex behaviours	The problem space and its constituent business processes would need to exhibit the complexity characteristics of complexity and would need to be understood beyond the restrictions of conventional models which ignored complex systems characteristics and be modelled as a formal system Assuming that the management goal was to implement controllable processes with predictable outcomes, the focus would have to be on processes exhibiting dynamic complexity and stochastic outcomes. The impact of change would have to be taken into consideration as one of the critical elements of the solution. This would have to include how a transfer from a process description to a state description could be accomplished. Also, order in the form of solutions may emerge and evolve therefore the research process would need to be iterative and evolving.
(**L2.5**) Should "complex" mean the same as "complicated," or should the former denote nonlinear dynamic properties and the latter mere multiplicity of moving parts?	For this research the second meaning is adopted as doing so distinguishes “complex” models of business processes “complicated” ones.
(**L3.4**) complexity insights have to do with	This observation tends to explain the resistance

Observations	Implications for this research
new possibilities for innovation in organizations, but these possibilities require new ways of thinking, and old models of thinking persist long after they are productive	encountered in the implementation of the proposed approach.
(**L2.6**) Should "adaptive" denote changes that are improvements as measured on some standard, and if so, on a standard internal or external to the system? Or can "adaptation" be merely change in response to change? (**L3.5**) adaptation seems to happen between a system and its surroundings whereas co-evolution takes place inside the system. Whether a process is co-evolution or adaptation thereby depends on the definition of a certain system (**L3.6**) three different schools of thinking within the complexity movement as: (1) the neo-reductionist school; (2) the metaphorical school; and (3) the critical pluralist school	(L2.6) for this research, the latter meaning is adopted as it denotes the process' response to change in meeting its goals. The proposed approach may be considered to encourage co-evolution within the business process addressed and adaptation to its environment. The latter implies the need for the business process addressed to be agile. (L3.6) This research adopts (3) in developing and approach to address **Q1**.
(**L3.7**) as yet, organization theorists do not appear to have moved beyond the stage of using it as metaphor rather than as a mathematical way of analysing and managing organizations	The organisations researched would need to have sufficient process maturity to be able to recognise the characteristics of complexity and distinguish complicated processes from complex ones; and be capable of perceiving complexity beyond its use as a metaphor. The discussion on the use of complexity as a metaphor leads to the development of hypothesis **H1**
(**L3.1**) Choosing the agents and defining the boundary of a certain system is a task the results of which vary according to the observer (**L3.2**) systems consisting of organisations or their parts may be easier to model than a system consisting of individuals (**L3.8**) corporate strategy and leadership are complex processes exhibiting entanglement and would impact business processes in complex ways	This observation has implications on the design of the approach (in terms of defining the boundary) and the choice of the participants in the research (in terms of representing implicated interests in the system and from different levels of management and different scales. The actors involved would need to include corporate strategy and leadership as these define process goals. The human component of the system can be seen to be constrained by the actors' roles and contractual obligations and can be seen as subsystems not requiring complex analysis. This adds support to the rationale for not including the political dimension for the purpose of this research. Entanglement is a useful concept that helps develop hypotheses H5-H9 and the **Approach**
(**L2.3**) application of method cannot remove subjectivity which must be addressed explicitly (**L3.9**) advocates of this approach will need to show either that it is more than just a	This has implications regarding the success criterion for the proposed approach and the instruments used to assess it. Such instruments would need to take the "Complexity as difficulty" perspective and be

Observations	Implications for this research
metaphorical device, or that even as such it is able to resolve the problems of managing and changing organizations more effectively than other approaches that are on offer	able to detect differences pre and post intervention. These would need to include a way to identify the process could cope with the impact of change in terms of management difficulty

2.6 Summary of this chapter

This chapter surveyed the literature on complexity, complex systems and organisations as complex systems in order to understand how complexity and complex systems relate to organisations, how organisations are modelled as complex systems, how complexity exists in organisation, how it is managed. It then discussed the implications of the insights gained to the research. The key points of relevance to this research are summarised below.

Complexity is hard to define and measure, but it does exhibit indicative properties. It may be possible to categorise complexity, but the approaches to such categorisation are not necessarily commensurable. There have been several attempts to create measures for complexity but most of them approach complexity from a specific perspective when defining a measure. However, concerns exist about complexity as a unified concept.

Complexity is a key characteristic of complex systems. Complex systems too are hard to define. It is possible to identify some characteristics of complex systems which could be applied to business processes. Complexity theory views organizations as "complex adaptive systems" that coevolve with the environment through the self-organizing behaviour of agents navigating "fitness landscapes" of market opportunities and competitive dynamics.

Organization theory has often treated complexity as a structural variable that characterizes both organizations and their environments. There are a number of contemporary trends that seem to be contributing to the growth of interest in complex systems theories and complexity theory has important implications for the general framework we use to understand complex organisations

Emergence is a central process of business dynamics. Social systems are complex, and detail complexity increases while we move from the systems consisting of human beings to systems consisting of organisations. However, dynamic complexity does not increase to the same extent. Organisations may have even more narrow range of possible behaviours than individuals. Thus it is not reasonable to define some social systems to be more complex than others on the basis of detail complexity.

While a company itself is a product of self-organisation, the processes inside the organisation are seldom that clearly self-organising, since they do have outside control and commandment. In human organisation context the system may be brought out of equilibrium not by a supply of energy but of information, as information is the factor that guides human behaviour and creates order and disorder in human systems.

The complexity perspective is useful as a metaphor and some of its insights may be applicable to the management of organisations, but such application may in itself give rise to paradoxes and emergent notions of management.

The next chapter surveys the literature from two perspectives - business processes and knowledge management - in order to develop an understanding of each, how they are managed and the implications of complexity on each of these.

Chapter 3: Business Processes and Knowledge Management

3.1 Introduction

In the last chapter the researcher surveyed the literature from the perspective of organisations as complex systems in order to understand how complexity and complex systems relate to organisations, how organisations are modelled as complex systems, how complexity exists in organisation, how it is managed and to gain insights into aspects applicable to the research.

Businesses are increasingly under pressure to perform and their business processes are critical to their performance. Smith and Fingar (2003) identify seven major trends that are driving the pressure to become cheaper, faster and better and provide a whole new level of customer pleasing service. At the same time, knowledge has emerged as a creator of wealth in today's global economy: knowledge applied to work is productivity; knowledge applied to knowledge is innovation (Drucker, 1993). Particularly with the increasing customer demands for innovation, the "management" of knowledge through enabling organization design and controls promotes self-organizing behaviour in businesses. Accumulating knowledge is applied to the marketplace by some self-organizing, entrepreneurial companies in the process of adaptation to change (Miles, Coleman, Snow, Miles, & Mathews, 1998).

In this chapter the researcher surveys the literature from the perspective of business processes and their management; and how complexity relates to business processes. This is followed by a survey of literature from the perspective of business knowledge and its management, and the integration of business processes and knowledge management.

3.2 Understanding Business Processes

As the research questions **Q1**, **Q1.a** and **Q1.b** revolve around the concept of the business processes, it is necessary to survey literature on business processes from several perspectives including the history of the concept, definitions and classification schemes, analysis and modelling approaches, design, architecture and measurement. Such a review in turn influences the theoretical framework both in constructing the hypotheses **H5** to **H8** in section 4.2 and in proposing an approach.

The review of the literature reveals that business process as a concept has a long history. What is sometimes called the 'first wave' of business process, had a focus on efficiency through division of labour, which effectively downgraded the human element involved (Falconer, 2005). Humanism was re-introduced through the work of Mayo (1933), Maslow (1954), McGregor (1960) and Weick (1979).

The 'second wave' was launched by Davenport (1993), and Hammer & Champy (1993). This reified the business process and has been called re-engineering, redesign and process improvement.

The 'third wave' (Smith & Fingar, 2003) focuses on business process as a resource and attempts to align process work with other organisational concepts such as enterprise resource planning and management, customer relationship management and e-commerce and shared services including business process outsourcing. While technology has become a key element of business processes and there seem to be boundless opportunities to use technology to increase the responsiveness of one process to another, these opportunities come at a price. As Axelrod and Cohen (2000) point out, (**L4.1**) inter-process ties are increasing, and an information technology revolution begets a complexity revolution.

3.2.1 Defining Business Processes

In layman's terms business processes may be thought of as the collection of interdependent activities organised to achieve specific business goals. While numerous definitions for "business processes" exist in literature, all of these reflect, to some degree, the same ontology, i.e. a business process is a series of continuous or intermittent cross-functional activities, that are naturally connected together, for a particular outcome/purpose, with work flowing through these activities (Davenport & Short, 1990; Hammer & Champy, 1993; Davenport T. H., 1993; Ould, 1995; Zairi, 1997; Slack, Chambers, Johnston, & Betts, 2006; Harmon, 2010). Smith and Fingar (2003) add dynamism to the definition of a business process as "… the complete and dynamically co-ordinated set of collaborative and transactional activities that deliver value to customers". Smith and Fingar (2003) characterise business processes as: large and complex; dynamic; widely distributed and customised across boundaries; long running; automated; both business and technical in nature; dependent upon and supportive of intelligence and judgement of humans; and difficult to make visible.

Cardoso et al. (2006) view a business process as a traditional software program that has been partitioned into modules or functions (i.e. activities) that take in a group of inputs and provide some output. This is similar to a "systems" view of business process. Pahl & Beitz (1984) describe a system as a set of technical artefacts, which are interrelated and interact. These artefacts are concrete and dynamic and consist of sets of ordered elements, which are interrelated as well. Lindemann et al. (2008) extends the system's definition of Pahl & Beitz by denoting that a system possesses a system's border to its surrounding as well as inputs and outputs that connect the system to its surrounding. Biemans et al. (2001) define "business processes" to denote the (**L4.2**) ensemble of activities that realize a company's objectives. These views support the development of **H4** in section 4.2.

Lushka (2005) views the enterprise as a set of interdependent processes directed towards the reproduction of the entity in terms of the wholeness that it represents, where reproduction is viewed in a broader context of activities, roles, organisational structures, working and long term capital and work force, and incorporating several different types of simultaneous processes that operate within a network of socio-economic relations. From a similar perspective, Melao and Pidd (2000) describe organizations as sets of business processes that can be analysed and improved by approaches such as business process modelling. Some process theorists (Mackenzie, 1986; Van de Ven, 1992; Abbott, 1990) define organizational processes as consisting of multiple events. Thus, while there are different perspectives, (**L4.3**) the business process approach seems to be distinguished by not only its focus on activities, i.e. what is done and/or how they are done, but it also its emphasis on how these activities are interconnected and how work flows through these activities to produce efficient and effective results. This observation supports the development of **H5** in section 4.2.

3.2.2 Classifying Business Processes

The literature on business processes offers a variety of business processes classifications according to their purpose and function, such as: manage, operate and support processes (Childe, Maull, & Bennett, 1994); organisational and managerial processes (Garvin, 1998); management and organisational processes (Davenport T. H., 1993); and primary activities / 'main' processes that are beneficial to the owner, supporting / self-maintenance / self-reproduction / restoration activities that cost the owner, and co-ordination activities (also known as supporting activities) i.e. processes of management regulation and control (Porter, 1985).

It is commonly understood that whilst operational and support processes deliver performance in the present, it is the managerial processes that sustain performance over time. In attempting to better understand what these managerial processes are and how they influence organisational performance, Bitici et al. (2011) suggest that the five managerial processes they identify, and their constituent managerial activities, influence performance of organisations as an interconnected managerial system rather than as individual processes and activities. Also, they suggest that the (**L4.4**) execution and maturity of this managerial system is influenced by the perceptions of the managers who organise it.

Since classification is varied and the managerial system perception biased, for the purposes of this research focus is on the problem domain in order to identify implicated processes and ignores classification of this kind altogether.

3.2.3 Analysing and Modelling

In order to address **Q1** and **Q1.b** it is first necessary to model the business processes in question. The researcher therefore surveyed the literature for approaches to analysis and modelling of business processes.

Formal routines in modelling and analysis have their origins in the mechanistic (Melão & Pidd, 2000) "scientific management" movement in the early 1900's through the work of Taylor (1911) and Ford (1923). In a similar vein, Davenport & Short (1990) defined a business process as 'a set of logically related tasks performed to achieve a defined business outcome'. But modelling has historically been a challenge, and Smith and Fingar (2003) view third-wave BPM as a breakthrough that addresses nine points of resistance to modelling. While successful business process modelling relies on an adequate view of the nature of business processes, Melao and Pidd (2000) assert that there is a surprising divergence of opinion about the nature of these processes. They argue that (**L4.5**) the multifaceted nature of business processes calls for pluralistic and multidisciplinary modelling approaches. Recker et al. (2009) analyse 12 popular process modelling techniques and explore representational root causes for a number of shortcomings that remain in process modelling practice.

While there is much activity in the space of business process modelling (Ko, Lee, & Lee, 2009), there are challenges and reservations too. Melao and Pidd (2000) question the view of business processes as deterministic machines, which is very close to Morgan's (1997) bureaucratic machine metaphor, and assumes that the nature of a business process is unquestioned, and its design is analogous to a technical engineering activity[i]. Falconer (2005) identifies the key characteristics of process approaches as (**L4.6**) method-driven, mechanistic, focussed on customer, top-down, broad, clean-slate, hierarchical, and promoting information technology as a key enabler. He also identifies nine shortcomings of such approaches. Concerns have also been identified around adapting business

[i] Melao and Pidd (2000) argue that the mechanistic view has two major drawbacks. First, by assuming that business processes can only be designed in rational and technical terms, it neglects human and organizational issues and second by assuming that business processes are static.

processes[j] (Alonso, Dadam, & Rosemann, 2007), standardization of modelling approaches, identification of the value proposition of business process modelling, and model-driven process execution (Indulska, Recker, Rosemann, & Green, 2009).

Business process analysis has been pervaded by the modelling paradigm where the model becomes the object of focus[k] (Norman, 2001). Falconer (2005) challenges this concept by identifying the precepts for the use of models and points out that such use becomes suspect in complex human enterprise systems and contends that process modelling is at odds with target organisational systems in that they are complex and it is not. Falconer (2005) identifies (**L4.7**) characteristics of organisational complexity as intractably extensive interconnections, systemic unpredictability of actors to affect operational control, changing systemic boundaries and the suitability and affinity of patterns as emerging systemic properties. The assumption here is that organisational systems reflect organisational complexity.

Process models can impact complexity. Mendling et al (2008) maintain that larger real world process models tend to have more formal flaws (such as, for example, deadlocks or unreachable end states) than smaller models. A likely explanation for this phenomenon would be that human modellers lose track of the interrelations in large and complex models due to their limited cognitive capabilities (Simon H. , 1996; Maes & Poels, 2007). They then introduce errors that they would not insert in a small model, which will make the model less effective for communication purposes (Reijers & Mendling, 2011). Simon and Hayes (1964) show that (**L4.8**) problem representations can affect the ease of understanding a problem, which subsequently affects problem-solving performance. Similarly, Kaplan and Simon (1990) demonstrated that problem solving on an insight problem became significantly easier when subjects chose an appropriate representation. On the other hand complexity can have undesirable

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[j] The success of a business process depends on whether it meets its business goal as well as non-functional requirements associated with it. Business process specifications frequently need to accommodate changing business priorities, varying client preferences, etc. However, business process goals and preferences are rarely captured explicitly in the dominant business process modelling approaches.

[k] As opposed to Checkland's (1981) "soft systems methodology" embraces the non-mechanistic nature of human systems that emphasizes "intellectual constructs" over models

impacts on, among others, the correctness, maintainability, and understandability of business process models (Cardoso, Mendling, Neumann, & Reijers, 2006).

Over the last decade, (**L4.9**) an artefact-centric approach of coupling control and data emerged in the practice of BP design[1]. It focuses on the "moving" data as they are manipulated throughout a process (Alonso, Dadam, & Rosemann, 2007), which influences the development of **C1**, the proposed **Approach**.

3.2.4 Design and architecture

The literature suggests that the design of business processes has not yet matured to the level of the design of systems such as bridges, computers, and aircraft. Biemans et al. (2001) argue that the complexity of business processes is the major cause and maintain that business process "architecting," the high-level, functional design of business processes, is more an art than a science; consequently, experience is very important. The trend, however, seems to be towards design standards. Davenport (2005) identifies a broad set of process standards that will emerge in terms of: process activity and flow standards – with metrics but not benchmarks); process performance standards – with benchmarks; and process management standards – indicating how well their processes are managed and measured and whether they are on course for continuous improvement

Most (**L4.10**) process-oriented forms of organizational redesign strive to improve coordination among people and other process entities to achieve overall process goals more efficiently and effectively. To gain such coordination, process redesign experts advocate a horizontal process approach rather than the traditional hierarchical or functional view of an organization (Katzenstein & Lerch, 2000). The ultimate aim of a core business process is to deliver value to the customer. Therefore, managing these processes critically improves customer satisfaction whereas functional structures form barriers to customer satisfaction (Zairi, 1997). In practice, business processes are seldom designed from scratch

[1] Business process models usually capture data exchanged between tasks in terms of objects. These objects are commonly standardized using reference data models that prescribe, among other things, allowed object states. Allowed state transitions can be modelled as object life cycles that require compliance of business processes (Alonso, Dadam, & Rosemann, 2007)

and existing business processes are typically, taken as a starting point and adapted to changed requirements (Biemans, Lankhorst, Teeuw, & Wetering, 2001). Often information technology forms the core of such redesign efforts, coordinating process members' actions or constraining their possible behaviours, but the role of control objectives stemming from regulations and standards is becoming increasingly important for businesses in light of recent events that led to some of the largest scandals in corporate history (Alonso, Dadam, & Rosemann, 2007).

In line with this thinking, the approach that this research proposes begins with an existing set of processes which are then appropriately adapted. It also proposes an improvement metric associated with the application of the approach.

3.2.5 Measuring Business Processes

The literature reveals that, as organisation performance is impacted by the quality of its processes, process performance measurement is becoming increasingly important. Alonso et al. (2007) highlight key challenges pertaining to: deriving value from performance measurement practices; establishing appropriate and useful performance measures; and implementing effective information collation and dashboard practices. They identify a need to rethink major notions of balance and strategic relevance that have been advanced hitherto as leading design principles.

Cardoso (2005) defines process measurement as the task of empirically and objectively assigning numbers to the attributes of processes in such a way as to describe them. Desirable attributes to study and measure include complexity, cost, maintainability, and reliability. He then defines process complexity as the degree to which a process is difficult to analyse, understand or explain. Cardoso et al (2006) survey findings from neighbouring disciplines[m] on how complexity can be measured and identify four main types of complexity metrics for

[m] Cardoso et al (2006) gather insight from software engineering, cognitive science, and graph theory, and discuss in how far analogous metrics can be defined on business process models and provide an overview of some 50 different software complexity metrics

processes: activity complexity, control-flow complexity, data-flow complexity, and resource complexity.

Cardoso (2005) asserts that there is no single metric that can be used to measure the complexity of a process. However, one way to analyse a process' complexity is to use a process control-flow complexity measure. Cardoso (2006) attempts to evaluate the control-flow complexity measure, which must be satisfied by any complexity measure to qualify as a good and comprehensive one.

Whereas such measures focus on the complexity of the process itself, in the theoretical framework, measuring complexity focusses on metrics deemed relevant to the challenge of *managing* that complexity.

3.3 Managing Business Processes

The literature on business processes from the perspective of process maturity, agility and change reveals that, as organisation performance is impacted by the quality of its processes, managing these processes is crucial, and has resulted in the growth of the BPM approach.

Elzinga et al. (1995) define business process management (BPM) as a systematic, structured approach to analyse, improve, control, and manage processes with the aim of improving the quality of products and services. BPM is thereby the method by which an enterprise's "Quality" program is carried out, and the quality of the enterprise's products and services is a direct reflection of its ability to improve its processes via BPM.

BPM, in various forms, has progressed to a holistic management practice (Rosemann & Brun, 2005), that consolidates objectives and methodologies from a number of other approaches and has an inherent level of complexity resulting in part from the myriad of implementation options available. Unlike BPR, sustainability is a key objective of BPM (Armistead & Machin, 1997; Zairi, 1997). The popularity and significance of BPM leads to the question of how advanced different organisations are in their BPM development which in turn leads to the notion of process maturity.

(**L4.11**) Business processes must be co-ordinated in order to achieve the business goals of the organisation, which requires mechanisms to be created that bind or organise various aspects of the business process to meet process objectives. Researchers have therefore attempted to understand business processes through the concepts of co-ordination frameworks (Raghu & Vinze, 2007). From the perspective of a theoretical framework, this leads to the development of **H9** in section 4.2.

3.3.1 Business Process and Maturity

The literature reveals that evidence is building, showing the strategic value of processes, and process maturity is increasingly of relevance.

The notion of 'maturity' has been proposed in other management approaches as a way to evaluate "the state of being complete, perfect, or ready" and the "fullness or perfection of growth or development" (Rosemann & Brun, 2005). Bitici et al. (2011) suggest that in higher performing organisations, managers: demonstrate a wider awareness of the overall managerial system; achieve a balance between short-term and future-oriented activities; exploit their managerial activities for multiple purposes; demonstrate greater maturity of managerial activities; and pay greater attention to the organisation of the managerial system. McCormack and Johnson (2001) investigated Business Process Orientation and found that companies with strong signs of BPO also performed better.

(**L4.12**) Maturity as a measure to evaluate the capabilities of an organisation in regards to a certain discipline has become popular since the Capability Maturity Model (CMMI) (CMMI Product Team, 2010) was proposed by the Software Engineering Institute at Carnegie Mellon University for the evaluation of the software development process. BPM is a potential area for development of such a maturity model. (Rosemann & Brun, 2005)

A number of models have been proposed to measure the maturity of Business Process Management, the majority of these based upon CMMI[n] developed by the Software Engineering Institute at Carnegie Mellon University. Paulk et al. (1993) indicate that improved maturity results "in an increase in the process capability of the organisation". Harmon (2003; 2004) developed a BPM maturity model based on the Capability Maturity Model. Similarly, Fisher (2004) combines five "levers of change" with five states of maturity. Roseman and Brun (2005) propose a BPM Maturity model that provides a framework for the detailed evaluation of BPM capabilities and achievements within organisations.

From the point of view of this research therefore, it would help to focus on organisations that display a high level of process maturity, on the assumption that they would already have attempted improvements on their complex business processes.

However, Smith and Fingar (2004) argue that a CMM-based maturity model which hypothesises well-organised and repeatable processes cannot capture the need for business process innovation. A shortcoming of these BPM models has been the simplifying focus on only one dimension for measuring BPM maturity and the lack of actual applications of these models. (Rosemann & Brun, 2005).

3.3.2 Business Processes and Agility

(**L4.13**) Today's enterprise must operate in a highly dynamic competitive environment subject to internally and externally induced change. While many of these changes could be considered continuous there are some very disruptive changes that can dramatically impinge on the enterprise's ability to survive (Areta & Giachetti, 2004). To manoeuvre in this highly dynamic competitive environment and even thrive requires enterprises to have the ability to not only accommodate the changing environment but also to seize the change and put it to competitive advantage. Areta and Giachetti (2004) call this ability "agility".

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[n] This model was originally developed to assess the maturity of software development processes and is based on the concept of immature and mature software organisations. The CMM introduces the concept of five maturity levels defined by special requirements that are cumulative

(**L4.14**) An organisation's agility is closely linked to its business processes, and process management has become an important way for organisations to handle the changing environments they must face (Burlton, 2001). Having an overview of a process allows organizations to easily modify it and proactively look for possible solutions for problems due to deficiencies in the process. So being process-oriented means a more pronounced view on processes but also greater agility for the organisation (Smith & Fingar, 2003). The challenge is to have a flexible and efficient value chain at the same time (Buciuman-Coman & Sahlean, 2005).

(**L4.15**) Agility impacts product development processes as well. As customers demand increasingly complex and customised products, the product development process too is affected by complexity, and therefore, more flexible and adjustable processes in product development as well as in manufacturing and assembly are required in an enterprise and an often geographically dispersed organizational structure (Alonso, Dadam, & Rosemann, 2007) that can meet these demands (Daniilidis, Bauer, Eben, & Lindemann, 2012).

According to The Oxford Dictionary, to be "agile" means to be "quick-moving, nimble, active". This also associates to "flexibility", i.e. to Flexible Manufacturing Systems (FMS) (Putnik & Putnik, 2012). Agility then, is the ability of an organization to adapt to change and also to seize opportunities that become available due to change.

Those taking the "resource-based view" of strategy also develop the relationship between internal process capabilities and a firm's ability to generate rents, that is, revenues well in excess of marginal costs. These attempts to understand how resources internal to the firm act as sustainable sources of competitive advantage are reflected in such labels as the "resource based-view" (Wernerfelt, 1984), "core competence" (Prahalad & Hamel, 1990), "strategic flexibilities" (Sanchez, 1993), and "dynamic capabilities" (Teece, Pisano, & Shuen, 1994). In this view (**L4.16**) it is the necessity to sustain competitive advantage that drives the need for agility.

Measurement of agility is necessary for the strategic planning determining how much agility an organization currently possess, determining how much is needed, and then for assessing the gap and formulating a strategy for closing any perceived weaknesses (Areta & Giachetti, 2004). However, agility is difficult to measure since it must be measured in the context of a change and, consequently, most current agility measurement approaches are backward looking. Areta & Giachetti (2004) use complexity as a surrogate measure for agility with the hypothesis that a less complex enterprise in terms of systems and processes is easier to change and consequently more agile. Dove (2001) proposes a five level maturity model to measure the agility of a company similar to the capability maturity model (CMM) that is widely used by software industry to characterize the sophistication of the software development process.

Lean and Agile are two concepts that are often discussed in the context of organizational agility. Putnik & Putnik (2012) assert that these are mutually exclusive concepts and managers must choose between "agile" and "lean", considering the context of action: under the conditions of stable (and predictably, certain linear) environments, the managers should choose "lean", and with at most controlled application of "agile" (as "lean" instrument); and under the conditions of high dynamics of environment (i.e. unpredictable, uncertain, non-linear environment), the managers have to choose "agile".

The approach proposed by this research therefore leads towards greater agility whilst addressing complexity. It is important for the research to ensure that approaches like Lean and Agile have been attempted and failed, in order to validate the need for such an approach.

3.3.3 Business Processes and Change

The literature also reveals the strong relationship between complexity, organisation change, and change vehicles such as projects, which are primarily the means of achieving **O2**.

Given the rapidly changing environment in which organizations operate, while there is little doubt that the ability to manage change successfully needs to be a core competence for organizations, it is equally clear from the failure rate of change projects that the majority of organizations appear to lack this competence (Thomas & Mengel, 2008). Burnes (2005) points to the explosion of interest among management academics and practitioners in the complexity-based continuous transformation model of change, in order to explain and overcome the failure of many change projects.

Murray (2005) examines large scale organisational change (LSOC) from the perspective of complexity theory concepts and develops a systems model and a theory of integral complex organisation. He identifies the loss of integrity of organisation in relation to their environments as generating many of the challenges facing managers today.

(**L4.17**) Projects themselves have been described as complex systems that require management not only because they deal with technological issues but because they deal with the wider organizational factors largely beyond the project manager's control (Whitt & Maylor, 2008). Vidal et al. (2011) identify the multiple aspects of project complexity in order to propose a multi-criteria approach to project complexity evaluation. Richardson et al. (2005) identify different modes of complexity in the context of projects.

Managerial complexity in the project environment[2] comes not only from individual structural elements (categorised as being external stakeholders, task characteristics and organisational complexity) and their interaction, but also from the dynamic effects of each of these changing and then interacting as they change, causing further change in other parts of the system (Whitt & Maylor, 2008). Camci and Kotnour (2006) assert that the project technology is made up of two distinct types of complexity: product complexity and methods complexity. Transparency is often the key to project success and it is essential for the success of a project to specifically determine which measures must be taken in order to create transparency and how complexity should be managed (Daniilidis, Bauer, Eben, & Lindemann, 2012)

From the perspective of this research, a study of processes in the complex project environment would contribute to the development of the proposed approach. Consequently such a QDS has been selected for investigation.

The organisation structure is one element that impacts complexity. A complex organizational structure is one that contains differentiated parts so that the greater the differentiation the more complex the organization (Hall, 1979). An attribute of organizational complexity in projects is the degree of operational interdependencies and interaction between the project organizational elements (Bubshait & Selen; Gidado, 1993).

Technology is another element that impacts complexity. Broadly speaking, technology can be defined as the transformation processes which convert inputs into outputs (Kast & Rosenweig, 1979). This transformation process involves the utilization of material means, techniques, knowledge and skills (Mintzberg, 1991; Kast & Rosenweig, 1979). Technology is a multi-dimensional concept and can be categorized into two types: uncertainty and complexity (Ireland, 1985).

There are challenges to many of the long held beliefs about tools and techniques used in projects, but these apply across the board and are not necessarily limited to something that may be labelled as complex (Whitt & Maylor, 2008). Critical Path Method, for instance, is a useful part of project planning, but it does not model the reality of the uncertainty of the project environment well in either small or large projects, simple or complicated (Rand, 2000). Empirical evidence (Willcocks & Smith, 1995) strongly suggests that IT-driven BPR projects and a lack of attention to socio-political and organizational issues are major reasons why so many BPR projects fail. This means that while concern for technical and rational issues is important, their consideration should not be overemphasized at the cost of the mismanagement of human and organizational issues (Melão & Pidd, 2000)

IT products are often key components of business change projects. Noting that the complexity of configuring computing systems is a major impediment to the adoption of new information technology (IT) products and greatly increases the cost of IT services, Keller et al. (2007) develop a model of configuration complexity and demonstrates its value for a change management system. They define configuration complexity as the complexity of carrying out a configuration procedure as perceived by a human system manager.

Complexity theory and organization studies find some common ground in the concept of adaptation to change. Increasing interconnectedness between people both accelerates customers' demands for innovation and enables self-organizing behaviour in response to produce new offerings. Consequently, (**L4.18**) in the age of innovation, it may no longer be appropriate to use the change model of "unfreezing, transition, and refreezing", as disequilibrium may be the new equilibrium.

3.4 Complexity and Business Processes

As with complex dynamic systems, business processes complexity concerns the structure of business processes: the variety of elements and relationships between them. Besides, the perception of and changes in this structure are important. Biemans et al. (2001) identify several reasons why complexity is perceived to arise, including several knowledge domains, vastly different time scales, nearly independent business processes, more attention required to comprehend, uncontrolled modifications, resistance to large-scale overhauls and clean-ups, and the inability of the human mind to grasp multi-dimensional business process models easily. Melao and Pidd (2000) provide a critique of various perspectives of business processes, while Biemans et al. (2001) provide several heuristics for the design of business processes.

Several authors have suggested the application of Checkland's (1972) soft systems methodology (SSM) to provide a more balanced approach to modelling business processes. Galliers (1994) observed that little attention has been given to exploring the role of soft modelling in dealing with process issues and then goes on to outline an SSM-based approach to undertake IS strategy/process change studies. From a practitioner perspective, Patching (1995) showed how SSM provides a high-level, process-based language to approach business process change from a holistic point of view. Similarly, Chan & Choi (1997) showed how

SSM can be used to provide methodological support and an analytical framework as well as to deal with ill-defined situations in a business process setting.

Perona & Miragliotta (2004) suggest that the ability to control complexity within manufacturing and logistics systems can be regarded as a core competence in order to jointly improve efficiency and effectiveness at a supply chain wide scale. They highlight that there exist two different kinds of levers to control complexity, namely complexity reduction and management levers. (**L4.19**) A lower level of complexity of the system yields a joint improvement of system's efficiency and effectiveness, showing therefore its ability to shift the well-known trade off among these two performance domains. (Perona & Miragliotta, 2004). Consequently controlling complexity is important for organisations. This research addresses the complexity reduction lever through **C1**, the approach it proposes.

3.5 Understanding Knowledge Management

Knowledge intensive business processes, the subject of **Q1**, deal with knowledge, which makes it necessary to understand knowledge management.

Zack (1999) describes knowledge as that which we come to believe and value based upon organised accumulation of information through experience, communication or inference, and distinguishes knowledge from data and information in that data represents observations or facts out of context, while information places data in a meaningful context. The type of knowledge may be declarative, procedural or causal, the form tacit or explicit, and range from general to specific. Business knowledge can be defined as a complex conglomeration of information, workflow, decision and collaborations and all the associated interactions. The challenge of managing knowledge in an organizational context lies in effectively harnessing multiple knowledge sources into coherent business intelligence and embedding the intelligence into organization's memory. (Raghu & Vinze, 2007)

Knowledge Management (KM) is crucial to organisations. Nguyen and Mohamed (2011, p. 206) argue that "organizations are interested in KM to boost the efficiency of their processes, increase their productivity and quality of their services, and to achieve innovative solutions and products for their customers". (**L5.1**) As organizations become more global and/or virtual, a unifying, semantically developed structure to represent knowledge becomes increasingly imperative (Raghu & Vinze, 2007). Management theorists take a constructivist approach, recognizing that knowledge is socially constructed and that this makes the underlying values and historical assumptions in place a key part of the usefulness of any knowledge in any particular situation. (Thomas & Mengel, 2008). This observation is used to develop **H9** in section 4.2.

Therefore, (**L5.2**) KM solutions need to develop critical decision-making mechanisms necessary to reduce cognitive dissonance among decision-makers. This is especially relevant in scenarios where decision makers are geographically and organizationally dispersed and are concerned with rapidly evolving situations. Such decision problems are often ill-structured and intractable due to the multitude of events, evidences and facts that require careful consideration. (Raghu & Vinze, 2007)

3.5.1 Defining Knowledge Management

KM has been defined in different ways, but commonalities can be found among the various definitions. Based on such commonalities, Claver-Corte´s et al. (2007, p. 46) define KM "as the set of business policies and actions undertaken for the purpose of favouring the creation of knowledge, its transfer to all firm members and its subsequent application, all of it with a view to achieving distinctive competencies which can give the company a long-term competitive advantage". One may question the sustainability of long-term competitive advantages, but the capacity to renew knowledge as a path toward a succession of temporary competitive advantages seems hard to dispute (D'Aveni, Dagnino, & Smith, 2010)

Social factors are also relevant to knowledge management. Corso et al. (2009, p. 74) argue that KM is about "creating an environment that encourages people to learn and share knowledge by aligning goals, integrating bits and pieces of information within and across organizational boundaries, and producing new knowledge that is usable and useful to the organization". This observation is used to develop **H8** in section 4.2.

Zheng et al. (2010b, p. 764) state that KM "encompasses the managerial efforts in facilitating activities of acquiring, creating, storing, sharing, diffusing, developing, and deploying knowledge by individuals and groups". KM involves a conscious strategy for getting the right knowledge to the right people at the right time, and for helping people to share and put information into action in ways that improve organizational performance (O'Dell & Grayson, 1998). This observation is also used to develop **H9** in section 4.2.

3.5.2 Modelling and Knowledge Management

In the context of KIBPs, the business process models must take into account the complexity of the knowledge artefacts they must deal with, particularly when such processes tend to be automated. According to Kumaran et al. (2008), most approaches to IT-enabled automation of a business process take one of the following two paths: (1) business process models are used merely as requirement documents, from which, IT solutions are manually designed and implemented by writing new custom code, or by customizing and integrating legacy applications and packaged software; or (2) business process models are automatically converted into workflow definitions which are deployed on workflow engines and augmented with custom code. The first approach leads to a gap between the business process models and IT solutions

In response to this situation, another process modelling paradigm has been proposed, which models business processes as intersecting life cycles of information entities,. Appropriately, this approach is called information-centric process modelling. The information entities (Kumaran, Liu, & Wu, 2008) that are used to describe business processes in this manner have been called various names, including adaptive documents (ADoc) (Kumaran, Nandi, Heath, Bhaskaran, & Das, 2003), adaptive business objects (ABO) (Nandi & Kumaran, 2005), business artefacts (Nigam & Caswell, 2003), and lately business entities

(Kumaran, Liu, & Wu, 2008). (**L5.3**) Information entities are at the heart of information-centric modelling as well as the domination concept. Kumaran et al. (2008) formalize the information-centric approach and derive the relationships between the two approaches.

Nigam and Caswell (2003) introduced the concept of business artefacts and information-centric processing of artefact lifecycles. Kumaran et al. (2003) developed adaptive business documents as the programming model for information-centric business processes and this model later evolved into adaptive business objects (Nandi & Kumaran, 2005). Further studies on business artefacts and information-centric processes can be found in (Bhattacharya, et al., 2005; Bhattacharya, Gerede, Hull, Liu, & Su, 2007; Bhattacharya, Caswell, Kumaran, Nigam, & Wu, 2007; Liu, Bhattacharya, & Wu, 2007). Bhattacharya et al. (2005) describe a successful business engagement which applies business artefact techniques to industrialize discovery processes in pharmaceutical research.

The research takes the information centric approach to addressing complexity and the notion of the shared knowledge context in **H8** approximates a collection of integrated information entities.

3.6 Managing Business Knowledge

Understanding how best to manage knowledge and identify and understand barriers and facilitators to KM first requires an understanding of the processes supporting KM, i.e. the dynamic activities that allow organizations to produce valuable knowledge (2002). This understanding is necessary to develop **H8**, **H9** in section 4.2, and **C3**.

The literature proposes different KM process taxonomies. For example, Bhatt (2001) considers knowledge creation, validation, application, and distribution, (Sun, 2010) focused on the processes of acquisition, creation, utilization, and sharing. Coombs and Hull (1998) identifies the processes of knowledge generation, transfer, and use. Allameh et al (2011) consider knowledge creation, capture, organization, storage, dissemination, and application. Nonaka and

Takeuchi (1995) focus on the socialization, externalization, combination, and internalization processes. Perez et al. (2002) consider knowledge creation, acquisition, retention, and distribution.

Pinho et al. (2012) consider four processes: knowledge acquisition, creation, sharing, and transfer. These four processes cover the "sources-uses-outcomes approach" to knowledge creation (Devinney, Midgley, & Soo, 2005; Armbrecht, et al., 2001; Chang & Li, 2007).

Knowledge acquisition refers to searching for, identifying, selecting, collecting, organizing, and mapping information/knowledge. (**L5.4**) Knowledge creation "is the process of making available and amplifying knowledge created by individuals as well as crystallizing and connecting it to an organization's knowledge system" (Nonaka, Von Krogh, & Voelpel, 2006, p. 1179) and results from the interplay between individuals and organizations, from which successive conversions from tacit into explicit knowledge emerge (Nonaka, 1991; Nonaka & Takeuchi, 1995; Nonaka, Toyama, & Konno, 2000). This is the perspective adopted in developing **H8**, **H9** in section 4.2 and identifying **C3**.

The boundaries between knowledge sharing and knowledge transfer are unclear, and both terms are often used interchangeably (Kumar & Ganesh, 2009). However, one may consider that the former is more related to tacit knowledge (Polanyi, 1967), whereas the latter is more related to explicit knowledge (Hansen, Nohria, & Tierney, 1999). In other words knowledge sharing is the process of exchanging tacit knowledge, through social and collaborative processes (Nonaka, Toyama, & Konno, 2000; Nonaka, 1994) and knowledge transfer deals with transmitting explicit knowledge from one source/agent (individual, team/department, and/or organization) (Joshi, Sarker, & Sarker, 2007) to another (Argote & Ingram, 2000; Dyer & Hatch, 2006).

These four processes are interconnected in a complex way (Alavi & Leidner, 2001; Chen & Chen, 2006). They critically depend on the creation of a positive infrastructure and on the removal of the obstructions that interfere with knowledge management processes. For example, knowledge sharing is the cornerstone of knowledge creation (i.e. without knowledge sharing, creating knowledge is almost impossible). Both may be interactively developed if barriers (e.g. departmental/unity fragmentation) are removed and facilitators (e.g. interpersonal trust and other sources of social capital) are built.

Misalignment between IT systems and processes, and/or between IT systems/processes and users' needs, appear as an important technological barrier to knowledge sharing (Davis, Subrahmanian, & Westerberg, 2005; Riege, 2005). It is not enough to invest in technology, it is also necessary to ensure that technology, processes, and users' needs are aligned (Pinho, Rego, & Cunha, 2012).

3.6.1 Knowledge Intensive Firms

The understanding of how a firm can manage knowledge is an issue that has received increasing attention in both theory and practice over the past several years from two perspectives. On the one hand, we have the emergence of the knowledge-based theory of the firm, on the basis of which, knowledge and the capability to create and utilise such knowledge are the most important sources of competitive advantage (Prahalad & Hamel, 1990; Nelson, 1991; Henderson & & Cockburn, 1994; Nonaka & Takeuchi, 1995; Boland Jr. & Tenkasi, 1995; Grant R. M., 1996; Kogut & Zander, 1996; Nonaka, Toyama, & Nagata, 2000). On the other hand, there has been an attempt to define knowledge-intensive firms and explain their organizational and management features (Greenwood, Hinings, & Brown, 1990; Hinings, Brown, & Greenwood, 1991; Starbuck, 1992; Winch & Schneider, 1993; Nurmi, 1998; Alvesson M. , 1993). In answering **Q1**, the latter perspective is directly relevant to this research as it is focussed on knowledge intensive firms.

Knowledge-intensive firms have been defined in different ways by the various researchers as firms that use more than the average employees in fields that require a sophisticated knowledge, and whose expertise is the source of a competitive advantage (Bernardi & Warglien, 1989; Ekstedt, 1989; Winch & Schneider, 1993); or firms "in which . . . experts are at least one-third of the personnel" and experts are "those with formal education and experience equivalent to a doctoral degree" (Starbuck, 1992). Thus, in general, according to these definitions, knowledge-intensive firms' capital consists predominantly of human capital, their critical elements are in the minds of individuals and heavy demands are made on the knowledge of those who work in them (Ekstedt, 1989).

Alternatively, such a type of firms also has been characterized as those that deploy their "assets in a distinctive way, for they sell a capacity to produce, rather than a product" (Winch & Schneider, 1993, p. 923) and finally those that process what they know into unique knowledge products and services for their customers, or possibly goods in combination with services. They are, typically, less capital intensive than companies in the manufacturing industries and more learning-intensive than those operating in other service industries (Nurmi, 1998).

Put simply then knowledge-intensive firms can be viewed as organizations that use mainly the knowledge of their individuals to develop and trade immaterial responses to customer requirements. The one feature such firms possess is that their expertise is used to solve varied problems by offering a differentiated range of innovative responses to customers (Ekstedt, 1989; Starbuck, 1992). In addition, their knowledge is mainly embedded in human capital, even if this knowledge may be partially institutionalised and localised at the organisational level in the form of collective frames of reference, systematised methods of work, sophisticated routines and processes (Starbuck, 1992; Alvesson M. , 1995; Morris & Empson, 1998).

Knowledge-intensive firms have become more prevalent and more important as the business services sector has grown equally over the last twenty years (Winch & Schneider, 1993) and the world has been moving toward the so-called "post-industrial" economy (Drucker, 1993; Nonaka, 1994). Yet, research has only just started to scratch the surface in this area of business and most of the existing writings suggest simplistically that managing these organizations is mainly based on both attracting and keeping the key professional workforce—the most significant 'resource' of knowledge-intensive companies—and developing organization-specific knowledge of an informal nature, inscribed in organizational culture and a certain style of working (Maister, 1982; Alvesson M. , 2000).

The resource based paradigm and its elaborated version, the dynamic capability approach admits that each firm has certain relatively stable attributes that lead to its consistent heterogeneity regarding its market performance and provision of resources: its market strategy, its internal management and its specific competencies and capabilities (Penrose, 1959). The firm is looked upon as a bundle of productive physical and human resources (stocks) capable of internal development, whose produced results can be used for manufacturing purposes. As creation use and dissemination of individual and organisational knowledge is the most important task of the firm, this thinking can be extended to say that the firm is primarily a knowledge-integrating institution (Grant R. , 1996), thus yielding a knowledge–based view of the firm. From the perspective of this research, **H9** associated with **C3** supports a knowledge-based view of the firm.

3.6.2 Knowledge Intensive Business Processes

The most basic understanding of researchers and practitioners is that knowledge intensive processes[o] (KIBPs), the subject of **Q1**, require the collection and use of information and knowledge more than processes that are not knowledge intensive. Also, the role of a knowledge worker in terms of executing the process is highly critical for KIBPs.

From a broad, conceptual point of view, KIBPs can be defined as processes that require very specific process knowledge, typically expert involvement, that are hard to predict and vary in almost every instance of the process. They typically depend largely on human involvement and decisions although parts of the process could be supported by automation. KIBPs have been described in previous studies by researchers from different functional domains and knowledge intensity has been regarded as a continuum of complexity (Papavassiliou & Mentzas, 2003; Eppler, Seifried, & Röpnack, 1999; Marjanovic & Seethamraju, 2008; Panian, 2011).

[o] Examples of KIBPs can be a new product or service development, marketing processes, software development and strategy development.

Researchers have studied characteristics that constitute knowledge intensity of processes and suggest that the key difference lies in the enhanced role of the knowledge worker (Isik, Bergh, Mertens, & Leuven, 2012). Others suggest that KIBPs include higher number of stages as well as greater levels of uncertainty and ambiguity, compared to non-KIBPs (Kulkarni & Ipe, 2007; Marjanovic & Seethamraju, 2008). Yet another characterization is proposed by Hagen et al. (2005), suggesting that KIBPs are semi or unstructured and they add value only through the fulfilment of the knowledge requirements of the process workers. Other relevant characteristics in literature are the level of decision and the role of the decision maker in the process (Kulkarni & Ipe, 2007). The diversity of decision options, the link between process outcomes and decisions, and the required expertise of the decision maker have also been studied (Isik, Bergh, Mertens, & Leuven, 2012). Other recurring suggestions for discretionary process characteristics for KIBPs are the level of predictability (Hagen, Ratz, & R. Povalej, 2005; Panian, 2011), required creativity (Hagen, Ratz, & R. Povalej, 2005; Harmon, 2007; Marjanovic & Seethamraju, 2008), structure (Hagen, Ratz, & R. Povalej, 2005), repeatability (Slembek, 2003 ; Marjanovic & Seethamraju, 2008), eligibility for automation (Panian, 2011) and complexity (Eppler, Seifried, & Röpnack, 1999; Harmon, 2007; Marjanovic & Seethamraju, 2008; Davenport T. , 2010; Panian, 2011).

In today's business world, the role of knowledge and KIBPs is ever increasing. The capability of BPM in managing KIBPs is now being questioned. Academics and practitioners alike suggest that BPM needs to evolve into a more flexible discipline that is capable of dealing with KIBPs. (Isik, Bergh, Mertens, & Leuven, 2012).

3.6.3 Integrating Business Processes and Knowledge Management

Business processes typically involve several knowledge domains[p]. Many business processes, often executed by computers and people, deal with several of these

[p] A bank, e.g., employs a mixture of people with financial, commercial, technical, legal, or social backgrounds.

domains (Biemans, Lankhorst, Teeuw, & Wetering, 2001). On the other hand, KM itself is embedded in an iterative process that fluctuates between storage and retrieval, and knowledge sharing; with the ultimate aim of knowledge reuse and knowledge synthesis. Raghu & Vinze (2007) identify that (**L5.5**) knowledge and its management require: (a) collaboration between a wide spectrum of contributors that ranges from people and processes to supportive technologies in an organization; and (b) interactions between aspects of business processes including workflow execution, information processing, decision making and motivational structure.

Because production and consumption of knowledge occur within these aspects of business processes, Raghu & Vinze (2007) argue that a business process context provides the justification and rationale for organizing Knowledge Management efforts that address knowledge storage and retrieval, knowledge sharing and knowledge synthesis; and that the traditional view of knowledge as data and information fails to incorporate process and associated assumptions - thus causing loss of context for the knowledge that is stored (or retrieved), and shared.

Jung et al. (2007) observe that: (a) knowledge is used by performers of business processes and new knowledge is created as results of business processes – i.e. business processes are an excellent delivery medium of knowledge as well as an arena for the creation of knowledge; and (b) Information about a process itself and process execution results is valuable corporate knowledge – i.e. information derived from business processes can (or must) be gathered and formalized to enhance the performance of business processes, hence, the organization. They suggest that knowledge and business processes must be integrated and managed throughout their lifecycles to fully deliver the combined advantages. This is also the perspective adopted by this research in discussing **H8**, **H9** in section 4.2**,** and **C1** and **C3**.

Isik et al. (2012) summarize the information characteristics that apply to business processes in terms of source, scope aggregation, time horizon, currency, accuracy and frequency of use. Jung et al. (2007) propose an architecture for integrating knowledge management systems (KMSs) and business process management systems (BPMSs) to combine the advantages of the two paradigms, and suggest how the functionalities of existing KMSs and BPMSs must be extended to support the three types of process knowledge while satisfying the lifecycle requirements of both knowledge and business processes.

Researchers have explored mechanism design for optimising investments in knowledge (Ba, Stallaert, & Whinston, 2001), knowledge characteristics and organizational structure (Birkinshaw, Nobel, & Ridderstrale, 2002), knowledge creation and process change (Carrillo & Cheryl, 2000), knowledge reuse (Majchrzak, Cooper, & Neece, 2004) and knowledge transformation (Carlile & Rebentisch, 2003). Raghu and Vinze (2007) provide a summary of the evolution of KM as a research area. It is generally accepted that performance improvements from KM and associated technologies result when knowledge is actually applied, and application of knowledge is to a large extent driven by its context which defines the intent of usage. KM efforts have been developed and studied in a variety of contexts including in a business decision and process setting. However as Raghu and Vinze (2007) point out, problems with KM and knowledge sharing are well documented and often result from lack of applicability of available knowledge. Raghu and Vinze (2007) argue that these (**L5.6**) problems arise when investments in KM processes and KM technologies are made without a specific knowledge context[3].

3.7 Complexity and Knowledge Management

In today's business world, a variety of new opportunities is created by the emergence of new knowledge structures in scientific discoveries. These new market opportunities acting as attractors, "pull" a variety of entrepreneurs and their teams of colleagues to innovate within existing firms or to found new enterprises (Miles, Coleman, Snow, Miles, & Mathews, 1998). The increasing interconnectedness of people (agents) enables ideas to be translated into innovative offerings in response to rapidly communicated customer demands. However, this has an impact on complexity. As Kauffman (1995, pp. 296-7) puts it, "Diversity begets diversity, driving the growth of complexity". Appropriate management of knowledge can engender creativity in organisations.

The space for creativity in an organization is a dialectical state of tension between over-control, embodied in the legitimate system, and chaos, embodied in the shadow system (Pascale, 1990; Stacey R. D., 1996).

This is enabled by (**L5.7**) boundary-less-ness, "a matter of cooperation across all the artificial barriers that can separate people with common interests" (Tichy & Sherman, 1993, p. 285). The idea is to encourage: teamwork on a grand scale, making cooperation an essential characteristic of organizational success. Given the right kind of people and clearly understood goals, intricate webs of informal networks among employees can accomplish much more than any rigid, traditional organization, producing tangible competitive advantages. (Tichy & Sherman, 1993). However such flexibility and intricacies make knowledge more complex to manage particularly in knowledge intensive firms (Cilliers P. , 2005).

Knowledge is a key dimension when discussing agility, and in this context, Dove (2001) defines agility as the ability to manage and apply knowledge effectively, so that an organization has the potential to thrive in a continuous changing and unpredicted business environment. Agility implies not only the ability to respond to unanticipated change (response ability) but also to act proactively with regard to change (knowledge management). The complexity of business processes is also related to their knowledge intensity. Marjanovic and Freeze (2011) have differentiated between simple procedural processes and complex processes. Their research suggests that procedural processes require information that is predefined, highly structured that comes from BPM, ERP or workflow systems. On the other hand, they suggest that KIBPs require both structured and unstructured information yet the source cannot be predicted beforehand (Isik, Bergh, Mertens, & Leuven, 2012). In terms of knowledge requirements, KIBPs require predominantly experiential knowledge whereas non-KIBPs require explicit knowledge. This observation is relevant to **Q1, Q1.a** and **H6.**

Reynolds (2011) identifies the subtle difference between a 'repeatable' and a 'reproducible' process. The repeatability does not necessarily consider the complexity of the processes, but it is suggested that a reproducible process needs more details and more specificity regarding the expected outcomes. Isik et al. (2012) seem to imply that while KIBP's may seem repeatable when seen from a high level but with very limited instances in comparison to non-KIBPs and that KIBPs would be less reproducible. (**Q1, Q1.a, H6**). Isik et al. (2012) note that, while half of the non-KIBPs were named complex by their interviewees, most of KIBP cases turned out to be identified as complex. Eppler et al. (1999) have posed that complexity and knowledge intensity are two separate dimensions.

3.8 Implications for research

From the review, points for consideration in addressing the requirements and developing the theoretical framework are assessed in Table 8.

Table 8: Business Processes – Implications for research

Observations	**Implications for this research**
(**L4.11**) Business processes must be co-ordinated in order to achieve the business goals of the organisation, which requires mechanisms to be created that bind or organise various aspects of the business process to meet process objectives; (**L4.10**) process-oriented forms of organizational redesign strive to improve coordination among people and other process entities to achieve overall process goals more efficiently and effectively; (**L4.19**) A lower level of complexity of the system yields a joint improvement of system's efficiency and effectiveness	The need for co-ordination of aspects of the business processes in pursuit of their business objectives implies that improvement depends upon removing entanglements that come in the way of such co-ordination. This line of argument leads to **H5** and **H6.** The participants in the research would need to include those involved in defining and improving existing business processes
(**L4.17**) Projects themselves have been described as complex systems; (**L4.4**) execution and maturity of the system is influenced by the perceptions of the managers who organise it ; (**L4.12**) Maturity is a measure to evaluate the capabilities of an organisation in regards to a certain discipline; (**L4.18**) in the age of innovation, it may no longer be appropriate to use the change model of "unfreezing, transition, and refreezing", as disequilibrium may be the new equilibrium	The greater the process maturity of the organisation the more likely it is that it would have made attempts to improve process performance, and more capable of recognising and successfully delivering complex projects in doing so. Even so, organisations could still face challenges in managing KIBP's even after implementing BPM as process change is likely to be an on-going process rather than a single project
(**L4.2**) "business processes" denote the ensemble of activities that realize a company's objectives; (**L4.6**) key characteristics of process approaches are method-driven, mechanistic, focussed on customer, top-down, broad, clean-slate, hierarchical, and promoting information technology as a key enabler	The notion of an 'ensemble of processes', together with the mechanistic view of organising processes is used to support the development of hypothesis **H4**
(**L4.13**) Today's enterprise must operate in a highly dynamic competitive environment subject to internally and externally induced change; (**L4.7**) characteristics of organisational complexity as intractably extensive interconnections, systemic unpredictability of actors to affect operational control,	If organisations are subject to change due to the dynamic environment and they are themselves complex then changing them would create significant challenges. This line of argument leads to **H2**.

Observations	Implications for this research
changing systemic boundaries and the suitability and affinity of patterns as emerging systemic properties	
(**L4.3**) the business process approach seems to be distinguished by not only its focus on activities, i.e. what is done and/or how they are done, but it also its emphasis on how these activities are interconnected and how work flows through these activities to produce efficient and effective results; (**L4.1**) inter-process ties are increasing, and an information technology revolution begets a complexity revolution; (**L4.5**) the multifaceted nature of business processes calls for pluralistic and multidisciplinary modelling approaches	If business processes are internally interconnected and inter-process ties are increasing then management will become increasingly more challenging and will require fresh modelling approaches. This line of argument leads to **H3**
(**L4.8**) problem representations can affect the ease of understanding a problem, which subsequently affects problem-solving performance; (**L4.9**) an artefact-centric approach of coupling control and data emerged in the practice of BP design; (**L5.3**) Information entities are at the heart of information-centric modelling; (**L5.5**) knowledge and its management require: (a) collaboration between a wide spectrum of contributors; and (b) interactions between aspects of business processes	These observations support the development of hypothesis **H8** The problem space would need to be focussed on KIBP's, and may need to move beyond activity centric modelling towards information centric modelling. Design heuristics should be considered both in the definition of the problem and the solution. The solution would need to support multiple perspectives Assessing success would need to include not just current process complexity measures but measures of knowledge management complexity as well. The participants in the research would need to include those involved in managing process / organisation knowledge.
(**L4.16**) it is the necessity to sustain competitive advantage that drives the need for agility; (**L4.14**) An organisation's agility is closely linked to its business processes, and process management has become an important way for organisations to handle the changing environments they must face; (**L4.15**) Agility impacts product development processes as well; (**L5.1**) As organizations become more global and/or virtual, a unifying, semantically developed structure to represent knowledge becomes increasingly imperative; (**L5.2**) KM solutions need to develop critical decision-making mechanisms necessary to reduce cognitive dissonance among decision-makers; (**L5.7**) boundary-less-ness; (**L5.4**) Knowledge creation results from the interplay between individuals and organizations, from which successive conversions from tacit into explicit knowledge emerge; (**L5.6**) problems arise when investments in KM processes and KM technologies are made without a specific knowledge context	As agility is critical and closely linked to the organisation's business processes, then knowledge required to co-ordinate these needs to be organised and managed across boundaries in a unifying, semantically developed structure which is in itself complex. This line of argument leads to **H9**

3.9 Summary of this chapter

This chapter surveyed the literature from the perspective of business processes in order to develop an understanding of business processes in terms of their definitions, classifications, approaches to modelling, and their design, architecture and measurement. It then reviewed literature from the point of view of the management of business processes in terms of process maturity, agility, change and product management. This was followed by a review of how complexity relates to business processes. This was then followed by a review of literature relevant to business knowledge and its management from the perspective of business processes and complexity. It then examined the relationship between complexity, knowledge intensity and knowledge management and ended with an assessment of the impact of the review on this research. The survey of the literature supports the following conclusions:

Business processes are critical to business success and managing these is vitally important to organisations. The concept of the business process has been elaborated over several "waves" tending towards a lifecycle view and that technology is becoming a key element.

There are several definitions of business process and they tend towards the ontology of goal-oriented "ensemble of co-ordinated activities", "sequences of events", "software program like system", or "interdependent constituents that construct the enterprise". There are also varied ways in which business processes can be classified.

Analysis and modelling of business processes is of great importance. While there are many and varied techniques, there are reservations, particularly with respect to the ability to address dynamism, and the human dimension. There is an increasing drive towards process standards and recognition of the impact of complexity on the understandability of models. There are ways to measure complexity of business process when an appropriate model is provided.

Business process management (BPM) is a loosely defined but holistic way of managing the business processes in an organisation. Business processes can contribute to agility and "lean" and "agile" are two approaches that are increasingly discussed in the context of improving agility of complex processes. Improving business process maturity leads to increased business performance and there exist several approaches and frameworks to evaluate the process maturity.

The ability to manage change successfully needs to be a core competence for organizations. In the age of innovation, it may no longer be appropriate to use the change model of "unfreezing, transition, and refreezing" as the organisation may be more appropriately thought of as being in a constant state of disequilibrium.

Knowledge is distinguished from data and information, and is that which we come to believe and value based upon organised accumulation of information through experience, communication or inference. The type of knowledge may be declarative, procedural or causal, the form tacit or explicit, and range from general to specific. As organizations become more global and/or virtual, a unifying semantically developed and contextualised structure to represent knowledge becomes increasingly imperative.

Knowledge management is defined in many ways but usually includes the following: the set of business policies and actions; undertaken for the purpose of the creation of knowledge, its transfer to all firm members and its subsequent application; with a view to achieving benefit and competitive advantage. Knowledge management thrives in positive organizational contexts and fails when the infrastructure establishing positive contexts is absent.

Knowledge-intensive firms can be viewed as organizations that use mainly the knowledge of their individuals to develop and trade immaterial responses to customer requirements. These have become more prevalent and more important as the business services sector has grown.

KIBPs are processes that require very specific process knowledge, and typically expert involvement, that are hard to predict and vary in almost every instance of the process. The three types of process knowledge are process template knowledge, process instance knowledge, and process-related knowledge.

Knowledge intensity and complexity are related, although they may be separate dimensions.

The capability of BPM in managing KIBPs is now being questioned. Information-centric modelling has become an area of growing interest as opposed to activity-centric modelling. The literature proposes several different KM process taxonomies, but four key processes (knowledge acquisition, creation, sharing, and transfer) are interconnected in a complex way.

There is progress towards an architecture for integrating knowledge management systems (KMSs) and business process management systems (BPMSs) to combine the advantages of the two paradigms and support the three types of process knowledge while satisfying the lifecycle requirements of both knowledge and business processes. Misalignment between IT systems and processes, and/or between IT systems/processes and users' needs, appear as an important technological barrier to knowledge sharing.

The next chapter proposes a series of hypothesis based upon the literature review, argues for the need for specific capabilities to reduce the challenge involved in managing cKIBP's, and discusses the implications with respect to the research methodology.

Chapter 4: Towards a Theoretical Framework

4.1 Introduction

The last two chapters reviewed relevant literature as a preparatory step to create a theoretical framework in order to inform the research and design an appropriate research methodology.

There is clearly considerable literature that discusses complexity, complex systems, the (largely metaphorical) use of complexity theories in organisation, ways of measuring complexity, complex knowledge intensive business processes and knowledge management. However the literature does not seem to directly address the research questions in terms of complexity as it relates to the management of business processes. Also it does not meet the researcher objectives with respect to knowledge intensive business processes: (**O1**) to understand the nature of complexity as it relates to business processes in order to explain why the current paradigm does not always seem to work; and (**O2**) to provide practicing managers with a pragmatic way of recognising complexity and managing complex business processes.

This chapter develops a theoretical framework and perspective based upon the literature reviewed earlier. Through a series of hypothesis, this chapter argues for the need for specific capabilities to reduce the challenge involved in managing complex KIBP's (as described in Table 1: Regular v/s Knowledge Intensive Business Processes). These capabilities include an **Approach**[q] to recognising and addressing complex business processes, and a framework that can allow the integration and management of complex knowledge contexts and that agility is a critical success factor in any such framework. Finally it discusses the implications with respect to the research methodology.

These hypotheses are further discussed in the following section.

[q] To avoid confusion, the researcher has labelled the approach to managing process complexity as the **Approach**. Borrowing a convention from contract law, the specific Approach is distinguished from any more general uses of that term by the use of initial capital letter

4.2 Hypothesis

In making sense of the review of literature and in order to addressing the research questions, a useful framing device is a set of hypotheses[r] which can then be tested. These are discussed in this section.

In order to address **Q1.a:** *What does business process complexity mean*, on the basis of the literature review it could be argued that **H1**: *"Complexity" is hard to define in a way that is acceptable to all perspectives and is largely used as a metaphor, which makes it at best a partial description and difficult for traditional management to adopt*. Being hard to define is noted by several researchers (Casti, 2003; Gershenson & Heylighen, 2005; Whitt & Maylor, 2008). Most business processes are cross-functional (Davenport & Short, 1990) and multi-disciplinary, (Smith & Fingar, 2003) and therefore admit incommensurable perspectives (Richardson K. A., 2005). Its use as a metaphor (Lissack, 1999; Stacey R. D., 2001; Burnes, 2005), that supports only partial descriptions (Richardson K. A., 2005; Cilliers P. , 2005) is noted by several researchers as well. Axley & McMahon (2006) critique the mechanistic grounding of traditional management and point out that the mechanistic model, long the dominant perspective on organizing in the industrialized world, seems to have reached its limits of efficacy.

While the literature supports the view that managing complex business processes is difficult (Lissack, 1999), is this really a general and growing problem? In other words is **Q1:** *How can organisations manage the complexity of their knowledge intensive business processes (KIBP's)* - worth researching?

Moore (1996, p. 26) defines "business ecosystem" as: "An economic community supported by a foundation of interacting organizations and individuals—the organisms of the business world. The economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organisms also include suppliers, lead producers, competitors, and other stakeholders." Particularly in the age of the internet, knowledge is relatively

[r] These are to be construed as 'working' hypotheses – statements of expectations to be used as a conceptual framework to guide further investigation (Shields & Tajalli, 2006), in the hope that a tenable theory will be produced even if the hypotheses themselves ultimately fail.

easy to access, disseminate and harvest and knowledge intensive businesses are particularly adept at those skills. Knowledge is an unusual resource in that sharing knowledge does not reduce its immediate value to the sharer. Consequently the knowledge ecosystem in any particular field is a network of actors sharing knowledge implicitly or explicitly, and as the number and kind of relationships grows so does the complexity of the ecosystem. This is particularly evident in the financial ecosystem with a bewildering number of businesses, products and services configured in complex and dynamic value chains. Thus it is possible to argue that such business ecosystems grow ever more complex.

As the complexity literature points out, complexity arises out of the dynamic relationships (Cilliers P. , 2005). From the perspective of organisations as complex systems, the complexity of the business ecosystem is at the same time an opportunity and a threat, an opportunity because it provides way of differentiating, reducing costs and adding value, and a threat because exploiting opportunities usually requires the organisation to reconfigure internal processes (Cohen M. , 1999) which is often risky and expensive, while standing still usually means losing out to more agile competition.

As regards the member organisations in the business ecosystem, Moore (1996, p. 26) contends that: "Over time, they coevolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies. Those companies holding leadership roles may change over time, but the function of ecosystem leader is valued by the community because it enables members to move toward shared visions to align their investments, and to find mutually supportive roles." Therefore adaptation is both a growth and a survival strategy as organisations strive to attain positions of leadership. This involves new ways to use knowledge and the consequent implicit or explicit engagement of the business into new value chains. Thus it can be argued that knowledge intensive businesses tend to engage in ever more complex ecosystems. However, as organisations engage in more complex ecosystems, their own complexity is affected as a result (Galbraith, 1982). Therefore if one takes the perspective of organisation as a complex system then its own complexity must increase in line with the ecosystem complexity.

The work in the organisation is carried out in the context of business processes (Davenport & Short, 1990; Hammer & Champy, 1993; Harmon, 2010). Consequently the business processes must in turn grow more complex (Axelrod & Cohen, 2000). This can arise out of several factors: the need to interact with the more parts of the ecosystem at more points in the business processes; the need to satisfy multiple and sometimes conflicting requirements; the need to support larger volumes and greater variety; the need to improve efficiency and reduce risk; and the need to adapt quickly as the ecosystem around the organisation changes. Thus it can be argued that (**H2**) *Engaging in complex ecosystems implicitly or explicitly impacts the complexity of the business processes of knowledge intensive organisations and creates significant challenges for them.*

As regards **Q1.b: W***hat does it mean to manage business process complexity* - several authors note that complexity creates challenges in managing business processes from the point of view of control, and results (Lissack, 1999), strategic direction (Anderson, 1999; Mason, 2007), leadership (Uhl-Bien, Marion, & McKelvey, 2007) and decision making (Klijn, 2007). Therefore, as this research is focusses on KIBP's, it can be argued that (**H3)** *Management of cKIBP's will get increasingly more challenging as the rate of evolution, proliferation and integration of the processes being managed keeps increasing.*

The literature also suggests that there have been several approaches to modelling, designing and managing business processes. Given that a number of methodologies exist that deal with process improvement, why is complexity of business processes a problem at all? In other words is objective **O1:** T*o understand the nature of complexity as it relates to cKIBP's in order to explain why the current paradigm for managing such processes does not always seem to work* - worth pursuing?

The review of literature has already covered aspects of complex dynamic systems and the perspective of organisations as complex dynamic systems. The business process literature is replete with attempts to define business processes and Lindsay et al (2003) chronicle some of these. In order to develop a conceptual framework with which to understand business processes more fully, Melao and Pidd (2000) use metaphors to specifically describe business processes and give four perspectives: (1) Business processes as deterministic machines; (2) Business processes as complex dynamic systems; (3) Business processes as interacting feedback loops; (4) Business processes as social constructs. Of specific interest to this thesis are perspectives (2) and (3), which deal with a process's interaction with its environment and ways to capture the variable or unpredictable nature of these interactions. Therefore the concepts of complex dynamic systems may also be applied to business processes and their management and business processes can be thought of as complex dynamic systems.

However, as Lindsay et al (2003) point out, models are simplifications in order to bring clarity and understanding to some aspect of a problem where there is complexity, uncertainty or change of assumptions. The problem in reality is complex and more variability exists than can be modelled.

Systems theory treats a system as a set of elements and their relationships that exist inside an arbitrary boundary (Boulding, 1956; Bertalanffy, 1968). As seen in the literature on complex systems the existence of interactions and dependencies is an attribute of complex dynamic systems (Capra, 1996). Relationships are a very useful concept in discussing complexity as they are a generalisation of the notion of dependency. Relationships can capture not just the fact that a dependency exists but the direction (or lack thereof) of dependency as well. Relationships can also be used to model flows within processes, internal or external influences and constraints, structural and causal linkages and so on. Relationships themselves can be dynamic and that dynamism further influences and influenced by the relevant elements.

An important observation is that dynamism in any kind of relationship can trigger complexity (Senge, 1990). In the case of processes this is not restricted to the flows between activities but can include the association of resources, constraints, linkages to knowledge contexts, structural linkages within the knowledge contexts and so on (see also 2.5 - **L1.3**, **L3.3, L4.2,** and **L4.6**). Crucially, it is the dynamism in the behaviour of the elements and the influence of such dynamic behaviour through the relationships that causes complexity.

In the current paradigm, most approaches to process improvement assume a deterministic model of a business process, which becomes the basis for creating an improved model, which is still deterministic. Such approaches take a mechanistic view of business processes. As Lindsay et al (2003) point out, however, underlying the mechanistic view of process are also a number of assumptions, such as perfect knowledge of the human actors involved, that humans work in a rational and logical way, and that problems have a solution. Since these assumptions are not sustainable, the mechanistic view of business process ignores such complexity factors and is thus insufficient in addressing complexity of business processes.

Indeed, Meloa & Pidd's (2000) conceptualizations of process can be construed as efforts to deal with some of their other aspects that restrict the effectiveness of current modelling techniques, and recognize that whilst the mechanistic/deterministic view of process gives a rich opportunity to model its tangible aspects, failure to appreciate the limitations of these models can be dangerous. Therefore complexity of business processes creates a problem that merely applying current approaches cannot solve.

Consequently it can be argued that (**H4)** (1) *an ensemble of business processes can be regarded as a complex system, but (2) the mechanistic view of business processes does not sufficiently capture the complexity since it obscures the role of relationships which are crucial to determining the complexity of a system*.

Entanglement is a useful concept in discussing complexity of processes from the perspective of complex adaptive systems. For the purpose of addressing **Q1** and **Q1.a** of this research, researcher defines entanglement as a dynamic intertwining relationship between two or more business process elements (process steps or activities). Gell-Mann (1995/96) notes that entanglement is a key feature of the way complexity arises out of simplicity. Entanglement goes beyond the concept of a relationship in that it requires the business process elements to both interact and be interdependent. While interaction refers to the movement and dynamic interplay of information, interdependency drives action. The interdependency arises out of networks of conflicting constraints which come to light when the information provided by one process element is incompatible with that requested by another. Such constraints drive agents and processes to adjust their actions and to elaborate their information.

An ensemble of business processes can be considered to be complex adaptive systems that display such interactions and interdependencies. It is the resulting dynamism and indeterminacy that drives complexity. Therefore, complexity can be argued to arise because of entanglements between processes, and by extension, the more the entanglements the greater the complexity. While the notion of entanglement was originally used to describe interaction in quantum theory it has been used to study complexity of finite directed graphs, which is often the way business processes are modelled. Baader & Voronkov (2005) propose entanglement as a new measure for the complexity of finite directed graphs which measures to what extent the cycles of the graph are intertwined. Berwanger et al. (2012) study complexity issues for entanglement and compare it to other structural parameters of directed graphs. They also study graphs of entanglement which allow arbitrary nesting of cycles, and form a sufficiently rich class for modelling relevant classes of structured systems.

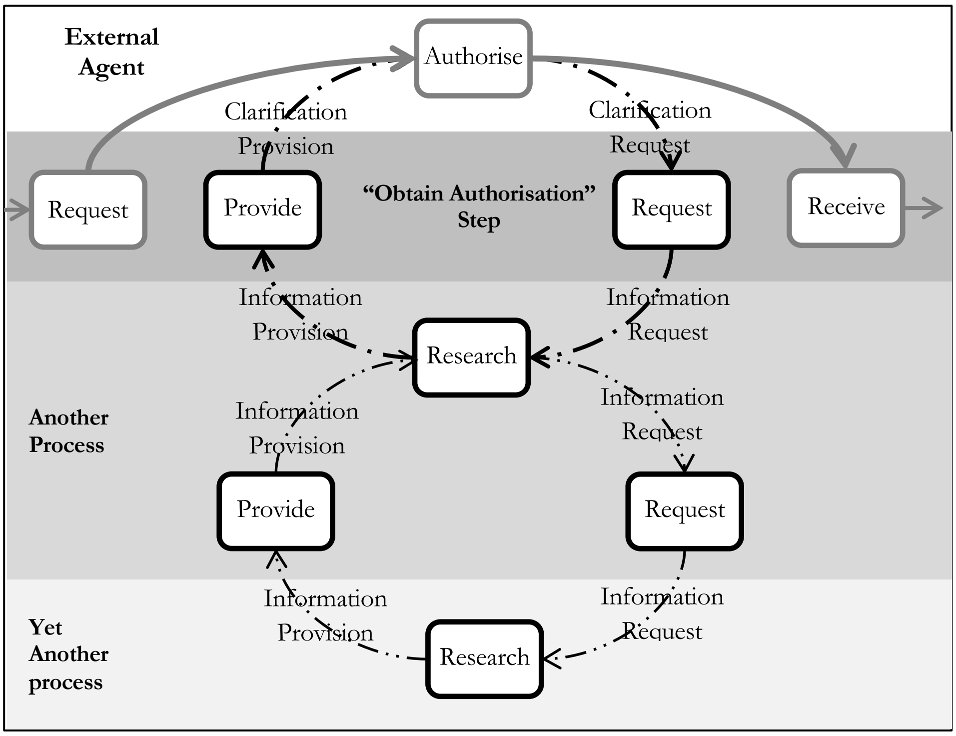


Figure 3: Illustrating Knowledge Entanglement

Figure 3 depicts an example of a common process step "Obtain Authorisation". This is usually modelled as a simple set of "Request" -> "Authorise" -> "Receive" activities as shown in grey outlines in the figure. However as the figure illustrates, this simple step can lead to a dynamic cascade of activities in other entangled processes. As noted earlier it is this dynamism and indeterminacy that drives complexity. It follows therefore that addressing complexity requires reduction or removal of such entanglements. If such entanglement problems are left unmanaged then, over time, and due to the adjustments they are driven into making, the processes involved would tend to degrade either in terms of their performance or their transparency. Thus it can be argued that **(H5)**: (1) *Complexity arises because of entanglements between processes and (2) addressing complexity requires reduction or removal of such entanglements*.

While such entanglements may have many causes such as resource conflicts and synchronisation requirements, this research is primarily concerned with entanglements due to knowledge sharing. McKelvey (2003) discusses a similar concept of entanglement in explaining order in firms. With the perspective of organisations as complex adaptive systems, Uhl-Bien et al (2007) propose a leadership framework that envisions three leadership functions, adaptive, administrative, and enabling. In their framework enabling leadership works to catalyse the conditions in which adaptive leadership can thrive and to manage the entanglement between the bureaucratic (administrative leadership) and emergent (adaptive leadership) functions of the organization. Managing entanglement involves two roles: (1) creating appropriate organizational conditions (or enabling conditions) to foster effective adaptive leadership in places where innovation and adaptability are needed, and (2) facilitating the flow of knowledge and creativity from adaptive structures into administrative structures.

In discussing **H1** it has been noted that managing complex business processes is difficult (Lissack, 1999). The researcher defines the ***management challenge*** as the degree of difficulty in sustaining the process operation within defined parameters in the context of defined constraints, while meeting defined process goals. Now with regard to **Q1.b**, from a pragmatic point of view together with a view of the process from the perspective of "complexity as difficulty" (Moldoveanu, 2005), it can be argued that the management challenge correlates with the complexity of the business processes.

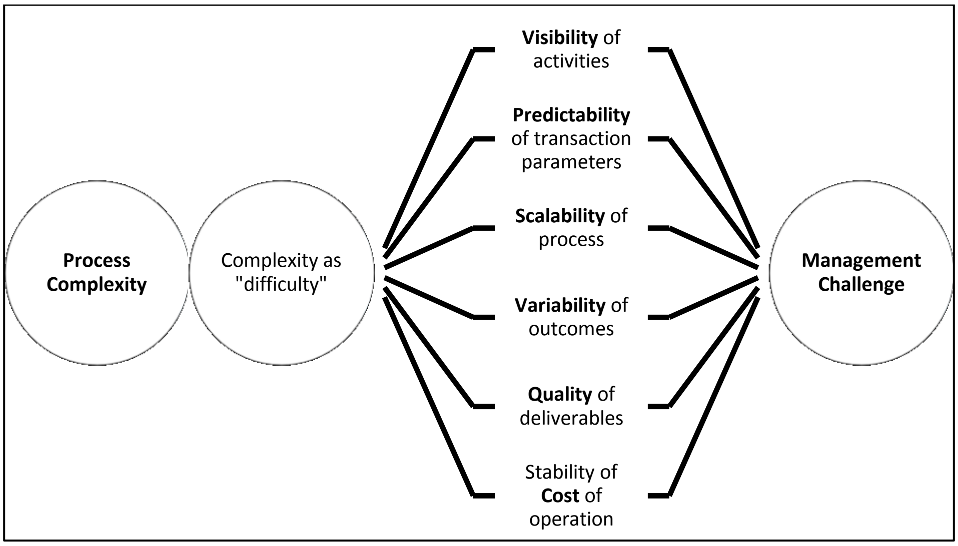


Figure 4: Process Complexity leads to Management Challenge

Figure 4, illustrates this argument. On the assumption that the process is functionally complete, it also identifies relevant attributes[s] of the process (visibility of activities, predictability of transaction parameters, scalability of process, variability of outcomes, quality of deliverables and the stability of cost of operation) that make it difficult to manage.

Table 9: Classifying business processes

		Dynamic Complexity		
		Low	**High**	
			Apparent	**Inherent**
Detail Complexity	**High**	Complicated Processes	**Complex Processes**	Chaotic Processes
	Low	Simple Processes		

Then with regard to **Q1**, it can be argued that management challenge can be reduced by transforming complex to complicated processes. In order to understand why this is so, and thus help address **Q1.a**, the researcher first

[s] These attributes were selected based upon existing approaches, and discussions with practitioners of process improvement, with the objective of choosing a minimum number of attributes that would reflect management difficulty and also be readily understandable. There are of course other ways of defining attributes from different points of view. For example, from the IS viewpoint, see (Guceglioglu & Demirors, 2005)

proposes a way of classifying business processes so that complex processes can be pragmatically identified. The proposal is built upon the distinction between detail and dynamic complexity (Chia, 1998; Sterman, 2000; Senge, 1990), as well as the concepts of apparent (see 2.5, **L1.1**, **L1.2**, **L1.4**) and inherent complexity (Evans & Marciniak, 1987; IEEE, 1990). The classification is depicted in Table 9, and then discussed further.

Simple processes exhibit low detail complexity (they have relatively few activities, information flows and dependencies, and low dynamism; they remain stable in terms of process and information structure over time, which makes them both repeatable and reproducible (Reynolds, 2011). In Moldoveanu's (2005) model these would be tractable and informationally shallow. Consequently, managing them focusses on execution rather than orchestration, and can therefore be well supported by automation, knowledge management and communication technologies. For simple processes therefore, management challenge is trivial.

Complicated processes on the other hand exhibit much greater detail complexity. They have significantly greater number of activities, dependencies and information flows, which makes them significantly more difficult to orchestrate since resource conflicts and synchronisation issues come to the forefront. However they still remain stable in terms of process and information structure over time, so they are also both repeatable and reproducible (Reynolds, 2011). From the perspective of Marjanovic and Freeze (2011) these are procedural processes. In Moldoveanu's (2005) model these would be less tractable and likely to be informationally deeper. Consequently managing them focusses on orchestration (Smith & Fingar, 2003) as well as execution and poses a significantly greater management challenge. However technologies which enable orchestration in addition to automation and communication can be used to support such processes. Therefore the challenge is one of scale and co-ordination, and can be addressed with appropriate technologies and sufficient management resources.

Chaotic processes exhibit a high degree of inherent dynamism that is an intrinsic property of the process itself, and not due to its design or implementation. They are therefore neither repeatable nor reproducible. Chaotic processes resist management as they are impossible to control in a meaningful way. All that management can hope for is to monitor and influence such processes towards a goal. But there can be no certainty as to when (or even if) such processes would converge to a goal or how they will do so. In Moldoveanu's (2005) model these would be "impossible" and informationally very deep. Chaotic processes defy stability, so it does not make sense to speak of defined parameters or constraints. Therefore the definition of management challenge cannot be applied to chaotic processes.

Complex processes exhibit a high degree of apparent dynamism and high or low detail complexity. However that dynamism is not an intrinsic property of the process itself, rather it is attributable to its design or implementation. Complex processes do not contain any chaotic elements, but they do contain knowledge entangled elements. They are therefore reproducible but not repeatable (Reynolds, 2011) as the dynamism implies a change in the context of the process over time. From the perspective of Marjanovic and Freeze (2011) these are complex processes as well. In Moldoveanu's (2005) model these would be intractable and informationally very deep. As noted earlier the management challenge is significant for complex processes, as entanglements cause the process structures and behaviours to change. And of course, as argued in **H5**, as entanglements increase, so does the complexity[t] and consequently the management challenge. Managers would naturally prefer processes to be simple. However significant business processes are rarely simple and part of the value addition that an organisation provides is its ability to manage processes that are not simple. Therefore managers are forced to confront complicated and complex processes. There is considerable support for analysing, simplifying, modelling and automating complicated business processes through conventional approaches such as BPM, Lean, Six Sigma, Agile and Theory of Constraints, as well as technologies like Business Process Management Systems, ERP systems and the like. But as discussed in **H4**, these conventional approaches assume a deterministic model of the business process and are thus insufficient in

[t] Using understandability as a proxy for quality of process models, Alonso et al. (2007) find the number of arcs in models has an important influence on understandability.

addressing complex business processes, and there is little comparable support for managing complex business processes.

Thus taken together the foregoing arguments lead to the hypothesis that (**H6)** (1) *the level of entanglement correlates with the management challenge in managing the process, and, (2) while effective in addressing complicated processes, conventional approaches are less effective in addressing complex processes with entanglements due to knowledge sharing.*

A consequence of **H6** is that, one indicator of knowledge entanglements is the ineffectiveness of conventional approaches in resolving the problems. However, should those knowledge entanglements be reduced or eliminated from the implicated process ensemble, the process as a whole would then be classed as complicated, rather than complex. As discussed in H6, conventional approaches would once again become effective on this redesigned complicated process. Thus it is possible to argue that (**H7)**: (1) *Once knowledge entanglements are reduced or removed, conventional approaches once again become effective on the reorganised process ensemble, and therefore, (2) one indicator of knowledge entanglements is the ineffectiveness of conventional approaches in resolving the problems.*

Therefore, provided it was possible, one approach to addressing complexity would be to transform the business process from being complex to being complicated. Consequently, managing the complexity of the process must focus on managing the entangling knowledge context.

Processes need to access information to execute, and the totality of the information required for a specific instance of the process to execute is its knowledge context (KC). Processes and activities interact through information sharing. But there is considerable variety in the type of information shared as well as the way the information is shared. The researcher defines the entangling knowledge context as consisting of all the information requested by the requesting process from the providing process. If the entangling knowledge context is simple, well-structured and stable then transformation from complex to complicated processes is easier and most business process management methodologies and technologies provide support for such a requirement. However if the entangling knowledge context is itself complex, due to the instability of its structure, content and composition, then the challenge is much greater (Raghu & Vinze, 2007). The complexity of the entangling knowledge context also needs to be managed in addition to that of the entangled business processes.

At one extreme is the case of control flow between activities or processes, where the information communicated is usually a simple well-structured signal or notification and no further information is needed to execute the notified process. So long as the private knowledge contexts of the processes involved are completely independent, the sole entangling knowledge context is the notification itself. Entanglements of this nature rarely cause problems, other than the case where a notification is delayed or never arrives. This can be handled by means of a timeout arrangement that triggers a reminder or proceeds on the basis of default assumptions or both.

In between is the case where the entangled processes need to share sufficient structured information that can accompany the notification. The notified process can then unambiguously act on that information. Most case based workflow techniques use this mechanism where the shared knowledge context consists of an appropriate package of documents, electronic or otherwise accompanies the notification (Nigam & Caswell, 2003; Nandi & Kumaran, 2005). Again, such entanglements are not difficult to manage provided the completeness, consistency and unambiguity of the package can be assured. Most current BPM technologies support and encourage such solutions.

At the other extreme is the case where the union of the entangled knowledge contexts of the ensemble of entangled processes is an overwhelming proportion of their private knowledge contexts. In such cases it makes sense to speak of a single integrated knowledge context that the ensemble of processes shares. When processes operate on integrated knowledge contexts with stable structures, the integrated knowledge context degenerates to a case (albeit a large one), in an information centric process (Bhattacharya, et al., 2005; Bhattacharya, Gerede, Hull, Liu, & Su, 2007; Bhattacharya, Caswell, Kumaran, Nigam, & Wu, 2007; Liu, Bhattacharya, & Wu, 2007), and the communication mechanism usually involves a reference to a shared repository containing the case rather than a copy of the case itself.

It is possible that individual processes asynchronously modify the content of the shared knowledge context in which case such an integrated knowledge context is deemed to be dynamic and therefore complex (**CKC**). If the individual processes can additionally modify the structure of the shared knowledge context then the complex knowledge context is deemed to be agile in the sense of being "flexible" (Putnik & Putnik, 2012). Thus an information centric approach to process modelling (Bhattacharya, et al., 2005), sharing an agile knowledge context (**aKC**) rather than merely a large case, would transform the entanglements between individual processes in the ensemble to information sharing between the individual processes and the aKC. In Moldoveanu's (2005) model this would be equivalent to making the process more tractable at the cost of making it informationally deeper. From the foregoing arguments it is possible to hypothesise that (**H8)**: (1) *Knowledge sharing entanglements arise when the information flow contains entangling complex knowledge contexts, and (2) can be resolved by reorganising the process ensemble to contribute and consume from a set of integrated knowledge contexts.*

If only two processes or activities share a dynamic or agile knowledge context one strategy to manage entanglement problems is to treat the two processes as a single process. However if more processes are involved, then the management challenge is essentially one of managing the complexity of the knowledge context (see 2.5 – **L4.14-L4.16**, **L5.1, L5.2, L5.4, L5.6** and **L5.7**). If an agile knowledge context is modelled as a network of connected knowledge fragments, similar to information entities as discussed by Kumaran et al. (2008), it could be considered a complex adaptive system since it fulfils many of the attributes such as the number and variety of its information fragments, the number and variety of the relationships between the information fragments, the behaviour of processes driven by its semantics and the dynamism inherent in both, the discovery of relevant information fragments and the modification of the network as a result of process execution. Therefore an agile knowledge context is more complex to manage since it involves dynamic structures, relationships and content of fragments, and like any other complex system would require a framework to define and organise the information fragments in a process neutral way, a process to assure the consistency of the agile knowledge context and a toolset to support knowledge management processes associated with the agile knowledge context (Chang & Li, 2007; Sun, 2010; Allameh, Zare, & Davoodi, 2011; Pinho, Rego, & Cunha, 2012). This argument leads to the hypothesis (**H9)**: *While knowledge sharing entanglements can be addressed through a shared knowledge context, creating and managing a complex shared agile knowledge context requires an information framework, processes and tools*. The argument in the series of hypothesis is summarised, and the links to the relevant research questions, research objectives, and literature review sections are identified in Table 10.

Table 10: Hypothesis and related research elements

Hypothesis	Relevance
H1: "Complexity" is hard to define in a way that is acceptable to all perspectives and is largely used as a metaphor, which makes it at best a partial description and difficult for traditional management to adopt	**Q1.a, Q1.b, O2, L1, L3**
H2: Engaging in complex ecosystems implicitly or explicitly impacts the complexity of the business processes of knowledge intensive organisations and creates significant challenges for them	**Q1, L3, L4.13**
H3: Management of cKIBP's will get increasingly more challenging as the rate of evolution, proliferation and integration of the processes being managed keeps increasing	**Q1.b, O2, L3, L4.1, L4.3, L4.5**
H4: (1) An ensemble of business processes can be regarded as a complex system, but (2) the mechanistic view of business processes does not sufficiently capture the complexity since it obscures the role of relationships	**L1.3**, **L2, L3.3, L4.2,** and **L4.6**
H5: (1) Complexity arises because of entanglements between processes and (2) addressing complexity requires reduction or removal of such entanglements	**Q1.b, O2, L1, L3, L4.10, L4.11**
H6: (1) The level of entanglement correlates with the management challenge in managing the process, and, (2) while effective in addressing complicated processes, conventional approaches are less effective in addressing complex processes with knowledge entanglements	**O1, L4.10, L4.11**
H7: (1) Once knowledge entanglements are reduced or removed, conventional approaches once again become effective on the reorganised process ensemble, and therefore, (2) one indicator of knowledge entanglements is the ineffectiveness of conventional approaches in resolving the problems	**O1, O2, L4.17, L4.18, L4.19**
H8: (1) Knowledge sharing entanglements arise when the information flow contains entangled complex knowledge contexts, and (2) can be resolved by reorganising the process ensemble to contribute and consume from a set of integrated knowledge contexts	**Q1.b, O2, L4.8, L4.9, L5.3, L5.5**
H9: While knowledge sharing entanglements can be addressed through a shared knowledge context, creating and managing a complex shared agile knowledge context requires an information framework, processes and tools	**Q1.b, O2, L4.14, L4.15, L4.16, L5.1, L5.2, L5.4, L5.6, L5.7**

4.3 Perspective on Complexity

Researchers have approached complexity from several perspectives, and identified many of its characteristics (as discussed in 2.2.1). This research adopts a perspective on complexity as a phenomenon characterised by some degree of:

a) failure of the Newtonian paradigm in modelling the process,

b) incommensurability and incompressibility of its definition,

c) presence of both distinction (variety of elements) and connection (dependency between elements), and

d) symmetry breaking under scale transformations.

All of these influence the development of the hypotheses and appear in some form and degree in each of the complex processes the research investigates

This research approaches complexity from a critical pluralist perspective as discussed in 2.4.3. It selects and synthesises from a set of models that are more appropriate in addressing business process complexity, rather than privileging a specific models above all others. This is evidenced in the development of hypothesis H6.

Taking the foregoing hypothesis into account leads to further development of the research perspective on complexity as it relates to complex knowledge intensive business processes.

- Complexity is an inevitable and increasingly challenging consequence for organisations engaging in complex ecosystems, and makes process modelling challenging in line with the characteristics (a) and (b) identified above. This is implied by H1 – H3.

- Complex processes are complex systems where the complexity and consequently the management challenge arises because of entanglements (in line with characteristic (c) and (d) above), which need to be reduced or removed to address the complexity. An indicator of complexity is the failure of conventional approaches in resolving the problems. This is implied by H4 – H7.

- Complexity that arises as a result of entangled complex knowledge contexts can be addressed through the creation of an integrated shared knowledge context, which processes contribute to or consume from, but doing so creates a different management challenge. This is implied by H8 – H9. This is in line with neo-reductionist thinking in that, conceptually, the complex business process is reformulated in terms of simpler underlying processes of contribution and consumption of knowledge.

Given this perspective, in order to address cKIBP's, an organisation could adopt a strategy of transforming processes in the entangled process ensemble from being complex to being complicated by creating an aKC that is contributed to, and consumed from, by the entangled process ensemble. However, in order to execute such a strategy, the organisation would need to have or develop certain capabilities. In the first place it would need to formulate (**C1**) an approach to operationalize such a strategy. In the second place it would need (**C2**) an instrument to assess the management challenge before and after the intervention, to ensure that the intervention actually succeeded. And finally, it would need (**C3**) an information framework, process and tools in order to manage the resulting agile knowledge context as discussed in **H9**.

4.3.1 Formulating an Approach

A key assumption being made in the research is that in managing complex processes, the competence of the managers is not in question. The implication is that competent managers would already have attempted to reduce the management challenge of managing a complex process using conventional approaches and failed to do so. This would have involved eliminating other entanglements, so that the complexity can be deemed to exist because of knowledge entanglements. Therefore, the alternate **Approach** proposed is based upon a strategy of reducing knowledge entanglements. As discussed earlier this is possible by means of creating a shared agile knowledge context.

However in doing so, there arises another management challenge of managing the shared knowledge context itself. Therefore the success of the approach must be judged not just upon its ability to reduce the challenge of managing the complex business process, but reducing the total management challenge involved in managing both, the complex business process and the shared knowledge context management process as well.

The **Approach**, (which would be classified as a pattern in Falconer's (2005) framework), consists of the following steps

1. **Identify the complex business process**. This involves an understanding what makes the business process complex (**H1**) and verifying that it cannot be addressed by more conventional means. This first step also determines the scope of the business process.

2. **Identify the process ensemble associated with the complex process**. On the basis of **H4 (1)**, this step includes the identification and analysis of the individual processes within the scope of the earlier identified complex business processes. Such processes may consist of steps or individual activities, the composition determined by the grouping those activities within the process that need entangled knowledge contexts.

3. **Identify entangled knowledge contexts**. On the basis of **H5 (1)**, this step includes the definition of the entangled knowledge contexts as well as the cause of the entanglement. As discussed earlier, mere delivery of complex information, for example, the delivery of a detailed report does not in itself constitute entanglement, if there is no direct or indirect reciprocal dependency between the processes involved.

4. **Create a shared agile knowledge context**. On the basis of **H8 (2)**, such a shared knowledge context can be created by aggregating all the entangled knowledge contexts, identifying the information fragments involved and their relationships through a process similar to normalisation (Codd, 1982) and then redefining each entangled knowledge context as a subset of the shared agile knowledge context.

5. **Reorganise process ensemble to engage with the shared agile knowledge context**. The previous step results in the situation where the shared agile knowledge context becomes in effect a "broker" between the previously entangled processes. This allows reorganising the process around the shared agile knowledge context acting as a hub, reducing the dependencies between individual processes, in effect addressing **H8 (2)**.

6. **Manage the shared agile knowledge context within the reorganised process ensemble**. A shared agile knowledge context with the capabilities discussed earlier is in itself an informationally deep and dynamic structure that is a point of failure within the reorganised process ensemble, and on the basis of **H9** would require specific management attention.

If valid and appropriately applied, then the **Approach** should result in a reduction in knowledge entanglements, thus reducing management difficulty (addressing **Q1** and **O2**), while supporting agility (see 2.5, **L2.6**) through the shared aKC.

4.3.2 Assessing the Management Challenge

If the objective of addressing cKIBP's is to reduce the management challenge as discussed in **H6 (1)**, an **instrument for assessing the management challenge** would need to take the "Complexity as difficulty" perspective (Moldoveanu, 2005) and be able to detect differences pre and post intervention. It would require (1) a way to identify how much the current model represented reality and whether the gap was due to ignoring complexity, (2) a way to identify the process could cope with the impact of change in terms of management challenge, and (3) a way to reflect not just management challenge measures for the process but measures of its agility and knowledge management complexity as well.

While assessing the process complexity directly could be interesting, there are several reasons why this is not practical. (a) Current process models may not map well with reality, which in itself is a sign of complexity, (b) most conventional modelling approaches models abstract out entangling knowledge contexts and their complexity, (c) complicated processes may score higher on traditional measures like cyclomatic complexity than complex processes (d) the models would reflect apparent complexity which may not correspond with the inherent complexity (see 2.5, **L1.1**, **L1.2**, **L1.4**) (e) organisations may not want to invest in determining a (theoretical) model of inherent complexity, (f) creating a viable complexity measure would in itself be a challenging task (Cardoso J. , 2005), beyond the scope of this research, and finally (g) determining the degree of complexity of the process adds no particular value in the approach to reducing its management challenge. In addition such an approach would not result in an instrument which also integrated the three requirements identified above.

The alternative then is to develop an instrument to assess the management challenge from the perspective of the relevant stakeholders in the process, using attributes identified in Figure 4. While subjective, in the researcher's view, this would be much simpler to develop and understand, and would more reliably reflect the apparent complexity of the process from multiple perspectives, while integrating the requirements identified above (see 2.5, **L2.3**, **L3.9**). This would also provide the opportunity to test and extend the instrument through the course of the field research. This instrument can then be applied pre and post intervention, and with respect to each attribute, a positive change in assessment would reflect the assessor's view that management challenge has indeed been reduced.

4.3.3 Framework, Process and Tools

As noted earlier, the management of agile knowledge contexts requires three elements to be in place.

Firstly it requires a framework to define complex knowledge contexts across problem spaces in an organisation. This is challenging because as Raghu & Vinze (2007) point out, while storage and retrieval in data management systems mirror one another, this is not necessarily the case when retrieval activities are performed in a knowledge context, and this challenge in KM system usage stems from the nature of knowledge itself, which could be construed as a set of related accumulated information fragments (Zack, 1999).

Secondly, while processes in the reorganised process ensemble would emphasize contextual and interactive decision making and knowledge reuse (Raghu & Vinze, 2007) the effectiveness of aKC's and efficiency of the process ensemble represent contradictory goals (Raghu & Vinze, 2007) This implies the need for a process to manage agile knowledge contexts uniformly across business processes.

Thirdly, while knowledge sharing addresses the needs related to generation and collaborative aspects of knowledge, the knowledge artefacts used in the sharing and generative processes are inherently unstructured, and come from disparate sources causing the sharing process to be asymmetrical in orientation. (Raghu & Vinze, 2007). This makes the process of managing the knowledge context complex, which in turn makes the use of tools necessary in managing the process.

Together, these elements must provide the following key features:

Support for Agile Definition: Agility is the ability to adapt (Areta & Giachetti, 2004). In the ideal case the ensemble of entangled processes to be addressed using a knowledge context would be completely defined and the definition would remain stable through the lifetime of the knowledge context. If these assumptions were true then it would be possible to define the knowledge context completely at inception and it would not change in semantics or structure through its lifetime, only in information content. It would not need to adapt. Unfortunately these assumptions are simply not valid. Firstly, identifying entangled processes is an on-going exercise and even for well-defined processes, the scope, boundary, structure, goals and priorities are subjective and subject to change over time. This makes not just the content but the structure fluid and dynamic as well. Secondly, individuals in the organisation hold different perspectives and these often are reconciled only through the construction of the knowledge context, and not before. Thirdly, knowledge gaps are often identified through process failures after processes have been implemented for which the knowledge context must already have been in existence. Finally the nature of knowledge is one of on-going discovery as knowledge is incremental, reflexive and dynamic. Inquiry in a knowledge sharing context may not necessarily involve an end-state. When an end-state exists, it is usually in the form of a solution to an unstructured problem with no verifiable (and perhaps, single) true end-state. (Raghu & Vinze, 2007). While complexity is a feature of such knowledge contexts, agility is critical capability required for the development of the knowledge context. Consequently a framework for managing knowledge contexts must support agile definition of the knowledge context.

Support for Evolving Scope: One consequence of the **Approach** is that the identification of the processes in the ensemble is itself dynamic as process entanglements are often discovered when exceptions occur in the current process ensemble. The newly discovered entangled processes must then share the knowledge context of the current ensemble. Therefore the scope of the knowledge context must evolve to support the requirements of the new processes. Consequently the scope of the knowledge context is dynamic and expanding.

Support for Domain Specific Vocabulary: As noted in the discussion on **H1**, business processes are inter-disciplinary and cross both functional and knowledge domains. Each such domain is likely to have its own vocabulary to describe the information fragments that define the knowledge contexts. However that context must now be shared which means there are likely to be vocabulary conflicts. While a consistent vocabulary can be mandated, it is politically and practically difficult to define and implement a vocabulary that is acceptable to all. Further, it is difficult to ensure that the new vocabulary is uniformly and consistently applied on an on-going basis. Often the old vocabulary is so deeply embedded in the existing systems and practices that it simply resurfaces and overlays the modified vocabulary. Consequently the practical alternative is to support multiple vocabularies and manage the antonym and synonym issues that may arise.

Support for multi-Perspective View: The way information accessed and explored depends upon the role of the person accessing and the process in the context of which the information is accessed. Therefore the framework must support viewing the knowledge context from multiple perspectives conforming to the role and context of access.

Support for Extensibility: A key feature of information fragments is that they tend to specialisations of classes, which go beyond the domination concept (Kumaran, Liu, & Wu, 2008). For example a customer may be defined by an information fragment in sufficient detail for a process such as KYC. However, in addition to the basic KYC information, a retail banking customer information fragment will need to hold additional information to support retail banking processes as would a customer of private wealth management processes. Both these information fragments would be considered as specialisations of the generic customer class. This mechanism allows for extending the semantics and content of classes of information fragments so that common features can be shared but process specific information requirements can also be supported.

4.4 Implications for research

The requirements from thee research are then fourfold: **R1**: test the foregoing hypotheses, **R2**: develop and test the proposed **Approach** to take into account issues and limitations discovered in 1, and **R3**: test the instrument to assess the management challenge and **R4**: test the existence and need for an information framework, processes and tools. This has several implications for the research and these are discussed below.

The nature of inquiry would require empirical data to be collected in order to validate the propositions and also to validate the developed approach. Such an inquiry would also need to be participative, particularly when developing the approach. The development itself would benefit from iterative cycles of change and validation, so that results could be formatively (rather than summatively) assessed.

The choice of the organisations for research would need to be selected from those that had (a) a sufficiently level of process maturity (see 2.5, **L3.7, L4.4,**

L4.12, L4.17 and **L4.18**) to recognise the characteristics of complexity, beyond its use as a metaphor, and to be able to distinguish between complex and complicated processes, (b) an assured quality of process management and process improvement practices, and (c) a capability and track record of process improvement using conventional approaches.

The choice of the problem space and its constituent business processes would need to exhibit the characteristics of complexity such as dynamic complexity and stochastic outcomes. The problem space would need to be understood beyond the restrictions of conventional models which ignored complex systems characteristics, while still being modelled as a formal system, with multiple perspectives. The problem space would need to be focussed on KIBP's, and may need to move beyond activity centric modelling towards information centric modelling. However, the human component of the system can be seen to be constrained by the actors' roles and contractual obligations and can be seen as subsystems not requiring complex analysis. Also order in the form of solutions may emerge and evolve therefore the research process would need to be iterative and evolving. The research would need to address apparent rather than inherent complexity as the latter could be masked by design, implementation and documentation difficulties and therefore difficult to ascertain. Also, in addition to core cKIBP's it would add to the generalizability of the results to include cKIBP's in problem spaces like product development, the project environment and knowledge management.

The essential elements of the problem and solution would have to include how a change in complexity could be accomplished. The impact of change would have to be taken into consideration as one of the critical elements of the solution Essential elements would be influenced by the problem domain as well as the process maturity, the need for agility, the impact of change where projects are concerned and product management as well. Essential elements would need to include a unifying semantic structure.

In **choosing the participants in the research**, because of the symmetry breaking effects of scale transformation under conditions of complexity (Havel, 1995), it would be necessary to involve actors that viewed the business process from different levels of management and therefore at different scales. The actors involved would need to be made familiar with the distinctions of relevance when thinking about complex systems and include those involved in defining and improving existing business processes(see 2.5, **L4.10, L4.11**), corporate strategy and leadership, and those involved in managing process / organisation knowledge (see 2.5, **L4.8, L4.9, L5.3** and **L5.5**).

The approach to testing the validity of the Approach and hypotheses would be a matter of (a) identifying organisations that have already reduced the management challenge of complex business processes in the target problem space, (b) testing the hypotheses against their experience, (c) measuring the reduction in management challenge, and then (d) comparing their approach with the approach proposed in this thesis. If the approaches were incompatible then the proposed approach would be invalidated. On the other hand, if the approaches were compatible, any substantive differences could be incorporated into the development of the **Approach**.

However this is not sufficient for two reasons: (a) this does not validate that conventional approaches do not work because the organisations involved may not have applied the conventional approaches appropriately or may have done so without the complexity perspective in mind and (b) it is unlikely that they would have developed a formal approach for addressing complex business processes and the approach they described would be a matter of recollection rather than design. Therefore the **Approach** would need to be developed in a controlled way that included the systematic application of more conventional approaches with appropriate measurements of change in management challenge and followed by the proposed approach and its impact on management challenge.

However even this is not sufficient, as this would demonstrate that the **Approach** was valid for a particular use case following a particular series of interventions. Therefore it would be necessary to follow up the development of the **Approach** with a validation of the approach in other qualifying contexts but without the series of interventions that involved developing that **Approach** in the first place.

In summary, this calls for a three phase approach, (1) a pilot phase to carry out an initial validation and identify additional features of interest, (2) a development phase in which the approach is systematically developed, and (3) a validation phase where the developed approach is applied without further development iterations and the results used to validate the approach, as depicted in Figure 5.

Finally how would one go about **determining the success of the Approach**? A mere reduction of management challenge as measured by the assessment instrument would not be sufficient, as it may be possible for that to happen using other approaches as well as by sacrificing certain process goals. Therefore the researcher proposes to use a more stringent success criterion **SC**: *For a given intervention and its target process, the Approach is successful if it can demonstrate a reduction in management challenge on* ***all*** *attributes in the assessment instrument while* ***simultaneously*** *meeting* ***all*** *process goals*. For a given intervention then, the success criterion equates to obtaining a positive change assessment on all attributes while simultaneously meeting the functional requirements of the process and satisfying the design constraints.

4.5 Review of this chapter

This chapter developed a theoretical framework and perspective based upon the literature reviewed earlier in terms of a series of hypotheses. It then discussed the perspective and capabilities required to execute a strategy to address complex knowledge intensive business processes based upon those hypotheses. These capabilities include an **Approach** to addressing complex business processes, an instrument to assess the management challenge, and a framework, process and toolset to support the management of the resulting agile knowledge context. Finally it discussed the issues in operationalizing these in terms of the research design and conduct of the research. The next chapter defines and justifies the methodology adopted for this research.

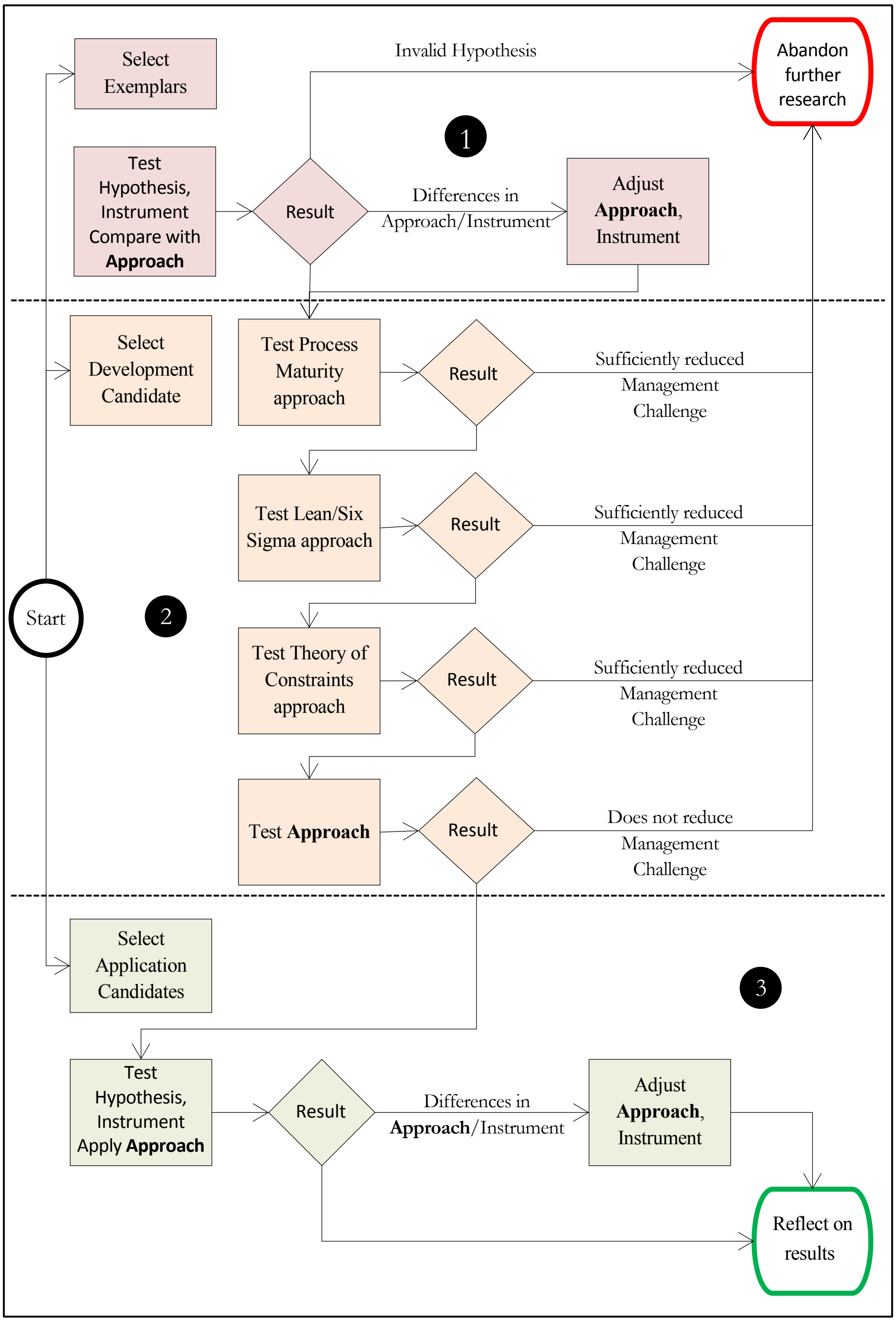


Figure 5: Research Flowchart

Chapter 5: Research Methodology and Design

5.1 Introduction

The last chapter discussed a research framework that (a) formulated hypotheses relevant to addressing cKIBP's, (b) identified capabilities required to reduce management challenge, and then set out the requirements that the research needed to fulfil.

To recapitulate, the requirements from the research are **R1**: test the foregoing hypotheses, **R2**: develop and test the proposed **Approach** to take into account issues and limitations discovered in 1, **R3**: test the instrument to assess the management challenge and **R4**: test the existence and need for an information framework, processes and tools.

This chapter describes and justifies the action research methodology and QDS investigation method adopted; the design of the research necessary to fulfil the requirements from the research; and the methods chosen (workshops, action research cycles, QDS investigations, measurement instruments).

5.2 Considerations for selecting methodology and methods

Whereas, according to Verma and Mallick, (1999, p. 1) "Simply expressed, research involves finding out something which was previously not known, or shedding fresh light on an issue or problem", this thesis takes a more problem driven perspective on research to the goal of advancing knowledge. As Cohen and Manion (1994, p. 194) put it, "Research is best conceived as the process of arriving at dependable solutions to problems through the planned and systematic collection, analysis, and interpretation of data".

Essentially, developing an **Approach** would involve working through a number of widely varying QDSs, to discover which components worked well, which needed improvement, and what interactions might exist between the different components. Therefore, a feasible solution would have to be both participative and iterative. The researcher then reviewed qualitative methods of social inquiry, and quantitative methods preparatory to choosing the research methodology and methods[4].

The possible choices in terms of an appropriate research method depend upon a sequence of issues relevant to the present research. Table 11 presents these, and summarizes answers obtained and justified in the remainder of this section.

Table 11: Issues in choosing a development method

Issue	Description	Answer
Theoretical or Empirical?	Does the development of the **Approach** require theoretical or empirical data?	Empirical
Primary or Secondary Data?	Can the developer rely on existing (secondary) data – or must primary data be collected?	Mainly primary, some secondary
Gold Standard Feasible?	If empirical data is necessary, is a "gold standard" quantitative method (such as a controlled experiment) feasible?	No
Summative or Formative approach?	Should a summative or formative approach be used?	Formative
Formal Hypothesis or evidence based?	Are formal hypotheses appropriate in these circumstances?	No: use evidence-based approach
Single or Multiple QDSs?	Should the method be developed through a single QDS, or multiple QDSs?	Multiple QDSs
Sequential or Simultaneous	If multiple QDSs are investigated, should they be sequential or simultaneous?	Sequential
Appropriate Qualitative Method?	If a quantitative method is not feasible, which qualitative method (or combination) is most appropriate?	A form of action research

Theoretical or Empirical

The first issue was to determine whether empirical data was required, or whether the research question could be resolved theoretically. While empirics are not always necessary for the development of a theory, as Alvesson & Sköldberg (2000) point out, and it is possible to develop a method solely from introspective sources, this would depend upon being able to predict all the circumstances of application, which from the researcher's experience in design and development of systems, did not seem possible. Therefore such an approach would run a serious risk of failure on encountering an unexpected set of circumstances. A "thought experiment" approach (Horowitz & Massey, 1991; McAllister, 1996) would be likely to miss important issues and problems. Therefore an empirical approach was chosen.

However, in developing an **Approach**, using exclusively empirical data does not make sense; as such data has to have an intrinsic purpose determined by a conceptual framework. Further there is a need for dialectic between the conceptual framework and the empirical data which is another feature of the action research approach chosen. The conceptual framework itself was developed by beginning with extensive reading, not rushing into the fieldwork phase of the research, discussing the researcher's ideas with other managers and improving the planned **Approach** before beginning the fieldwork.

Primary or Secondary data

The next issue was whether it was possible to rely on existing data or whether primary data had to be collected. Because the **Approach** the researcher was proposing to develop was one that relied very much on the participation of individual stakeholders, from a less conventional perspective, it was clear that the empirics would need to come from primary sources. However, because it was possible that the use of secondary data would reveal different issues from the use of primary data, a decision was made that secondary data could be used to test and validate results from the primary data.

Quantitative or qualitative approach

The quantitative approach usually involves deriving hypotheses from theories, expressing the hypotheses in terms of operational variables, and measuring the mathematical relationships between sets of variables. The logical rigour of quantitative research begins with the statement of hypotheses, and ends with the evaluation of the hypotheses based on the data collected. However this is only the core of the scientific process: it is preceded by the selection and generation of hypotheses, and often followed by an attempted generalization to a wider situation. While this set of methods was developed over the last few hundred years by scientists studying the physical world, and labelled "positivism" in the early 20th century, quantitative research is positivist only in its core process, as noted by Gephart (1988).

In order to determine whether to apply positivist thinking to the current investigation, the researcher conducted a "thought experiment" using a design based upon the "gold standard" (Campbell & Boruch, 1975) RCT method: the random controlled trial, or formal experiment, and concluded that the positivist approach was not feasible for developing the **Approach** because (1) the scale and cost would be enormous, (2) there is no accepted standard **Approach** that could be used for the control group, (3) it would be difficult to find hundreds of organizations willing to co-operate with the research, (4) the results from the research could be inconclusive, and that a further research would be required to clarify them, (5) the rigid procedures necessary for successful accomplishment of such a large-scale research would make it impossible to introduce minor improvements to the method, except after each round of investigations, (6) because of the time delay, it is likely that business process change would have superseded some of the earlier findings by the time the research was completed, and crucially (7) the entire exercise may be flawed because it addresses an inappropriate question.

While the positivist approach is dominant in the physical and natural sciences, the qualitative approach tends to be used mostly in the social sciences. Qualitative research has been more concerned with identifying and distinguishing concepts, rather than measuring them. In contrast with the quantitative approach (in which "variables" are tightly defined, do not overlap, and can readily be measured) the qualitative approach deals with concepts which are often not clearly defined, or for which there exist a range of interpretations. As the analytical tool used by qualitative researchers is words rather than numbers, verbally oriented research techniques are normally employed – though not always; for example, content analysis, essentially a quantitative technique, has been widely used by qualitative researchers.

The researcher takes the position that given a range of available approaches to research, it is the research question that should drive the choice of approach and not vice versa. Given that the positivist quantitative approach was clearly untenable in the context of this research a qualitative approach was chosen.

Summative or formative

Scriven (1967) makes a distinctive between summative and formative evaluation, which has come to be widely applied in the field of evaluation (particularly for educational programs) and is highly relevant for the present **Approach**. Summative evaluation sums up the accomplishment of a program on its completion, while formative evaluation is a continuing process during development.

A summative evaluation of the **Approach** would answer the question "How good is this **Approach**?" – in comparison either to an absolute criterion, or to other comparable processes. In contrast, a formative evaluation would answer the question "How can this **Approach** be improved?" Given that the purpose of the present research was not simply to determine whether the **Approach** was "good" or "bad" – particularly given the difficulty of developing testable criteria – but rather to detect weakness and strengths and to iteratively improve the method, a formative approach was chosen.

Hypothesis or evidence based evaluation

The hypothesis based evaluation uses the "laboratory" model, testing whether a single relevant variable causes an effect under controlled conditions. In contrast to a hypothesis based method, an evidence-based method uses the "courtroom" model, where evidence is weighed up in all its detail and a verdict arrived at. One implication of Kuhn's (1962) thinking is that all science is consensus-based, and that consensus is largely based on generally-known evidence. The use of "evidence-based medicine" and "evidence-based practice" has recently become popular in health and education, often using meta-analysis of findings of multiple studies. According to Pawson (2002), this can be either quantitative, or a narrative review, more theoretically based, using qualitative tables in the style of Miles and Huberman (1994).

For the present research, the evidence-based evaluation was judged more appropriate by the researcher because: (a) testable hypotheses could not be formed at the outset of the development process, and (b) evaluation of the **Approach** came through a wide variety of sources, both formal and informal, and an evidence-based evaluation was more suitable for integrating this information and deciding how to modify the **Approach**.

Single or multiple Qualitative Data Sources (QDSs)

The above sequence of decisions (empirical, mainly primary research, qualitative, formative, and evidence-based), combined with the relatively large scale of the **Approach** and the fact that the **Approach** is one that involves whole social entities, meant that it would have been almost impossible to carry out this project without using QDSs. The issue therefore was whether the **Approach** should be developed in a single QDS, or a number of QDSs. The researcher concluded that the multiple-QDS approach was more appropriate in this situation because: (a) using only a single QDS, and providing no basis for comparisons, would make it dangerous to produce any generalizations. Instead of being able to say "this method works in a variety of situations" the claim could only be "this method worked in one particular situation" – provided, of course, that it had worked in that situation (Kennedy, 1979; Donmoyer, 1990; Becker, 1990; Lewis, 1998); (b) given the researcher's inability to control the circumstances under which the research would be carried out, a multiple QDS investigation allows for more speedy recovery if one QDS investigation fails to be completed or for some reason is unusable; and (c) by working with a single QDS it was possible, even likely that either the fieldwork would almost inevitably become highly detailed, or else a single QDS would be too perfunctory for doctoral fieldwork and would not provide enough data to illuminate an entire thesis.

Sequential or simultaneous development

Given that multiple QDSs were to be used, this issue can be discussed in terms of two sub-issues: (a) whether each QDS should be investigated sequentially, or all QDSs should be investigated at once; and (b) whether the entire **Approach** should be developed as a whole, or separate components of it should be developed sequentially.

With regard to point (a) it was not feasible to conduct all QDS investigations simultaneously, and even if this had been possible, it would not have been as useful as sequential investigation of QDSs. As the process of iteration is itself highly valuable, allowing as it does the continuous comparison of each QDS with each previous QDS (Pope, Ziebland, & Mays, 2000), sequential development was used for the QDSs. On the other hand, the researcher judged it necessary to conduct a pilot phase that would determine the feasibility, provide insights and reveal the outlines of an envisaged **Approach** and to also apply the **Approach** to other QDSs in order to determine its validity. In order to achieve the benefits of both simultaneity and iteration the researcher decided to split the research into three phases: pilot, development and validation. Thus the QDS investigations in the pilot phase were conducted simultaneously, the development phase consisted of a single action research exercise with multiple iterations conducted sequentially, and the QDS investigations in the validation phase were again conducted simultaneously.

Regarding point (b) above, when it comes to the development of components of the **Approach**, each method has advantages and disadvantages. The advantage of sequential development is that the effect of each component can be separately assessed. The disadvantage is the possibility of interactions between components, such that two components, each of which worked separately, might not work when combined. A further disadvantage is that the components themselves need to be identified a priori and their interfaces and interactions preserved through the research, thus negating the benefits of learning. Therefore the components were developed simultaneously in the development phase.

Which qualitative approaches?

While to an extent, the choice of qualitative approaches had effectively been decided by the sequence of decisions made above, it was necessary to identify the particular qualitative approach or approaches to use, in case it proved necessary to use more than one.

Qualitative research offers an enormous array of potential approaches. As Patton (2002, pp. 131-134) points out, different writers on qualitative research have produced different epistemological categorizations of qualitative research such as five "perspectives" (Crotty M. J., 1998); five "traditions" (Creswell, 2003); three "epistemological stances" (Schwandt, 2000); seven "paradigms/theories." (Denzin & Lincoln, 2000); four "world hypotheses" underlying the major philosophies and corresponding research paradigms (Pepper, 1957). Patton (2002) offers another set of 16 categorisations. These various groupings are not clear alternatives to one another, but overlap in various aspects, and address different issues, which make these sets of paradigms basically incommensurable (Miles & Huberman, 1994).

The researcher's position is that it is not a question of choosing one particular approach, rather a matter of choosing, (whether explicitly or implicitly), a configuration of qualitative approaches. The model is one of a toolbox, rather than a tool. The researcher has thus embraced Dadds' and Hart's (2001) idea of methodological inventiveness in choosing the research methodology for this research.

One way of making sense of all these approaches is to sort them into a chronological sequence of choice decisions: ontological, epistemological and methodological (including praxiological)[5]. These categories are not mutually exclusive, and the boundaries between them are not widely agreed (Peters & Robinson, 1984). Using that sequence, the following qualitative approaches were applied:

Ontological*:* In terms of ontology, viewed in this context as the nature of reality, the focus is on human groups and processes as systems, which form the central unit of inquiry for this research. Thus a constructionist viewpoint, closer to the social constructionism of (Gergen, 1999) was taken because a central focus of the **Approach** is to understand shared human perspectives on process complexity, and such perspectives are but a social construct.

Epistemological: Because of its focus on the practical effectiveness, the development of any method implies a pragmatic viewpoint, as expressed in the pragmatism of Peirce (1955) and Dewey (1960). Essentially, the pragmatists' position is that objective truth is not knowable, so propositions should be judged by the outcomes they produce. Action research thus implies a pragmatist epistemology.

Methodological: Developing an **Approach** in the context of operational business process essentially dictates the need for a participatory approach. The discussion on single v/s multiple QDSs above demonstrates the value of QDS investigations for the present research. Given the iterative nature of **Approach** development, action research was the only qualitative method that both explicitly uses iteration and can involve a high level of participation. Also the research involves a study of processes and complexity. Processes can be studied from the perspective of systems. Ison (2001) identifies five clusters that have influenced contemporary systems approaches, one of them being complexity studies and makes the case for the application of systems thinking and practice for action research.

Many writers, particularly on information systems and operational research, support the utility of action research in such a situation. Baskerville and Wood-Harper (1996, p. 240) argue that action research is the most suitable method for studying purposeful human activity: "We suggest that action research, as a research method in the study of human methods, is the most scientifically legitimate approach available. Indeed, where a specific new methodology is being studied, the action research method may be the only relevant research method presently available." Eden (1995) concurs, stating that an action research approach is the most relevant for evaluations with complex goals.

Since a systems approach would be necessary for a research that involved both a process and a complexity perspective, action research thus became a key methodology for this research.

5.3 Action Research

The dominant approach or paradigm in management and organizational studies has been positivism and its successors (explanation, hypothetic deductive, multi-method eclecticism). They adhere to objectivist (realist) ontology and an objectivist epistemology. The hermeneutic tradition, the other main approach (also known as phenomenology, constructivist, interpretivist, post-modern interpretivism, relativist approach), argues that there is no objective or single knowable external reality, and that the researcher is an integral part of the research process, not separate from it. This approach follows a subjectivist (relativist) ontology and epistemology. The third approach identified by Johnson and Duberley (2000) is critical realism incorporating pragmatic critical realism, and follows a subjectivist epistemology similar to the hermeneutic tradition but objectivist ontology like the positivists, and concentrates on epistemic reflexivity.

Action research methodology fits within the paradigm of critical realism. It is an emergent process which takes shape as understanding increases; it is an iterative process which converges towards a better understanding of what happens. Almost all writers appear to regard it as cyclic (or a spiral), either explicitly or implicitly. At the very least, intention or planning precedes action, and critique or review follows. An important element is working with multiple information sources whose similarities and differences can be used to increase the accuracy of information through triangulation. The disagreement between the original data and the exceptions can then be resolved, leading to a deeper understanding of the situation being researched. Also action research tends to be qualitative and participative. Coghlan and Brannick (2005) provide a good introduction to Action Research in organisations.

Participatory action research is distinguished by the additional characteristic involvement of the practitioners as both subjects and co-researchers. "It is based on the Lewinian proposition that causal inferences about the behaviour of human beings are more likely to be valid and enactable when the human beings in question participate in building and testing them" (Argyris & Schön, 1991, p. 86).

Baskerville (1999) notes that the ideal domain of the action research method is characterized by a social setting where: (1) the researcher is actively involved, with expected benefit for both researcher and organization, (2) the knowledge obtained can be immediately applied, there is not the sense of the detached observer, but that of an active participant wishing to utilize any new knowledge based on an explicit, clear conceptual framework, and (3) the research is a (typically cyclical) process linking theory and practice

Action research is more applicable than mainstream research methods in situations requiring responsiveness and flexibility and action. It provides a mix of responsiveness (because it adapts to the situation) and rigour (doing this within a reflective spiral), thus meeting both the action and research requirements. Each turn of the spiral integrates research, theory and practice, action, and informs the next turn. Because it is intervention and research, it draws upon intervention procedures and research procedures. It is usually participative.

While the founder of action research is generally acknowledged to be Kurt Lewin (1946), Hart and Bond (1995) acknowledge the work of Collier and others in the 1930s and early 1940s, and McKernan (1991) notes even earlier roots. The key contribution to action research in Lewin's (1946) paper appears to be the cyclic concept of planning, action and reflection.

As discussed earlier, some variety of action research seemed the most appropriate method to use. But this gave rise to three questions: (a) which varieties of action research are most relevant for the **Approach**? (b) if no single variety is fully applicable, can elements of several varieties be used in developing the Process – and is it defensible to combine elements in such a way? and (c) can the development of a research method qualify as action research?

Since its original articulation by Lewin (1946), action research has developed into a variety of related streams. Peters and Robinson (1984) surveyed 11 early writers on action research, including Lewin, Argyris, and Kemmis, and compiled a summary of 18 characteristics of action research. Reason and Bradbury (2001) adds some more[6]. Two of these methodologies explicitly use the concept of "double loops" – the action science of Argyris, and the soft systems methodology of Checkland. This is relevant because an inner loop can be considered to apply to the use of a method within a QDS investigation, and an outer loop to the development of the method between QDS investigations – for example the review of the **Approach** and its evaluation criteria. Checkland's Soft

Systems Methodology, was the closest in terms of relevance, and the LUMAS model (Checkland P. , 2000), and while not designed for generalization, does allow for revision of the initial framework.

The review of the literature of action research revealed four key elements that were considered essential for this research – (1) from PAR: participatory development, in which all stakeholders in an entity are invited to contribute to the development of the **Approach**; (2) from Lewin (1946), and Carr & Kemmis (1986): the explicit use of cycles and specifically the version presented by Coghlan & Brannick (2005); (3) from action science (Argyris, Putnam, & Smith, 1985) and Soft Systems Methodology (Checkland P. , 1999): the concept of double-loop learning, and the comparison of the present situation with an envisaged ideal; and (4) from critical system heuristics and its derivatives: the questioning of the boundaries and exclusions of the systems being studied, or "boundary judgements" (Churchman, 1971; Ulrich W. , 1994; Ulrich W. , 2000; Midgley, Munlo, & Brown, 1998).

However combining elements from various methods runs the risk of adverse interactions i.e. elements which, in their original context work well individually, do not work well when combined, and that the resulting methodology would not be considered Action Research. Reviewing this risk in the context of the present research revealed that: (a) the various approaches to action research already shared those key characteristics, to varying extents; (b) no clear contradiction was evident between any pair of the four elements; and (c) each of these would be less useful if applied in isolation. Consequently, after assessing the drivers and risks of doing so (as discussed in this endnote[7]), the researcher decided to combine the four elements of action research in the methodology used for developing the **Approach**.

5.4 Research Design

Action research as a methodology fits the research context by satisfying the requirements of the phase of the research concerned with developing the **Approach.** However**,** a QDS investigation that provides a deep description through discussion and review of the QDS is more appropriate for the pilot, and validation phases, as the goals for these are defined and there is no scope for iteration.

In order to carry out the research, therefore, a customised methodology that integrates action research methodology with a QDS investigation method for different phases of the research needs to be constructed. There is support for such an approach in the literature. Dadds and Hart (2001, p. 169) put the need for methodological inventiveness very clearly when they say that "No methodology is, or should, cast in stone, if we accept that professional intention should be informing research processes, not pre-set ideas about methods of techniques…". Or as Crotty (2003, p. 13) puts it "In a very real sense, every piece of research is unique and calls for a unique methodology".

5.4.1 Phases of research

The need for a three phase approach was discussed in the previous chapter and depicted in Figure 5. Such an approach also achieves the benefits of both simultaneity and iteration. The methodology is depicted in Table 12 and calls for the development of a discussion structure and an instrument to measure management challenge which are then outlined.

5.4.2 Pilot Phase

The pilot phase consists of two QDSs where in the experience of the researcher, some elements of the **Approach** had been applied, although not in a structured way, and there is evidence of progress in managing complexity.

The goal of the pilot is to develop an understanding of how the business process was transformed and the implications of that transformation on the management challenge. The objectives of the pilot phase are fivefold: **(1)** test the hypotheses, **(2)** test the **Approach** to take into account issues and limitations discovered in 1, **(3)** test the instrument to assess the management challenge, **(4)** test the existence and need for an information framework, processes and tools and **(5)** gain insights from the experience of the transformation. The two QDSs identified belong to two different organisations, and the participants involved are the senior managers involved in both the operation and the transformation of the process in question.

5.4.2.1 QDS Discussion

The objectives of the QDS discussion are to: (a) build a description of the QDS in terms of a systems transformation, (b) determine the role of complexity and the attributes affected, and (c) draw insights from the experience of the participants, in terms of their perspective on addressing complexity. The QDS discussion is conducted over a series of two workshops.

In the first workshop, the researcher begins by discussing with the participants the basic concepts of complexity, systems thinking, process management, process maturity and change. The objective is to develop a common understanding and vocabulary of the concepts and approaches among participants. In the next stage the participants undertake a semi-structured discussion of the QDS (based upon the prototype discussion structure) from their individual perspectives before the intervention and agree a state description. A systems map corresponding to that state description is constructed. The key transformations are then identified and the post intervention systems map is constructed. A period of reflection is then allowed for.

In the second workshop, the participants contribute their reflections in terms of the changes that have occurred and their experience of the process of change. They then develop an instrument (based upon the prototype instrument) that identifies the complexity perspectives that they would consider relevant to the management challenge, apply that instrument on a pre-change and post-change perspective and reach a consensus on the change in management and management challenge according to that instrument.

Table 12: Research Design

<table>
<tr><th>Phase</th><th>Objectives</th><th>Problem</th><th>Method</th><th>Actions</th></tr>
<tr><td rowspan="2">1 – Pilot Phase</td><td rowspan="2">Test / Extend
Hypotheses
Approach
Instrument
Framework, Process, Tools</td><td>Product / Service Configuration</td><td>QDS Discussion
QDS Description
QDS Review</td><td>Examine causes of and criteria for complexity
Examine solution characteristics and limitations</td></tr>
<tr><td>Programme Management</td><td>QDS Discussion
QDS Description
QDS Review</td><td>Examine causes of and criteria for complexity
Examine solution characteristics and limitations</td></tr>
<tr><td rowspan="6">2 – Development Phase</td><td rowspan="6">Develop Approach / Capabilities over multiple iterations</td><td rowspan="6">Knowledge Management</td><td>Development Initiation</td><td>Introduce concepts
Identify initial problem</td></tr>
<tr><td>Action Research Cycle
Cycle Review</td><td>Develop Approach through “Process Maturity” thinking</td></tr>
<tr><td>Action Research Cycle
Cycle Review</td><td>Develop Approach through “Process Improvement” thinking</td></tr>
<tr><td>Action Research Cycle
Cycle Review</td><td>Develop Approach through “Theory of Constraints” thinking</td></tr>
<tr><td>Action Research Cycle
Cycle Review</td><td>Develop Approach through “Complex Agile Knowledge Contexts” thinking</td></tr>
<tr><td>Development Review</td><td>Review of learning through the Action Research Cycles</td></tr>
<tr><td rowspan="2">3 – Validation Phase</td><td rowspan="2">Test
Hypotheses
Approach
Instrument
Framework, Process, Tools</td><td>Account Management</td><td>Implementation Initiation
Approach Implementation
Implementation Review</td><td>Assess Approach Implementation
Assess change in management challenge</td></tr>
<tr><td>Fund Administration</td><td>Implementation Initiation
Approach Implementation
Implementation Review</td><td>Assess Approach Implementation
Assess change in management challenge</td></tr>
</table>

5.4.2.2 QDS Description

The output of the QDS discussion / action research cycles is collated by the researcher in the form of a QDS description that captures the points salient to the research while maintaining the integrity of the shared description of the QDS developed in the QDS discussion workshops / action research. The structure of the QDS description follows a standard format that has been agreed with the participants. This is shown in Table 13. The QDS description takes approximately four weeks to construct and the researcher would solicit clarifications from individual participants during the construction.

Table 13: QDS Description Components

Element	Components
Background to the QDS	The entity involved in the QDS: its purpose, activities, scale, history, ownership, governance, and funding (though not all of these were relevant for all entities studied).
Procedure for this QDS	Recruitment of participants. Environment for the study. Activities carried out.
Findings from this QDS	Findings including those relevant to the problem, the solution, the hypotheses, the Approach, the assessment factors, the change in management challenge and other observations specific to the organisation
Reflections on this QDS	Reflections on this QDS including issues to be resolved, separated into practical (concerned with improving the administration of the **Approach** / Methodology) and theoretical (concerned with questioning the theory in its current state)

5.4.2.3 QDS Review

The QDS description is reviewed by participants in a workshop to ensure its validity. The review includes reflection on key observations made in the QDS description and these may be then modified or extended to reflect participant views. This is also an opportunity for the participants to add or clarify observations for discussion and inclusion in the QDS description. This can happen since participants may form fresh perspectives in the period while the QDS description is being constructed, sometimes as a result of the clarifications sought. The instrument is also reviewed again and the change from the previous measurement discussed, explanations sought and reconciled.

Participant bias is reduced by comparing views; by offering several perspectives, the understanding of individual participants and of the team is deepened; and patterns emerge and connections are made leading to some significant insights. The participants sign off the QDS description as being representative of the QDS being reviewed.

Because the focus of this thesis is on the hypotheses and the **Approach**, coupled with the restrictions on publication imposed by the organisations researched, the version of the QDS description presented in this thesis is summarized (in terms of content), and discussed here only in so far as it sheds light on the research. Also content is completely anonymised and material that is specific to the organisation or confers competitive advantage is removed.

5.4.3 Development Phase

The development phase consists of a single QDS where the **Approach** was developed through four cycles with the goal of documenting and instrumenting how the system is transformed and the implications of that transformation on complexity. The expected outcome of the development phase is an **Approach** that can be applied to other contexts which shared the characteristics of the QDS within which the **Approach** was developed. The objectives of the development phase are fourfold: **(1)** test the hypotheses; **(2)** test and develop the **Approach** after trialling more conventional approaches; **(3)** test the instrument to assess the management challenge; and **(4)** test the existence and need for an information framework, processes and tools.

Since such development is expected to span twelve to eighteen months and requires full time commitment from both the researcher and the organisation, it would not have been feasible to do so in more than one organisation at a time. Also the development necessitates sufficient influence with the researcher in order to drive the transformation forward and this was possible only in the organisation where the researcher was employed. Therefore the development phase was restricted to a single organisation are the senior managers involved in both the operation and the transformation of the process in question.

5.4.3.1 Development Initiation

Through a workshop, the researcher discusses with the participants the basic concepts of complexity, process management, process maturity and change. The objective of the workshops is to develop a common understanding of the concepts and approaches among potential participants and to create a description of the problem to be solved. The initiation workshop also introduces the action research methodology and confirms the roles and agreement of the participants. The instrument developed is also applied at this stage.

5.4.3.2 Action Research Cycle

Among the multiple research approaches within Action Research, this research adopts a version of the action research cycle presented by Coghlan and Brannick (2005), which is briefly described below.

Diagnosing involves provisionally naming issues as a working theme on the basis of which action may be planned and taken. A key requirement is that such diagnosing should be a collaborative process. The diagnosis may itself change in subsequent cycles.

Planning action follows from the analysis of the context and purpose step and the framing of the issue and diagnosis and must remain consistent with both.

Taking action is the step in which the interventions are made and the actions implemented

Evaluating action step examines the outcomes of the action, whether intended or unintended, in order to assess the validity of the original diagnosis, the appropriateness of the action selected, appropriateness of its implementation, and the learning that feeds into the next cycle. The evaluation is by means of a workshop where outcomes are compared to plans formed in the earlier step.

Typically each cycle takes place several times. A better understanding develops through these iterations. Continuing uncertainty or ambiguity at any stage may trigger a return to an earlier stage.

While there are no prescribed limits to the number of cycles, the researcher provisionally identified four cycles with their corresponding objectives, with the understanding that these could change in the course of the action research. (It so happened that neither the number nor the key objectives required significant change.) The speed and number of cycles was aided by the use of IT tools for process management and agile methodologies.

5.4.3.3 Cycle Review

Through a workshop the participants reflect upon the cycle to review its degree of success, glean observations, insights and learning and develop alternative explanations for the phenomena observed. The objective of the workshops is to develop a shared description of the cycle where differing perspectives are either reconciled, or the basis and divergences identified. Participant bias is reduced by comparing views; by offering several perspectives, the understanding of individual participants and of the team is deepened; and patterns emerge and connections are made leading to some significant insights.

5.4.3.4 Development Review

The development phase as a whole is reviewed by participants in a workshop and captured in the form of a QDS description. In a second workshop, the review includes reflection on key observations made in the QDS description and these may be then modified or extended to reflect participant views. This is also an opportunity for the participants to add or clarify observations for discussion and inclusion in the QDS description. This can happen since participants may form fresh perspectives in the period while the QDS description is being constructed, sometimes as a result of the clarifications sought. The instrument is also applied again and the change from the previous measurement discussed, explanations sought and reconciled. Participant bias is reduced by comparing views; by offering several perspectives, the understanding of individual participants and of the team is deepened; and patterns emerge and connections are made leading to some significant insights. The participants sign off the QDS description as being representative of the QDS being reviewed.

5.4.4 Validation Phase

The validation phase consists of two QDSs where the context of the problem matched the characteristics that the **Approach** appeared to be effective for, but in a completely different problem domain. The goal of the validation phase is to validate the effectiveness of the **Approach**. The objectives of the validation phase are fourfold: **(1)** test the hypotheses; **(2)** test the **Approach**; **(3)** test the instrument to assess the management challenge; and **(4)** test the existence and need for an information framework, processes and tools. The two QDSs identified belonged to two different organisations, and the participants involved were the senior managers involved in both the operation and the transformation of the process in question.

5.4.4.1 Implementation Initiation

Through a workshop, the researcher discusses with the participants the basic concepts of complexity, process management, process maturity and change. The objective of the workshops is to develop a common understanding of the concepts and approaches among potential participants and to create a description of the problem to be solved. The initiation workshop also introduces the **Approach** and confirms the roles and agreement of the participants. The instrument developed is also applied at this stage.

5.4.4.2 Approach Implementation

The **Approach** is implemented using the business change, process change and systems implementation methodologies, according to the standards in use by the relevant organisation. The implementation ranges between two to four months.

5.4.4.3 Implementation Review

The implementation as a whole is reviewed by other participants through a workshop and captured in the form of a QDS description. In a second workshop, the review includes reflection on key observations made in the QDS description and these may be then modified or extended to reflect participant views. This is also an opportunity for the participants to add or clarify observations for discussion and inclusion in the QDS description. This can happen since participants may form fresh perspectives in the period while the QDS description is being constructed, sometimes as a result of the clarifications sought. The instrument is also applied again and the change from the previous measurement discussed, explanations sought and reconciled. Participant bias is reduced by comparing views; by offering several perspectives, the understanding of individual participants and of the team is deepened; and patterns emerge and connections are made leading to some significant insights. The participants sign off the QDS description as being representative of the QDS being reviewed.

5.4.5 Selection of QDSs

The main factor impinging on the selection of QDSs is the practical one of resources and time limits. Given the timetable laid down for a PhD thesis, and the amount of time involved in locating a suitable QDS, then working with the people, planning the engagements, developing the method, and reflection on the outcomes, it was clearly not going to be possible to work in detail on many QDS investigations. Action research values responsiveness over replicability and the context of the research demanded responsiveness as a necessary condition while still allowing for replicability in business processes with characteristics relevant to the **Approach**.

Consequently, the researcher decided to target a sample of 5 QDSs in 3 knowledge intensive organisations, the first two QDSs to test a nascent **Approach**, the third QDS to support the development of the nascent **Approach**, and the last two to validate the developed approach. The researcher hoped to maximize the possibility of discovering problems with the **Approach** by ensuring that the QDSs applied to different problem domains.

However with only 5 QDSs in the research, the Law of Large Numbers does not apply, and random sampling cannot be relied on to produce a representative sample – even when the population is enumerable (Kish, 1987). Because of this inherent statistical problem, different methods, generally involving purposive approaches to sampling have been developed. There are at least fifteen varieties of purposive sampling (Patton, 2002), of which the most relevant for this research was theoretical sampling.

Theoretical sampling is used in grounded theory (Glaser & Strauss, 1967; Coyne, 1997), with each successive case chosen so as to try to disconfirm the findings from the previous case. In principle, this method would have been ideal for developing this **Approach** as theoretical sampling assumes that enough is known about each member of the population that a likely disconfirming case can be identified in advance. While such preliminary knowledge was available in the light of the researcher's involvement in the QDSs, there existed the possibility that the variables affecting successful use of the method with one QDS often cannot be known in advance, and may be independent of externally identifiable characteristics of the QDS. However, the use of iterative cycles, with a provision for modifying the method for future cycles, as a consequence of the learning in the previous cycle, mitigated this problem. A further consideration is that of Stake (1995, p. 243), who notes that, "Potential for learning is a different and sometimes superior criterion to representativeness... "

Consequently, the researcher chose to target QDSs where (a) the business process was a cKIBP with characteristics as identified in Table 1: Regular v/s Knowledge Intensive Business Processes, (b) the entity involved demonstrated a high degree of innovation or change, (c) there was already a recognition that process complexity contributed to the problem, and conventional approaches were known or discovered to have failed in reducing management challenge (d) there was a conducive environment for research in terms of the researcher's influence and familiarity with the context and (e) the QDSs selected shared common context characteristics relevant to the **Approach** but, in order to improve generalizability, addressed completely different problem domains.

Since new information (with respect to feedback on the **Approach** and Framework) is likely to be obtained in the final QDS investigation, the point of sampling redundancy, when no new data is being added (Lincoln & Guba, 1985) is not expected to be reached.

The selected QDSs are summarised in Table 14

Table 14: QDSs Selected for Research

Phase	Label	Description	Problem Domain
Phase 1 - **Pilot**	AB	Respected merchant bank providing private banking, wealth management, and trust/fund administration services	Knowledge Intensiveness: High Problem Domain: **Product / Service Configuration** Innovation/Change: High change Process Complexity Awareness: High Research Opportunity: Researcher trusted and familiar with the context through involvement in earlier improvement efforts
	MN	International IT provider offering software development, systems integration, programme management, and business process outsourcing services	Knowledge Intensiveness: High Problem Domain: **Programme Management** Innovation/Change: Medium Innovation Process Complexity Awareness: High Research Opportunity: Researcher trusted and familiar with the context through involvement in earlier improvement efforts
Phase 2 - **Development**	ST	Management consultancy providing research, strategy and consultancy services in the digital money ecosystem and process, programme and systems management consultancy services	Knowledge Intensiveness: High Problem Domain: **Knowledge Management** Innovation/Change: High Innovation Process Complexity Awareness: High Research Opportunity: Researcher has authority and familiar with the context through overseeing the process
Phase 3 - **Validation**	ST	Management consultancy providing research, strategy and consultancy services in the digital money ecosystem and process, programme and systems management consultancy services	Knowledge Intensiveness: High Problem Domain: **Account Management** Innovation/Change: High Change Process Complexity Awareness: High Research Opportunity: Researcher has authority and familiar with the context through overseeing the process
	AB	Respected merchant bank providing private banking, wealth management, and trust/fund administration services	Knowledge Intensiveness: High Problem Domain: **Fund Administration** Innovation/Change: High Change Process Complexity: High Research Opportunity: Researcher trusted and familiar with the context through involvement in earlier improvement efforts

5.4.6 Selection of Participants

Three factors drive the selection of participants. Firstly, the participants need to be knowledge intensive firms who are very familiar with the problem and the business process under consideration. Secondly, the participants need to represent different stakes and therefore perspectives on the problem and the business process. (This also addresses the need for generalizability). Thirdly, the number of participants must be small enough to be able to organise workshops, encourage discussion and obtain clarifications. Consequently, the number of participants is restricted to 6 per QDS investigation, and they are chosen to be both familiar with the problem and the business process and to represent the strategic, operational and change perspectives. Thus there were officially 30 participants (though in fact several more were involved in various capacities).

5.5 Methods

Workshops are the primary method of interaction, supported by one-on-one interviews to clarify issues and positions with participants. These are supported by additional tools such as the instrument to assess management challenge.

5.5.1 Workshops

The content of the various workshops has already been discussed in the context of individual phases and stages within that phase for each QDS. This section deals with the general approach used to conduct a workshop. The workshop is scheduled at a time and location convenient to all participants and lasts between 2 and 4 hours. Once scheduled, all participants are sent an agenda for the workshop by e-mail.

The first workshop for every organisation begins with an introduction by the researcher, which includes the objectives of the research, the action research methodology applied, the rationale for the selection of the QDS, roles of and expectations from the participants. This is followed by a short introduction to the concepts of complexity, systems thinking, process and knowledge management.

In the QDS discussion, development initiation and implementation initiation workshops a discussion structure is adopted which is based upon questions that help test / extend the hypotheses, issues, capabilities and the **Approach**. The discussion structure is depicted in Table 15. The discussion topics are deliberately quite different from these in order to avoid biasing the participants. Since the discussion takes place after an introduction to complexity thinking, the participants are encouraged by the researcher to draw upon complexity concepts in the course of the discussion. In the QDS review, development review and implementation review workshops the discussion structure is revisited in the context of points raised through the earlier workshops and a draft QDS description. The focus is on the validity of the QDS description, along with a critical review of the **Approach** and the assessment instrument.

The workshops in the action research cycle follow a framework based upon Coghlan & Brannick (2005), with **Diagnosing** consisting of (1) determining the need for change in terms of the internal and external forces driving the change and the choices available, (2) the desired outcome and the consequences of non-intervention; **Planning** consisting of (3) identification of intervention points; **Taking action** consisting of (4) options, plans, resistance, commitment and transition management, ownership of outcomes, and resourcing, and **Evaluating** consisting of (5) review, learning and sharing.

There were 32 workshops formally conducted. These does not include implementation workshops involved in the Taking Action phase of each action research cycle, and the implementation workshops in the Validation phase as these do not contribute to the research. The primary role of the researcher in workshops is that of a facilitator and a mediator of perspectives and languages. The approach to facilitation varies with the organisation but in all QDSs participants are encouraged to raise points using Framing, Advocating, Illustrating and Inquiring approach (Torbert W. , 1999). They are encouraged to develop and test hypothesis (Argyris, Putnam, & Smith, 1985) through triangulation and reflect upon points being raised using the Observation, Reaction, Judgement and Intervention framework (Schein, 1999).

Table 15: Workshop discussion structure

Discussion Topic	In order to address hypothesis
History of the organisation, its ecosystems and its impact on the process	Engaging in complex ecosystems implicitly or explicitly impacts the complexity of the business processes of knowledge intensive organisations and creates significant challenges for them Management of cKIBP's will get increasingly more challenging as the rate of evolution, proliferation and integration of the processes being managed keeps increasing
What characteristics does this process possess that cause you to call it a complex process? What in your view makes this process complex	An ensemble of business processes can be regarded as a complex system The level of entanglement correlates with the management challenge in managing the process
What attempts have you made to improve the process? What methodologies have been applied? What kind of dependencies have you identified and how have these been addressed	The mechanistic view of business processes does not sufficiently capture the complexity since it obscures the role of relationships While effective in addressing complicated processes, conventional approaches are less effective in addressing complex processes with knowledge entanglements
Can we develop a map of the process before the improvement, and identify the kind of information used in the activities? Where are the problem areas?	Complexity arises because of entanglements between processes and addressing complexity requires reduction or removal of such entanglements
What did you focus on? What did you change? What does the new process map look like?	Knowledge sharing entanglements arise when the information flow contains entangled complex knowledge contexts, and can be resolved by reorganising the process ensemble to contribute and consume from a set of integrated knowledge contexts
How do you manage knowledge in the process now? How is it stored accessed and modified? How is it structured? Would you call it complex? Why?	Knowledge sharing entanglements can be addressed through a shared knowledge context
Has this solved all your problems with the process? What problems remain? How do they relate to the knowledge in the process?	Creating and managing a complex shared agile knowledge context requires an information framework, processes and tools

The output from all workshops is a set of points raised, which is documented by the researcher (when such support is not available) for further analyses against the hypotheses, issues, capabilities and the **Approach**. Data collection and analysis is discussed in more detail in 5.6.

Management Challenge Assessment Instrument

As discussed in 4.3.2, the instrument is based upon attributes that drive management challenge, and is depicted in Table 16. The instrument is anonymised for reasons discussed in 5.9 and is designed to be simple and easily understood by actors at various levels of management and operations, and focussed on measuring the ***direction*** of change rather than the ***quantum*** of change. It is completed by each participant and consists of a simple scale per factor ranging from -4 to +4, where 0 is the participant's judgement of the management challenge for processes with similar activities and volumes in their organisation.

Table 16: Management Challenge Assessment Instrument

Organisation:
Name of business process:
Role of participant:
State (pre/post change):

Factor	-4 means	+4 means	Your Score*
Visibility	Most activities cannot be identified, measured, scheduled or controlled	All activities can be identified, measured, scheduled and controlled	
Predictability	The quality, cost and duration of the process per transaction are completely unpredictable	The quality, cost and duration of the process per transaction are completely predictable	
Scalability	The throughput of the process cannot be scaled	The throughput of the process is completely scalable	
Variability of outcomes	No transaction can be guaranteed to complete Process goals are rarely met	Every transaction can be guaranteed to complete Process goals are always met	
Quality of deliverables	Quality of deliverables is highly variable and deliverables are frequently rejected	Quality of deliverables always meets process standards and no deliverable is rejected	
Cost of process	The cost per transaction is highly variable and the process cost is impossible to predict and control	The cost per transaction is completely determined and the process cost is completely predictable and controlled	

* In assigning your score consider 0 to be your judgement of how you would rate another process you know which has similar activities and volumes as this one

Please also provide your interpretation of each factor in your assessment

The instrument is applied pre and post intervention, and with respect to each attribute, a positive change in assessment reflects the assessor's view that management challenge has indeed been reduced.

5.5.2 Interviews

Interviews are a secondary method of interaction to support the workshops. All interviews are one-to-one and conducted either face-to-face, over the telephone or video-conferencing. Interviews become necessary for the purposes of (1) clarifying points raised and positions taken by individual participants in the workshops, (2) resolving conflicts between points raised by the same/different participants, (3) improving the researchers' understanding of specialist issues raised during the workshops in order to inform analysis and reflection, (4) searching for evidence and distinguishing fact from opinion, and (5) confirming the researcher's observations and deductions. Data collected during the interviews is recorded in the form of key points and confirmed back to the interviewee by e-mail (to address reliability and objectivity). These points are also appropriately referenced and reflected back in the review report. In cases where the conflict between points persists, or the issue is obscure, the points are highlighted for discussion in the review workshop. All points raised are input to the data analysis that goes into the production of the review report and QDS description.

5.6 Data Collection and Analysis

Data is collected from both workshops and interviews, and takes two forms (1) record of discussions in the workshop and interview in the form of points raised, and (2) assessment instruments as shown in Table 16 completed by participants.

Points raised in workshops and interviews

This points raised are analysed through an iterative process consisting of the following steps

1. Points raised are first classified by (1) discussion topic, (2) participant originating the point (to address traceability and objectivity), and (3) frame of reference for the point (to address generalizability).

2. Each point is then reviewed by the researcher to ensure that the point is completely understood (in order to address reliability). If the point is obscure or ambiguous it is marked as "obscure" or "ambiguous" for clarification through an interview with the originator.

3. The remaining points are tested against other points to identify conflicts or contradictions. This further enhances reliability through triangulation. If any are discovered the implicated points are marked as "conflicting" for clarification as above.

4. From the remaining points, those which are duplicated or similar to each other are merged but the original points are retained as references against them (addressing traceability and triangulation). All these remaining points are marked as "confirmed".

5. The points from the previous step are then analysed by the researcher against the discussion topic and the associated hypotheses as shown in Table 15 and the Approach and the ones that conflict with either of these are marked as "anomalous" for further clarification (addressing triangulation)

Points marked for clarification are then classified by the originating participants. These are then sent to the concerned participant in preparation for an interview. An interview is then scheduled, where these points are discussed. The points emanating from the interview are also recorded and communicated back to the participant as confirmation. These points are then fed back into step 1 of the analysis process for the next iteration. The process is iterated until all conflicting, obscure and ambiguous points have been resolved.

At this point only confirming and anomalous points remain. These are then analysed by the researcher to form further observations and deductions. These are verified through interviews with the appropriate participants. If confirmed they are added to the confirmed list. If contradicted then there are two courses of action. If the observation or deduction can be logically refuted (1) these are abandoned, otherwise (2) these are marked as anomalous.

These points are then used to construct a draft QDS description that is circulated to the participants prior to the review workshop (addressing the need for a deep description). The anomalous points are discussed in depth to understand the reason behind the anomaly (addressing triangulation through reflexivity). The remaining points are once again validated with the participants. Also any additional points raised during the review workshop are completely discussed in the review workshop and their impact on the QDS description agreed with the participants.

The results of the workshop are then used to construct a review report and amend the draft QDS description into its final form.

Assessment instruments completed

Assessment instruments are completed by each participant in two parts, the first representing their assessment of the management challenge pre intervention and the other their assessment post intervention. These assessments are recorded into a table analysed by (1) QDS ID, (2) Participant ID, (3) Role, (4) Selected to Provide, (5) Factor, (6) Assessment before intervention, and (7) Assessment after intervention. The (8) Change in assessment is calculated as the difference between assessments after and before intervention. The participant's interpretation of the factor is also analysed and in case it is highly inconsistent with other common interpretations, this is discussed with the participant through the interview process and the amended interpretations and assessments are recorded.

The resulting collated set of 288 data point pairs is available in Appendix II, appropriately anonymised. This is analysed per QDS by role, factor and change. The results of the analysis are presented as charts in the QDS description and form part of the criteria for success of the intervention.

Table 17 presents key data collection and analysis statistics in the course of this research.

Table 17: Data Collection and Analysis Statistics

	QDS 1	QDS 2	QDS 3	QDS 4	QDS 5	Totals
Phase	Pilot		Development	Validation		
Email exchanges	78	137	583	33	42	873
Review report versions	2	3	2	1	3	11
QDS Description versions	3	2	2	4	3	14
Workshops	3	3	20	3	3	32
Interviews	16	27	66	7	11	127
Points Analysed	76	64	220	22	28	410
Assessments analysed	36	36	144	36	36	288

5.7 Role of Researcher

As usual in participatory action research (Lewin K. , 1946; Lewin K. , 1947; Whyte, 1991; Fals-Borda & Rahman, 1991), particularly in its pragmatic form (Coghlan & Brannick, 2005), the researcher was required to play several roles. As a **consultant**, he was expected to bring to bear his specialised knowledge of process improvement methodologies and strategies, specific technical and domain expertise and experience of successful interventions, in order to analyse current problems and provide solutions specific to the customer's situation. As a **researcher** however, the role consisted of gathering data and analysing it in the context of current knowledge in order to generate theories that can be tested and applied more generally. As a **coach**, he was required to introduce the concepts of complexity and action research and assist participants in applying these. This was necessary mainly during the workshops but also during the interviews. Finally, as a **facilitator**, he was required to frame and conduct the workshops and interviews, help participants articulate and disambiguate their contributions in appropriate forms, manage conflicts of style, opinion and position, and resolve conflicts of fact.

The primary role from the point of view of the organisations researched was that of a consultant, and it was generally in this capacity that the QDS description at the conclusion of the QDS investigation was presented, the value being its specific analysis of their situation. On the other hand the primary role from the point of view of the research itself was that of a researcher, and while the participants were fully cognizant of the goals of the research they were less interested in the theory and generalizability that resulted from it.

From the perspective of the participatory action research methodology adopted, the coach, consultant and facilitator roles align closely with the participatory aspect of the methodology while the researcher role aligns with the observer aspect. This corresponds with Levin's (2012) analogy of the Janus face of action research and Baskerville's (1999) distinction and simultaneity between active participant and detached observer roles in action research.

The emphasis of the participatory roles differs between the phases of the research. The pilot phase concentrates on analysing the problem and the developed solution rather than crafting a solution. Consequently it has lower consulting emphasis, but a relatively high coaching and facilitation emphasis necessary to introduce concepts of complexity and action research. In the development phase, the content is more balanced initially, but tends to emphasise consulting as the participants become familiar with concepts and approach, and need less coaching and facilitation. In the validation phase, the emphasis is almost entirely on the consulting role as the participants are already familiar with the concepts.

The emphasis on the researcher role remains essentially the same through the course of the research. The focus of the role changes however, from data collection and analysis in the pilot phase, through theory generation in the development phase, to hypothesis validation in the validation phase.

5.8 Assuring rigour of research

The aim, from the researcher's perspective, is to provide information to other professionals, which may enable them to apply relevant aspects of the research and findings to their own context and to test them for themselves. Therefore the onus on the researcher is to ensure that the research is as rigorous and relevant as possible in the researcher's context, thus to provide others with the assurance that these were genuine results and findings in this particular context. Rigour is therefore critical to the quality of research and the use of Action Research has come in for some criticism from the scientific community, mainly because Action Research has an interpretivist lineage, and as Lincoln and Guba (1985) and Guba & Lincoln, (1989) point out, the two key concepts of reliability and validity are restricted by the conventional positivistic usage. Nonetheless, the findings from AR must be subject to the scrutiny of reliability and validity to ensure trustworthiness of the research.

As Cohen and Manion (1994) note, some of the criticisms of Action Research are that its sample is restricted and unrepresentative, it is subjective and situational and its findings are not generalizable but generally restricted to the environment in which it is carried out. Action Research is also mistrusted because of high involvement of the researcher in the field, but also as a consequence of the marginal scientific contribution (Levin M. , 2012). Therefore the challenge for AR is to show that standard criteria for rigor and relevance can be met or be even better in AR. The perspective is that no other social science has better prospects in facing the combined demand for rigor and relevance (Greenwood & Levin, 2008; Levin & Geenwood, 2011).

5.8.1 Criteria for trustworthiness

According to Guba's (1992) 'criteria of trustworthiness', the quality and rigour of research can be assessed in terms of the truth-value, applicability, consistency, neutrality of the research. To establish the quality and trustworthiness of the research, qualitative research is often assessed on credibility (validity), dependability (reliability) and confirmability (objectivity), and transferability (generalizability),

Credibility (validity, reliability and objectivity): Internal validity is concerned with causal effect, in which participants are able to acknowledge that the results and outcomes from a particular research represent the results and outcomes, which they may have expected themselves, given their knowledge of the context. In order to ensure this rigorous approach, a key aspect is triangulation of data. Cohen and Manion (1994, p. 233) give a clear definition of triangulation as "the use of two or more methods of data collection in the study of some aspect of human behaviour". The concept of triangulation (Denzin N. K., 1978) is to enable researchers to confirm the validity of data collected and results presented. In terms of reliability, most conventional research methods gain their rigour by control, standardisation, objectivity, and the use of numerical and statistical procedures. This sacrifices flexibility during a given experiment. In action research, standardisation defeats the purpose. Consequently, as in many numerical procedures, repeated cycles have been designed into this research to converge on appropriate conclusions. In terms of objectivity, Cohen and Manion (1994, p. 36) note that "Whereas normative studies are positivist, all theories constructed within the context of the interpretive paradigm tend to be anti-positivist." In other words, they assert that it is impossible to be entirely objective when there is a requirement, as in action research, to interpret data. Nevertheless, confirmability can at least be ensured in terms of the data itself, and the findings verified for appropriate contexts.

Generalizability (Transferability): Generalizability or external validity is concerned with the ability to generalise findings to other contexts. Generalisation, as defined by Verma and Mallick (1999, p. 198) refers to the "findings of research which can have applicability to other situation, contexts or settings". Consequently, the research must identify the characteristics of the contexts to which the findings would apply, in line with Stake's (1978) process of naturalistic generalisation.

5.8.2 Strategies to improve Trustworthiness

In order to build integrity of research Levin (2012) identifies, five main factors as warrants for rigor: research partners; awareness of own biases; standardized methods; alternative explanations; and trustworthiness and claims that these help in creating reliable and valid conclusions in research. In applying these factors, this research employs three strategies to improve the trustworthiness of the research (Cresswell & Miller, 2000). These are triangulation and perspective reconciliation, dense description and reflexivity.

Triangulation is achieved in different ways during the research (Denzin N. K., 1978). In terms of data sources, data generated through action research is triangulated using secondary sources and resolution of conflicting information and perspectives across participants. Triangulation across theories is further enhanced through wide reading of relevant literature during the course of the research. Finally, in terms of member checking (Lincoln & Guba, 1985), participant perspectives are sought, discussed and reconciled to establish the credibility of data and generate alternative explanations. Multiple opportunities for triangulation are built into the methodology. Triangulation occurs during initiation, the action research cycle iterations, reviews, and in the process of construction of the QDS descriptions, through the data collection and analysis methodology discussed later in this chapter. **Validity** is ensured through frequent participant checking (Lincoln & Guba, 1985), incorporating their prolonged and varied field experience (Cresswell & Miller, 2000) and promoting structural coherence, referential adequacy of the data gathered and the explanatory credibility of the conclusions reached. **Reliability** is ensured through using repeated cycles and multiple QDSs to converge to appropriate conclusions (Lewin K. , 1946). **Objectivity** is ensured through coherence and traceability of the data gathered, testing of interpretations against other interpretations by the participants and validating the **Approach** developed over multiple QDSs as part of the research methodology adopted. **Generalizability** is achieved by ensuring that the **Approach** developed can be verified to apply to the **class** of problems which have characteristics identified by the **Approach**, so there is opportunity for other professionals to adapt this research to meet their own needs (Stake R. E., 1978).

Dense description of each cycle is made possible by ensuring that salient aspects of each cycle, perspectives of individual participant as well as individual and combined explanations are recorded as part of the process of both workshops and interviews. This description then forms the basis for and is further expanded upon during the reviews, which then form the basis for constructing QDS descriptions (Cresswell & Miller, 2000). **Validity** is ensured through generating alternative explanations and multiple interpretations by participants, and actively searching for disconfirming evidence (Miles & Huberman, 1994). **Reliability** is ensured through documenting participant observations and reflections, on both, the **Approach** and the research methodology as part of the project process. **Objectivity** is ensured through consolidating reconciled observations, reflections, interpretations and explanations into QDS descriptions for review by participants. **Generalizability** is ensured through identification of generalities and common patterns (Stake R. E., 1978) across action research cycles (Lewin K. , 1946), at the level of both the individual cycle and the research as a whole.

Reflexivity (Johnson & Duberley, 2000) is a key theme in the research process and is applied in several ways. For the individual participant, the requirement to generate defensible explanations during the workshops and to develop perspectives encourages a great deal of reflexivity. For the process, there is continuous reflexive enquiry into the goals, approaches, tools and techniques involved in the intervention. For the methodology there is reflexive enquiry into its appropriateness at each of the initiation and review workshops which leads to its continuous refinement. **Validity** is ensured through generating alternative explanations and including periods of reflection and interpretation by participants, and the use of the ORJI model (Schein, 1999). **Reliability** is ensured by the research methodology having built in opportunities for itself to be reviewed for appropriateness and rigour very frequently and for appropriate refinements to be included in order to make it more effective. **Objectivity** is ensured by enhancing awareness of own bias, continually questioning the appropriateness of the goal, process and interpretations, both individually and collectively through the course of the research. **Generalizability** is ensured through identification, review and confirmation of problem characteristics to which the **Approach** would prove effective (Stake R. E., 1978).

5.9 Ethics

In carrying out the research the researcher was an active participant in the team undertaking each initiative. However he was also a director of the organisation, a manager with a functional remit, and a consultant with specialist knowledge in the areas of programme management, process management and information systems. This had the potential for conflict and the following steps were taken to manage that conflict: (1) in preparation for the research, the role, objectives and scope were agreed with the key participants within each organisation; (2) the methodology designed distinguished the researcher's role as a consultant at key stages.

Where there was potential for confusion, the researcher prefaced the conversation by clarifying which role was being played; (3) as an employee he strictly followed the policies of the organisation in all areas. Where there was potential for conflict, particularly with relevance to data usage, access to associates of the organisation, and access to employees of partner organisations, he explicitly clarified the conflict and sought guidance from participants in addressing the conflict; and (4) The key elements of the methodology were integrated into the management processes, which involved key participants, and the learning and goal setting for each cycle was achieved by a process of exchanging perspectives and building consensus between the participants.

In constructing this research, there were a number of participants who could be directly affected both by the research itself and potentially by its outcomes. The researcher ensured that the goals of the research were clarified, and the intention to participate confirmed for each participant during the initiation workshops. Also the perspectives and alternative explanations were specifically sought from each participant during the cycles and integrated into the QDS description.

The researcher was unable to persuade the entities involved to participate in the research unless their anonymity was protected and confidentiality guaranteed in terms of identities, correspondence, details of the processes being studied and transformed and reports and findings specific to the organisation. This was understandable as in all the cases the processes in question were considered core to the business and a source of competitive advantage. Privately, there was a fear expressed by the entities that publication of identities linking to problems identified in the core process would show the entity in a bad light to the industry and customers. Participants also expressed the fear that their association with the problems identified would disadvantage their careers within the organisation and the industry as a whole.

Consequently all references to the entities, participants and processes have been anonymised and source data and less relevant details of the process particularly those that could impact competitive advantage, as well as the detailed reports produced by the researcher for the entity have been excluded from the research[u].

5.10 Review of this chapter

This chapter has outlined the research methodology and design for this thesis. It began by examining the consideration for selecting a methodology. It then discussed action research methodology, and QDS investigation method, that could be applied to the development phase and the pilot and validation phases of the research respectively. This chapter then described the design of the Methodology in terms of its components and phases, (1) a pilot phase to carry out an initial validation and identify additional features of interest, (2) a development phase in which the approach is systematically developed, and (3) a validation phase where the developed approach is applied without further development iterations and the results used to validate the approach. This is illustrated in Figure 6.

[u] The board of directors of ST were persuaded to share the review report which (appropriately anonymised) is provided in Appendix I

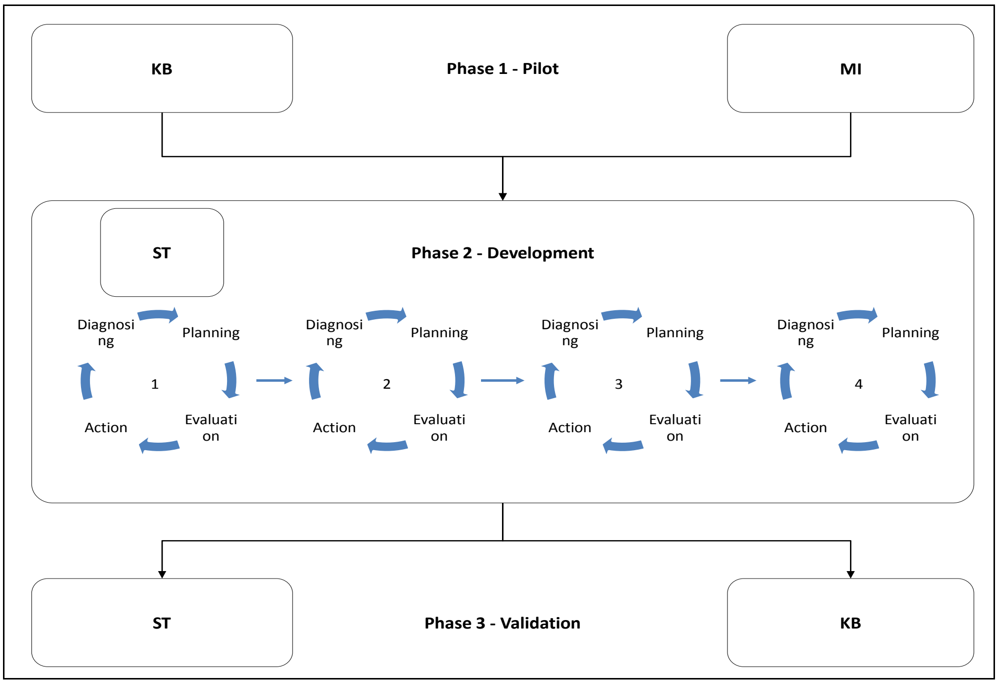


Figure 6: Research Design

The QDSs were selected across three organisations and to satisfy the following characteristics: (a) the process was knowledge intensive, (b) the entity involved demonstrated a high degree of innovation or change, (c) there was already a recognition that process complexity contributed to the problem, (d) there was a conducive environment for research in terms of the researcher's influence and familiarity with the context and (e) the QDSs selected shared common context characteristics relevant to the **Approach** but addressed completely different problem domains.

The chapter concludes with a brief section identifying the limitations of the evaluation method and the provisions for rigour incorporated in this research.

The next three chapters describe the QDSs investigated during the research and documents findings, reflections and issues. The next chapter focusses on the pilot phase.

Chapter 6: Pilot Phase

6.1 Introduction

The last chapter described the design of the Methodology in terms of three phases (a) the pilot phase consisting of two QDSs; (b) the development phase consisting of a single QDS; and (c) a validation phase consisting of two QDSs. This chapter and the next two chapters discuss the research carried out.

Each QDS investigated begins with a background of the QDS, procedures adopted during the QDS investigation and then documents findings, reflections and issues arising that need to be resolved in following QDSs.

System maps before and after intervention, are included to provide context in order to support the analysis. The system maps have been simplified and standardised in order to enhance comparability and emphasise elements relevant to this research. In the system maps, dashed grey lines denote the boundary of the system studied, entities external to the system are prefixed with '**E**' and process within the system are prefixed with '**P**'. Also in the system maps, arrows represent both the direction and flow of information and are the basis for deriving the information contexts in the system. Charts depicting the change in assessment before and after the intervention are also included to support the analysis. The charts measure the change in assessment averaged for each role.

The convention adopted in all the following QDS investigations is to refer to a supported hypotheses or capability by means of its identifying label in parenthesis next to the argument. As an example if an argument supports both hypotheses H1 and H2 and also supports capabilities C1 and C2, this will be represented at the appropriate point in the argument as (**H1**) or (**H1**, **H2**) or (**H1**, **C1**, **C2**) as appropriate.

This chapter describes the QDSs investigated in the pilot phase at a greater level of detail. To recapitulate, The objectives of the pilot phase were fivefold: **(1)** test the hypotheses, **(2)** test the **Approach** to take into account issues and limitations discovered in 1, **(3)** test the instrument to assess the management challenge, **(4)** test the existence and need for an information framework, processes and tools and **(5)** gain insights from the experience of the transformation.

The QDSs investigated cover two different problem domains (1) product/service configuration and (2) programme management. The primary methods used are workshops for QDS discussion and review, coupled with the QDS investigation method. Actions are directed to the examination of causes of and criteria for complexity in the QDS and the solution characteristics and limitations.

6.2 Pilot Phase - QDS Investigation 1 - AB

6.2.1 Background

AB is an international merchant bank providing private banking, wealth management, and trust/fund administration services to its customers for over a 100 years. Over its long history it has acquired, merged with and been acquired by several entities and has grown in terms of asset managed, products and services offered, geographical distributions and lines of business. The common thread has been the brand which is highly recognised and respected.

This is an extremely knowledge intensive business, that deals with intangible assets, and products and offers advisory, trust and fiduciary arrangements covering a range of specialised knowledge based services.

A key competitive advantage for AB is its rapid innovation of specialised multi-asset, multi-jurisdiction products, and ability to offer these through a multitude of wrapper arrangements. Along with the many mergers and acquisitions in its history, this has led to a complex product and service set in a complex operating environment.

AB is therefore familiar with complexity and has made progress in addressing the complexity of the product / service configuration process. This process satisfies all of the characteristics outlined in Table 1: Regular v/s Knowledge Intensive Business Processes. Having been involved in the process improvement initiative, the researcher is therefore trusted and familiar with the context.

6.2.2 Procedures

Bearing in mind the need to involve participants from several perspectives and at different levels, the following participants were selected.

Table 18: QDS Investigation 1 - AB - List of participants

Participant	Role	Selected To Provide
P1	Divisional Director	Strategic Perspective
P2	Chief Operating Officer	Operational Complexity Perspective
P3	Programme Director	Change Delivery Perspective
P4	Process Owner	Process Resourcing, Goals, Outcomes
P5	Process Administrator	Process Complexity Perspective
P6	Client Relationship Manager	Process (Internal) Client Perspective

The objectives of the QDS discussion were to: (a) build a description of the QDS in terms of a systems transformation, (b) determine the role of complexity and the attributes affected, and (c) draw insights from the experience of the participants, in terms of their perspective on addressing complexity.

This QDS discussion was conducted over two workshops, and a series of one-on-one interviews (either face-to-face or telephonically). All meeting were held at one of AB's offices. During the workshops, the Divisional Director's personal assistant also attended and kept a record of discussions for the researcher.

In the first workshop, the researcher discussed with the participants the basic concepts of complexity, systems thinking, process management, process maturity and change, in order to develop a common understanding and vocabulary of the concepts and approaches among participants. The participants then undertook a semi-structured discussion of the QDS (based upon the prototype discussion structure) from their individual perspectives and agreed a state description before the intervention. A systems map corresponding to that state description was constructed. The key transformations were then identified and the post intervention systems map is constructed.

The discussion was recorded and reported back to the participants and a period was allowed for in order for the participants to reflect upon the contents. This period was originally scheduled to be 2 weeks, but participant availability meant that it became 25 days.

This was followed by the second workshop, in which the participants contributed their reflections in terms of the changes that had occurred and their experience of the process of change. They then develop the instrument (based upon the prototype instrument), identifies the complexity perspectives that they would consider relevant to the management challenge, applied that instrument on a pre-intervention and post-intervention perspective and reflected upon the change in management and management challenge according to that instrument.

The record of the discussions was collated by the researcher in the form of a review report that captured the points raised during the discussion while maintaining the integrity of the shared description of the QDS developed in the workshops. The structure of the QDS description followed a standard format that had been agreed with the participants. This QDS description took approximately four weeks to construct and required the researcher to solicit clarifications from individual participants during the construction.

In the final workshop, the review report was presented and reviewed by the participants to ensure its validity. The review included reflection on key observations made in the QDS description and these were then modified or extended to reflect participant views. This was also an opportunity for the participants to add or clarify observations for discussion and inclusion in the QDS description. The instrument was also reviewed and the change from the previous measurement discussed, explanations sought and reconciled.

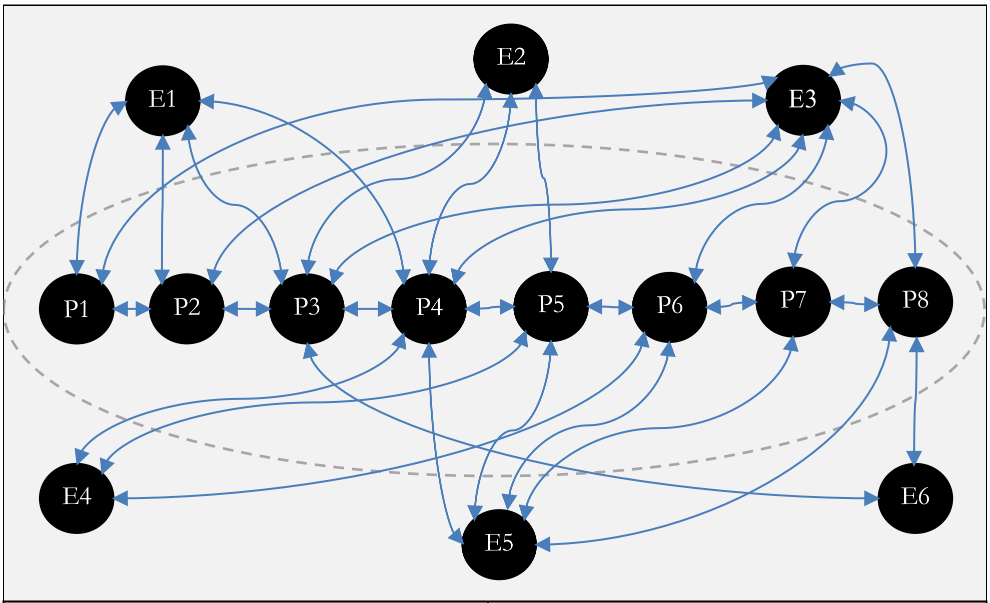
The participants signed off the amended review report as being representative of the QDS being reviewed. The points salient to this research were then abstracted out of the report into this QDS description.

6.2.3 Findings

AB has been involved in several mergers and acquisitions, driven by the need to scale, to acquire new products and services or to enter new geographies. In each QDS such mergers and acquisitions have exposed AB to a growing ecosystem of new processes and technologies, new products and services, and new regulatory environments. Integrating these with the existing process infrastructure has been complex and challenging and not always successful and has resulted in a complex and expensive infrastructure (**H2)**.

A key competitive advantage for AB is its rapid innovation of specialised multi-asset, multi-jurisdiction products, and ability to offer these through a multitude of wrapper arrangements. Along with the many mergers and acquisitions in its history, this has led to a complex product and service set in a complex operating environment **(H2)**.

While at a high level the process is straightforward and well defined in practice it is complex because of (a) the dynamism in the product set and the ecosystem (particularly the regulatory environment), (b) the nature and number of dependencies within the set of products and services, and (c) the asynchronous demands on the process by external entities that makes an integrated response challenging.



Entities external to system	Processes internal to system
E1. Market Research	P1. Requirements Management
E2. External Product Providers	P2. Prioritisation
E3. Client Relationship Managers	P3. Formulation
E4. Statutory Agencies	P4. Validation
E5. Compliance and Audit	P5. Authorization
E6. Finance and Accounting	P6. Publication
	P7. Distribution
	P8. Monitoring

Figure 7: QDS Investigation 1 - AB - System map pre-intervention

There have been many attempts to improve the process. These can be classified as (a) restructuring – reassigning ownership of the process to different functions such as marketing, finance, operations etc. (b) reorganisation – specialising and rationalising work descriptions, roles and responsibilities within the process, (c) process re-engineering – particularly using six sigma methodology, (d) systems integration between application involved, and (e) outsourcing the whole process. These have not achieved desired results (**H6 (2))**. The system map pre-intervention is depicted in Figure 7

Most of the information exchanged between the processes and external entities relate to the state of the product or service in question. However, development of that information involves keeping track of and processing the dependencies that exist between the products and services.

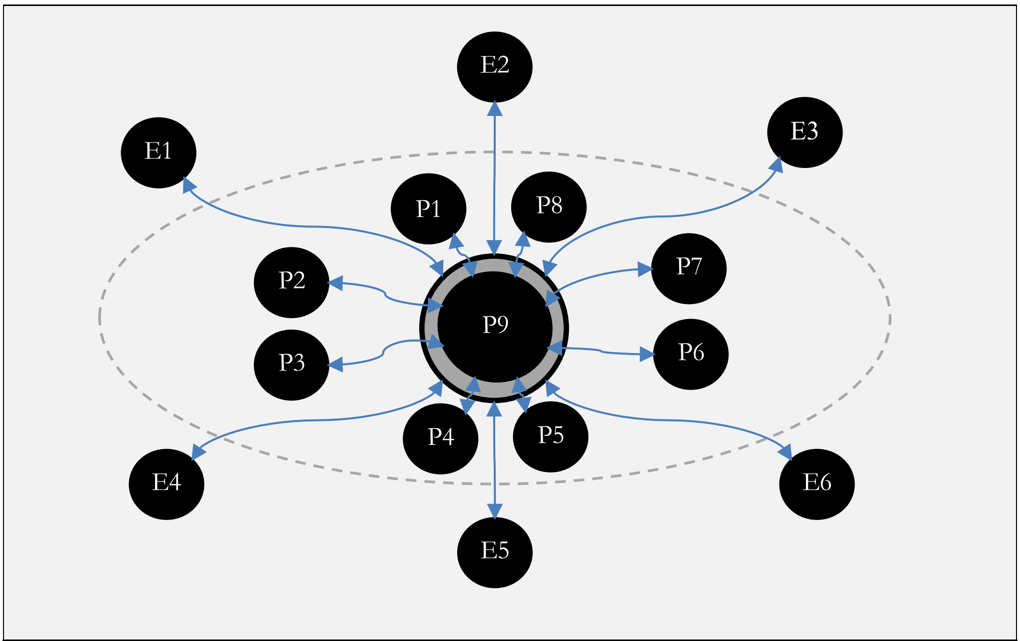
Since the product / service set is highly dynamic and the nature of information for a particular product is affected by the information associated with the dependencies (which can change asynchronously), information needs to be discovered and reassembled essentially on a per transaction basis. This is the fundamental problem which makes the process challenging to manage, and demonstrate the characteristics identified in Table 1: Regular v/s Knowledge Intensive Business Processes.

The focus of the intervention was therefore the management of the information associated with the product / service set as a whole, and in particular, keeping track of the information related to the dependencies between products and services with the set in an integrated and consistent way.

This required the creation of a knowledge architecture that could model the product/service set and its dependencies, coupled with a knowledge management infrastructure that could address the acquisition/storage/retrieval and integration issues in applying that knowledge architecture. The architecture takes the form of a network where the products / services are nodes, and the dependencies are arcs (**H8)**.

Once the architecture and the management infrastructure were in place, the processes were reorganised into a 'hub-and-spoke' formation, the 'hub' being the product configuration process infrastructure (called the 'product house'). The product house is considered complex because of the dependencies, but it is acknowledged that this complexity always existed – the product house only makes it explicit. The new system map is depicted in Figure 8.

However, the product configuration process itself is complex and challenging for the following reasons (a) the need to standardise vocabulary across stakeholders, (b) dependency on the IT function due to the new application for the 'product house', (c) inability to quickly introduce new information elements as this would need application change, and (d) keeping information synchronised between existing applications and the 'product house' (**H9)**.

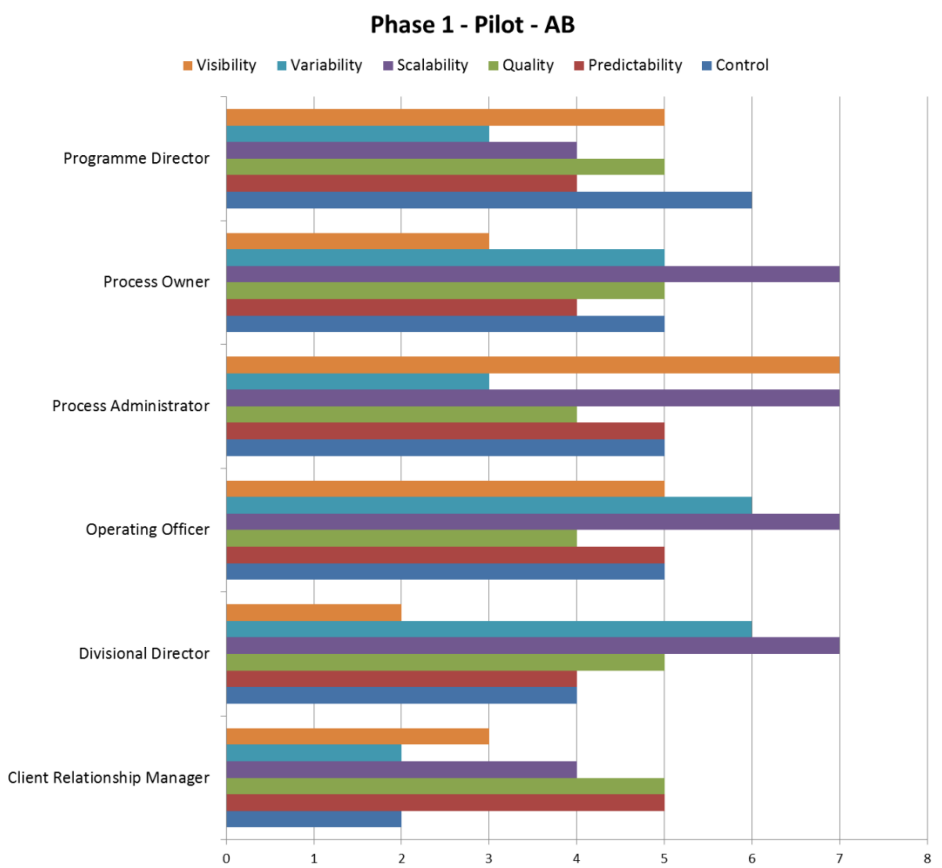


Entities external to system	Processes internal to system
E1. Market Research	P1. Requirements Management
E2. External Product Providers	P2. Prioritisation
E3. Client Relationship Managers	P3. Formulation
E4. Statutory Agencies	P4. Validation
E5. Compliance and Audit	P5. Authorization
E6. Finance and Accounting	P6. Publication
	P7. Distribution
	P8. Monitoring
	P9. **Product Configuration Management**

Figure 8: QDS Investigation 1 - AB - System map post-intervention

The overall process shows a significant positive change in the complexity assessment factors depicted in Figure 9. Simultaneously the process goals have been achieved. It is therefore possible to conclude that the success criterion (**SC**) has been met (**H6 (1))**.

The focus has now shifted to improving individual processes using the six sigma methodology. Some early successes are visible with respect to processes P6 and P7 through the creation of a redesigned portal to replace the existing one (**H7)**, since the earlier portal was also defined through six sigma methodology.



	Client Relationship Manager	Divisional Director	Operating Officer	Process Administrator	Process Owner	Programme Director
Visibility	3	2	5	7	3	5
Variability	2	6	6	3	5	3
Scalability	4	7	7	7	7	4
Quality	5	5	4	4	5	5
Predictability	5	4	5	5	4	4
Control	2	4	5	5	5	6

Figure 9: QDS Investigation 1 - AB - Change in Assessment

6.2.4 Reflections

From the history of AB it is evident that AB as a knowledge intensive business has engaged in ever more complex business ecosystems, and will need to continue to do so. This has resulted in the complexity of the product management also growing with the complexity of the ecosystems[v], with its operation growing ever more challenging (**H2**, **H3)**.

The participants provided their own definitions of the factors identified in the instrument, and after much debate, the participants came to the conclusion that these did adequately reflect complexity, and although the terminology used by individual participants differed, the concepts were essentially the same. Thus no change in the instrument was necessary (**H1**, **C2)**.

AB views the product configuration process as a complex system, the complexity arising for reasons discussed in the findings. The participants used a variety of terms such as 'requirements', 'contracts', 'responses', 'dependencies' etc., to describe relationships, and were clear that it was the number, nature and dynamism of these that made the system complex. The sub-processes were entangled from both, resource and knowledge perspectives, and this made the process as a whole challenging to manage (**H5** (1)).

The earlier attempts to improve the product management process could be interpreted as taking a mechanistic view of the process and clearly did not succeed in addressing complexity as the efforts to improve resource efficiency and scheduling consistency were defeated by the need for agility in meeting dynamic demands. Taken together with mechanistic process models resulting from the pre-intervention attempts at process improvement, this tends to support **H4 (2)**.

In discussing hard process problems, the participants discussed the case of the 'billing process' that was challenging because of different groups working separately on different services and at different cycles. This was addressed by reorganising the resources into a single group and standardising on a single process cycle. The participants agreed that the billing process, while highly intricate, could not be classed as complex as there was little dynamism involved. That is why the intricacies could be resolved into a set of stable rules and a standard cycle. The edge cases were then addressed by adding relevant resources

[v] The Divisional Director related the story of several acquisitions, where the objective was to reduce costs by assimilating superior capabilities, but ended up in increased costs and complexity, and in two cases the acquisition was eventually run as a completely separate operation.

or reviewing the contracts with the customers (sometimes providing discounts to induce them to change to the standard process cycle). In one case a customer chose to leave but that was accepted as a risk. The participants classed activities in the process as simple, and processes as either intricate (complicated) or complex.

AB's approach to addressing the complexity of the process focussed on identifying and managing the entangling knowledge contexts, (the participants called these information dependencies), and the fact that these were in themselves complex made the implementation of the approach challenging. The resulting 'product house' is essentially a set of information fragments connected together in the form of a network. The participants clearly identified that this was complex because of the nature of relationships between the information fragments (**H5)**.

One practical issue that arose was that frustrations arose and considerable time was lost in the participants trying to arrive at a common definition of the factors involved in the assessment of complexity, simply because the researcher had asked for participants to provide their definition of these factors. The researcher clarified that these needed to be defined individually and there was no need to reconcile the definitions as the differences in definitions could in themselves prove to be illuminating. Going forward the researcher would need to clarify this point before discussions commenced.

Theoretical issues concerned with questioning the **Approach** in its current state are discussed below:

1. Identify the complex business process and add to addressed business processes list – AB did not formally carry out this step, nor did it formally identify the product management process as complex. This does not invalidate the **Approach**, since AB had not set out to develop an **Approach**, only to address a challenging process.

2. Identify the entangled processes associated with the complex process and add to process ensemble list – Again AB did not formally carry out this step,

however, the system map shows that their definition of the system did encompass the implicated processes, as the **Approach** suggests.

3. Identify entangled knowledge contexts – AB formally carried out this step, they did not call these knowledge contexts, but information dependencies. The researcher realised that it was much easier to continue the use of participant's terminology rather than impose a foreign one, so long as the underlying concept was clearly understood to be the same.

4. Create a shared knowledge context – AB carried out this step resulting in a 'product house'. However the design process did not formally distinguish process control information from the knowledge context, the separation occurred informally as part of the systems design. In the researcher's view, in terms of the **Approach**, it did not matter when the separation occurred so long as it did at some stage.

5. Reorganise process ensemble to engage with the shared knowledge context – AB formally carried out this step. However, they called the process ensemble the 'product house processes'. Again in the researcher's view, in terms of the **Approach**, the difference in terminology is not significant.

6. Manage the reorganised ensemble – AB formally carries out this step as part of its process management methodology. It does not make any distinction between this process ensemble and other business processes. This does not affect the **Approach** in any significant way.

In summary, the QDS investigation fleshed out the practical aspects of the approach and the instrument, rather than change the approach itself in any significant way (**C1).**

AB implemented their approach by developing a 'knowledge architecture' (framework), a 'product configuration process' (process), and the 'product house' application (toolset). The framework supports definition in the sense that the definition is embedded in the metadata of the underlying database and the application. Evolving scope is managed through database and application changes. It does incorporate domain specific vocabulary, and supports views for each stakeholder perspective. However extensibility is limited and is cause for concern. The remaining problems with the process can be seen as limitations of the framework, process and toolset AB have adopted (**C3)**.

6.3 Pilot Phase - QDS Investigation 2 - MN

6.3.1 Background

MN is an international services provider offering software development, systems integration, programme management, and business process outsourcing services.

The key competitive advantage for MN is its ability to architect and deliver large scale programmes, integrating innovative technologies and processes, including own and external products, and to offer these through a range of options from turn-key deliver, build-operate-transfer, business process outsourcing, and outcome based payment. MN operates in all the major markets world-wide and delivers its services from delivery centres around the world using a delivery model it calls 'right-shoring'. This has led to a complex programme management capability set in a complex operating environment.

MN is familiar with complexity and has made progress in addressing the complexity of project delivery and business process outsourcing processes. Being an early adopter of the CMMI (2010) model[w], through an initiative that the researcher was involved with, MN has a strong quality function co-ordinated by the Operational Review Group, with emphasis on formal process management, and strong capabilities in most well-known process improvement methodologies.

MN have made significant progress in an initiative in managing the complexity of a large scale programme delivery process. This process satisfied all of the characteristics outlined in Table 1: Regular v/s Knowledge Intensive Business Processes, prior to the initiative. Having been involved in the process improvement initiative, the researcher is therefore trusted and familiar with the context.

[w] MN was the earliest organisation in the world to achieve a level 5 assessment from the Software Engineering Institute in both software and people categories.

6.3.2 Procedures

Bearing in mind the need to involve participants from several perspectives and at different levels, the following participants were selected.

Table 19: QDS Investigation 2 - MN - List of Participants

Participant	Role	Selected To Provide
P1	Country Managing Director	Strategic Perspective
P2	Operating Officer	Operational Complexity Perspective
P3	Programme Manager	Change Delivery Perspective
P4	Client Services Director	Process Resourcing, Goals, Outcomes
P5	Project Office Head	Process Complexity Perspective
P6	Account Director	Process (Internal) Client Perspective

The objectives of the QDS discussion were to: (a) build a description of the QDS in terms of a systems transformation, (b) determine the role of complexity and the attributes affected, and (c) draw insights from the experience of the participants, in terms of their perspective on addressing complexity.

This QDS discussion was conducted over two workshops, and a series of one-on-one interviews (either face-to-face or telephonically). All meeting were held at one of MN's offices. During the workshops, representatives from the project office in the programme recorded the discussions as part of their review process, and these were then made available to the researcher.

In the first workshop, the researcher discussed with the participants the basic concepts of complexity, systems thinking, process management, process maturity and change, in order to develop a common understanding and vocabulary of the concepts and approaches among participants. The participants then undertook a semi-structured discussion of the QDS (based upon the prototype discussion structure) from their individual perspectives and agreed a state description before the intervention. A systems map corresponding to that state description was constructed. The key transformations were then identified and the post intervention systems map was constructed.

The discussion was recorded and reported back to the participants and a period was allowed for in order for the participants to reflect upon the contents. This period was originally scheduled to be 2 weeks, but participant availability meant that it became nearly 3 months. The delay was largely because the programme was geographically dispersed, and scheduling a second workshop where all the participants could attend proved challenging. It seemed prudent therefore to extend the period of reflection to fill the gap between the workshops.

This was followed by the second workshop, in which the participants contributed their reflections in terms of the changes that had occurred and their experience of the process of change. They then developed the instrument (based upon the prototype instrument), identified the complexity perspectives that they considered relevant to the management challenge, applied that instrument on a pre-intervention and post-intervention perspective and reflected upon the change in management and management challenge according to that instrument.

The record of the discussions was collated by the project office representatives. This record was used as the basis of a review report by the researcher that captured the points raised during the discussion while maintaining the integrity of the shared description of the QDS developed in the workshops. The structure of the QDS description followed a standard format that had been agreed with the participants. This QDS description took approximately eight weeks to construct and required the researcher to solicit clarifications from individual participants, and the project office, during the construction.

In the final workshop, the review report was presented and reviewed by the participants to ensure its validity. The review included reflection on key observations made in the QDS description and these were then modified or extended to reflect participant views. The participants also added to or clarified observations for discussion and inclusion in the QDS description. The instrument was also reviewed and the change from the previous measurement discussed, explanations sought and reconciled.

The participants signed off the amended review report as being representative of the QDS being reviewed. The points salient to this research were then abstracted out of the report into this QDS description.

6.3.3 Findings

MN has been involved in several programmes, which have exposed MN to a growing ecosystem of changing customer styles and process maturity, new processes and technologies, new products and services, and new regulatory environments (**H2)**.

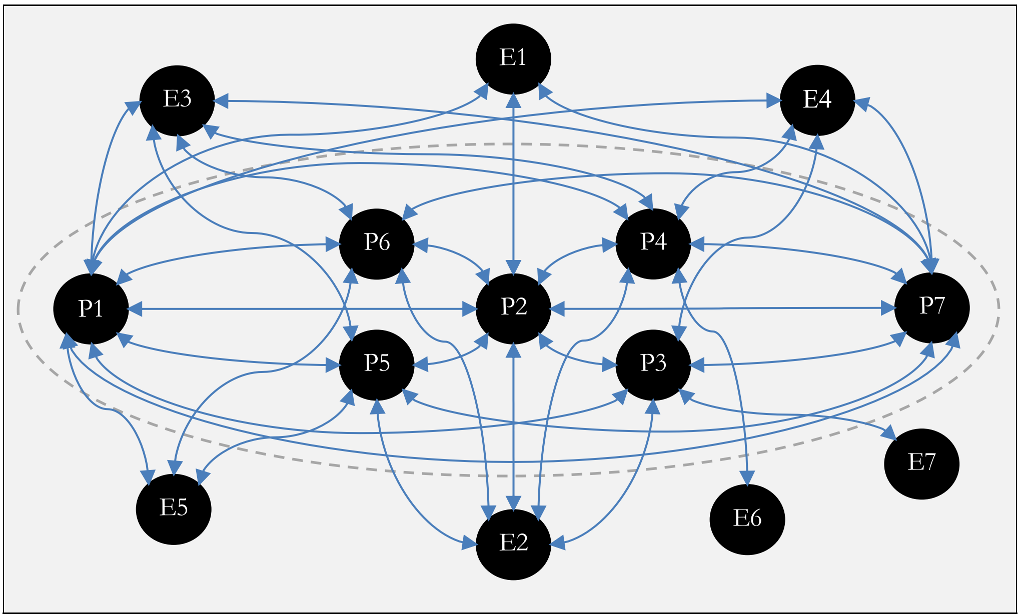
Integrating such change and variety with the standard programme management process has been complex and challenging and not always successful and has resulted in programmes that become increasingly complex and fragmented rather than cohesive and integrated (**H3)**.

All programmes tend to have the same core elements (a) a list of outcomes to be achieved, (b) a list of benefits to be realised, (c) a cost envelope within which the outcomes needed to be achieved, (d) a limited set of resources to deliver the outcomes, (e) a list of projects as delivery vehicles for the outcomes, and (f) risks to the programme that needed to be managed.

Given its long experience of successful programme delivery, the programme management process itself was quite mature and at a high level the process was straightforward and well defined. However, in practice the process became complex, and demonstrate the characteristics identified in Table 1: Regular v/s Knowledge Intensive Business Processes, because of (a) evolving clarity through the course of the programme about its scope and delivery strategy, (b) the nature and number of dependencies within the elements of the programme, (c) dynamism in scheduling, (d) shared resources, (e) multiplicity of stakeholders with different perspective, priorities, availabilities and process maturities, and (f) the asynchronous demands on the process by stakeholders that make it difficult to keep the programme aligned and provide an integrated response (**H3)**.

There have been many attempts to improve the process. These can be classified as (a) restructuring – changing the project portfolio, redefining project boundaries, redefining product scope etc. (b) reorganisation – specialising and rationalising work descriptions, roles and responsibilities within the projects and process variously by skill-set, role, geography, customer and programme type, (c) process re-engineering – particularly using six sigma methodology, and elements of the 'critical chain' methodology (d) systems integration between the various programme, project, portfolio management applications and systems development infrastructure involved, and (e) outsourcing parts of the process to local providers or forming / joining consortia to access capabilities. These have not produced the desired results (**H4 (2))**.

Most of the information exchanged between the processes and external entities relate to the state of the programme or specific element thereof. However, development of that information involves keeping track of and processing the dependencies that exist between the various elements. Since the elements are highly dynamic and the nature of information for a particular element is affected by the information associated with the dependencies (which can change asynchronously), information needs to be discovered and reassembled essentially on a per-perspective and per-request basis.



Entities external to system	Processes internal to system
E1. Programme Review Board	P1. Programme Direction
E2. Customer Departments Involved in programme	P2. Project Direction and Delivery
E3. Client Services Function	P3. Programme Benefits Management
E4. Account Management Function	P4. Programme Cost Management
E5. Operational Review Group	P5. Programme Risk Management
E6. Finance and Accounting	P6. Programme Resource Management
E7. Customer Communications	P7. Programme Monitoring and Reporting

Figure 10: QDS Investigation 2 - MN - System map pre-intervention

However coherent decision making (which is essential to keep the programme aligned) requires that all such information be at all times both consistent and reasonably complete. Meeting both objectives is the fundamental problem which makes the process challenging to manage. The focus of the intervention was therefore the management of the information associated with the elements of the programme as a whole (**H5)**. The system map pre-intervention is depicted in Figure 10

This required the creation of an information architecture that could model the dependencies between the elements in the programme, coupled with a programme information management infrastructure that could address the acquisition/storage/retrieval and integration issues in applying that information architecture. The information architecture takes the form of a directed graph that models the 'programme map', where the outcomes are nodes, and the projects are directed arcs. Risk classes, benefit classes and individual resources are also modelled as nodes. Risks associated with projects are modelled as arcs between risk classes and the specific project. Similarly benefits are modelled as arcs between benefit classes and specific outcomes. Individual resources are attached to specific projects as arcs reflecting their availability and role during the attachment. This information architecture simultaneously allows updating or extending the network at any point, assessing the impact of change through the network and reporting consistently on the network as a whole (**H9, C3)**.

Once the architecture and the management infrastructure were in place, the processes were reorganised into a 'star' formation, the 'core' being the programme alignment process, which replaced the programme monitoring and reporting process. The new programme alignment process incorporates the programme information management infrastructure (called the 'programme repository'). The complexity of the 'programme repository' essentially reflects the complexity of the programme itself[x].

The new system map is depicted in Figure 11 (**H8)**.

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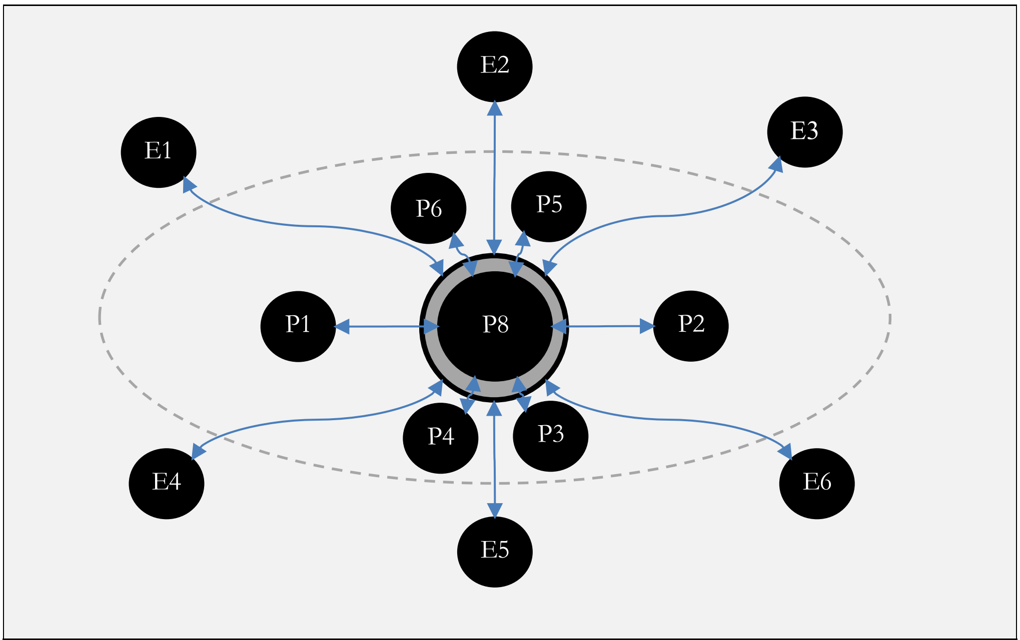
[x] MN measure this as the number of distinct paths through the network

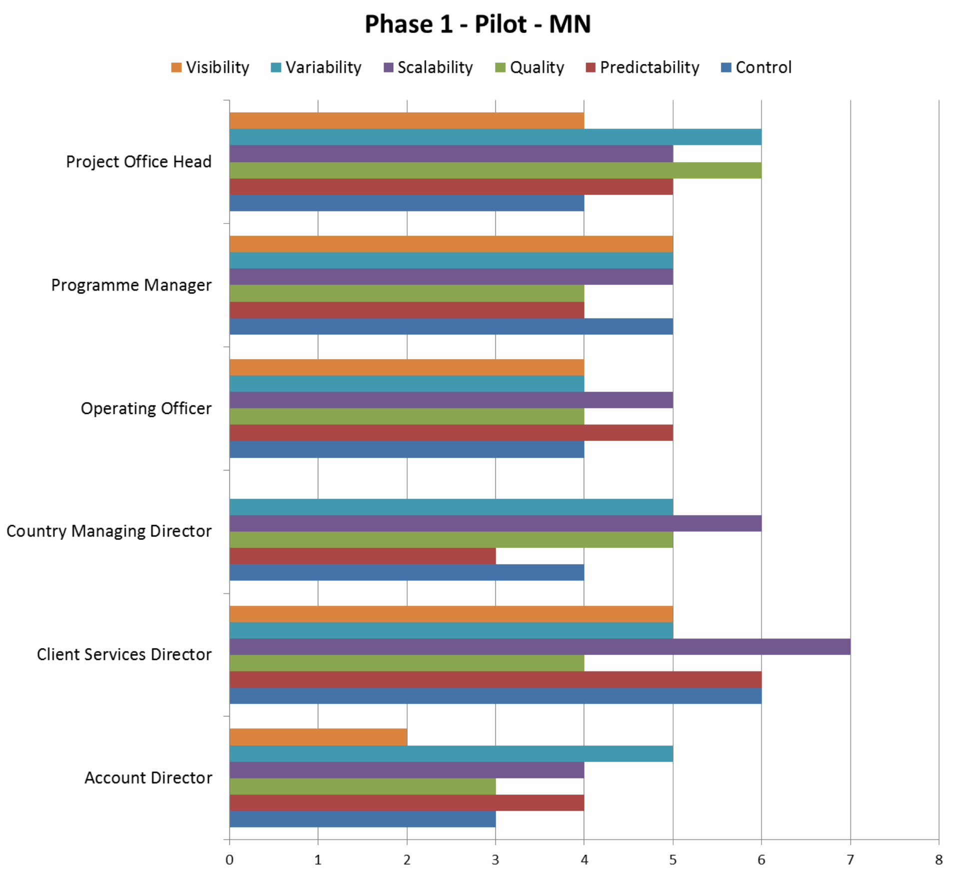


Entities external to system	Processes internal to system
E1. Programme Review Board	P1. Programme Direction
E2. Customer Departments Involved in programme	P2. Project Direction and Delivery
E3. Client Services Function	P3. Programme Benefits Management
E4. Account Management Function	P4. Programme Cost Management
E5. Operational Review Group	P5. Programme Risk Management
E6. Finance and Accounting	P6. Programme Resource Management
E7. Customer Communications	~~P7. Programme Monitoring and Reporting~~
	P8. **Programme Alignment**

Figure 11: QDS Investigation 2 - MN - System map post-intervention

The intervention shows significant positive change in the complexity assessment factors depicted in Figure 12. Simultaneously the process goals have been achieved. It is therefore possible to conclude that the success criterion (**SC**) has been met (**H6 (1))**. MN is now concentrating upon improving the interface between programme direction and project delivery through P2 using its in-house methodology. Some early successes are visible with respect to alignment and responsiveness of projects to programme changes (**H7)**.

However, the programme alignment process itself is complex and challenging for the following reasons (a) the need to maintain multiple perspectives and vocabulary across stakeholders, (b) 'programme repository' becoming a new single point of failure, (c) inability to quickly enhance repository with new information elements, (d) 'bridge' between other programmes and resource pools and (d) keeping information synchronised between existing applications (requirements management, PMO) and the 'programme repository'.



	Account Director	Client Services Director	Country Managing Director	Operating Officer	Programme Manager	Project Office Head
Visibility	2	5	0	4	5	4
Variability	5	5	5	4	5	6
Scalability	4	7	6	5	5	5
Quality	3	4	5	4	4	6
Predictability	4	6	3	5	4	5
Control	3	6	4	4	5	4

Figure 12: QDS Investigation 2 - MN - Change in Assessment

6.3.4 Reflections

From the background in the QDS description of MN it is evident that MN as a knowledge intensive business and the nature of its business model has driven its engagement into ever more complex business ecosystems, and will continue to do so. This has resulted in the complexity of the programme management process also growing with the complexity of the ecosystems[y] (**H2)**.

[y] MN actively measures the complexity of its programmes and that measurement forms part of the positioning of its distinctive capability and also the incentive schemes for its programme managers.

MN views the programme management process as a complex system, the complexity arising for reasons discussed in the findings. The participants tended to use the term 'dependencies' to describe relationships[z], and were clear that it was the number, nature and dynamism of these that made the system complex. The sub-processes were entangled from both, resource and knowledge perspectives, and this made the process as a whole challenging to manage (**H4 (1), H6 (1))**.

The participants could readily distinguish and provide examples of programmes and projects that could be adequately managed through scaling of resources and sequencing of activities[aa], and those that could not[bb]. They had no difficulty in relating to the latter as being complex. They described their earlier attempts to improve the programme management process as 'turning the process into a software application', which could be interpreted as taking a mechanistic view of the process. They were clear that this approach did not succeed in addressing complexity as the efforts to improve resource efficiency and scheduling consistency were in conflict with the dynamism in the programme environment (**H4 (2), H6 (2))**.

MN's approach to addressing the complexity of the process focussed on identifying and managing the entangling knowledge contexts, (the participants called these 'dependencies'), and the resulting 'programme repository' is essentially a set of information fragments connected together in the form of a network. The participants clearly identified that this was complex because of the nature of relationships between the information fragments (**H5)**.

MN implemented their approach by developing an 'information architecture' (framework), a 'programme alignment process' (process), and the 'programme repository' application (toolset). The remaining problems with the process can be seen as limitations of the framework, process and toolset MN have adopted (**H9, C3)**.

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[z] This probably reflected their strong software and systems engineering background

[aa] They called these 'painting by numbers' or 'making movies' projects respectively, and informally 'clean' and 'dirty' projects

[bb] They called these 'quest' or 'fog' projects, and informally 'nasty' projects

One practical issue was in managing the considerable tension which arose between the country managing director and the operations officer during the discussion on complexity. The country managing director interpreted complexity as an indicator of the lack of clarity, competence or discipline in the programme management function, and therefore something to be eliminated (a strongly 'mechanistic' view)[cc]. The operations officer on the other hand saw complexity as the state of reality, which needed to be recognised and managed appropriately. Consequently, the country managing director, while acknowledging the progress made, saw it not so much as a different approach as the programme management function 'finally getting its act together' (**H1).** Given his seniority, this attitude impacted the quality of the discussion in the workshops, and in several cases the researcher could only glean the detailed thinking of the participants through one-on-one conversations. However, apart from recognising this risk and attempting to manage it, it was hard to see how the Methodology could be changed to eliminate it.

The participants provided their own definitions of the factors identified in the instrument, and agreed that these did adequately reflect complexity, and although the terminology used by individual participants differed, the concepts were essentially the same (**H1, C2)**.

MN have identified other programmes and the requirements management, product development and systems engineering processes as adjacent to the current process, but their current toolset limitations prevent them from simply extending the current approach to addressing those processes. Consequently, they suggested the inclusion of 'extensibility' as a factor as they saw that as a key limitation of their strategy for addressing complexity. By 'extensibility' they meant the 'ability to incorporate elements not initially within the scope of the programme repository'. However, the researcher views 'extensibility' as a property of the toolset MN chose to implement their knowledge infrastructure,

[cc] The country managing director came from a manufacturing background in the automotive industry where most of the production processes would indeed be amenable to a mechanistic view, and he consistently transferred that thinking to programmes as standardised processes that should be engineered to 'produce' benefits consistently and efficiently.

and not a complexity factor. Therefore, 'extensibility' is not added to the list of factors that form the instrument.

Theoretical issues concerning the **Approach** are discussed below:

1. *Identify the complex business process and add to addressed business processes list* – MN did not formally carry out this step, but it did formally identify the programme management process as complex (or 'nasty' in its informal terminology). In the researcher's opinion, this does not invalidate the **Approach**, since MN had not at that time set out to develop an **Approach**, only to address a challenging process. In any case, having addressed programme management, MN is rolling out the strategy to other programmes and reviewing other business processes to see if they fit the same pattern.

2. *Identify the entangled processes associated with the complex process and add to the process ensemble list* – Again MN did not formally carry out this step. However, the system map shows that their definition of the system did encompass the implicated processes as suggested by the **Approach**

3. *Identify entangled knowledge contexts* – MN formally carried out this step, they did not call these knowledge contexts, but dependencies. The change in terminology is not significant in terms of the **Approach**.

4. *Create a shared knowledge context* – MN formally carried out this step resulting in a 'programme repository'. The change in terminology is again not significant in terms of the approach.

5. *Reorganise process ensemble to engage with the shared knowledge context* – MN formally carried out this step; however they call it the programme oversight process. Again the change in terminology is not significant.

6. *Manage the reorganised ensemble* – MN formally carries out this step, but only as part of its overall programme management methodology. This is not significant in terms of the approach, so long as the step is carried out.

In summary, the QDS investigation fleshed out the practical details of implementing the **Approach**, and identified the fact that limitations in the framework, process and toolset can impede the **Approach** (**C1, C3).**

6.4 Review of Pilot Phase

In both QDSs investigated the entities involved appear to have applied the steps of the **Approach**. They use different terminologies as compared to the **Approach** (and each other). The difference in terminology however is not significant as the underlying concepts are the same. The terminology in use seems to reflect the terminology of the process domain. Therefore, the **Approach** should not insist upon a specific terminology but allow its internal terminology to be mapped to other terminologies and back. In both QDSs the entities studied did not go beyond the core steps of the **Approach**. In the researcher's view, this reflects the difference between two different motivations (a) solving a specific problem, and (b) developing an **Approach** to solving problems of a specific class. This also had the effect of limiting the solution. In both QDSs, the solution developed applied to the specific problem and could not be easily adapted to other similar problems. In both QDSs there was a significant positive change in the complexity assessment which equated to a significant reduction in the management challenge. This would tend to confirm that the **Approach** did have a beneficial impact on the QDSs investigated.

A final observation was that the transformation in the system architecture tended to follow a pattern, from an intricate network of interfaces to a managed hub and spoke arrangement, the hub containing the integrated knowledge contexts. In terms of the **Approach**, there is insufficient evidence to make this a recommendation. Therefore this can only be an observation at this stage.

In summary, there was sufficient evidence of hypotheses and **Approach** validity, and existence of the capabilities identified (see Figure 5) to proceed to phase 2 of the Research – the Development Phase, which is discussed in the following chapter.

Chapter 7: Development Phase

This chapter describes the QDS investigated in the development phase at a greater level of detail. To recapitulate, the objectives of the development phase are fourfold: **(1)** test the hypotheses; **(2)** test and develop the **Approach** after trialling more conventional approaches; **(3)** test the instrument to assess the management challenge; and **(4)** test the existence and need for an information framework, processes and tools. The QDS investigated covers a single problem domain, through four action research cycles (iterations), respectively applying (1) a process maturity approach, (2) a process optimisation approach, (3) a theory of constraints approach, and (4) the **Approach**. The primary methods used are workshops for QDS discussion and review, coupled with the QDS investigation method.

7.1 Background

ST is an organisation with the mission of creating shifts in thinking. Founded in 2003, ST helps businesses understand and manage complexity through crucial thinking and simple actions. In line with its mission, it is natural for ST to be involved in advising organisations managing complex business ecosystems. One such ecosystem is digital money. This is a dynamic ecosystem with a size of over one trillion and a growth rate as high as 54% in some sectors, with a global reach, and a highly knowledge intensive character, which places it right in the sweet spot for ST. This includes all transactions involving value transfer in dematerialised form and includes the dematerialisation, transmission, transformation, storage, accounting, control, security and re-materialisation across organisation and state boundaries.

As a knowledge intensive business ST provides consulting and analytic reporting services to players in this ecosystem. When the organisation started tracking this ecosystem in 2003, if was a simpler ecosystem with very few players, mainly banks and money transfer operators, providing a few well defined services in the mature economies. The process involved in delivering these services was relatively straightforward, with well-defined sources of information, fairly stable research requirements and a stable customer base. However, the ecosystem is now exploding, offering an opportunity to organisations like ST. The challenge lies in finding a way of managing internal processes that is more appropriate to the unfolding complexity of the ecosystem. . These processes satisfy all of the characteristics outlined in Table 1: Regular v/s Knowledge Intensive Business Processes, prior to the initiative. This chapter covers how ST addressed that challenge.

7.2 Procedures

Bearing in mind the need to involve participants from several perspectives and at different levels, the following participants were selected.

Table 20: QDS Investigation 3 - ST - List of Participants

Participant	Role	Selected To Provide
P1	Managing Director	Strategic Perspective
P2	Practice Lead	Operational Complexity Perspective
P3	Marketing Associate	Marketing Perspective
P4	Account Associate	Account Research Perspective
P5	Product Associate	Product Management Perspective
P6	Research Associate	Research Process Perspective

The development initiation was conducted over one workshop, which was held at one of ST's offices over web-conference. The workshop was recorded using the web-conference capability and the recording was used by the researcher for further analysis

In the workshop, the researcher discussed with the participants the basic concepts of complexity, process management, process maturity and change. The objectives of the workshop were to (a) develop a common understanding of the concepts and approaches among potential participants, (b) to create a description of the problem to be solved, (c) obtain a baseline assessment of complexity, (d) introduce the action research methodology, and (e) confirm the roles and agreement of the participants for the investigation.

The researcher introduced the concepts of complexity and reviewed with the participants their experience of addressing complexity in other initiatives and the concepts and insights they could leverage for the current initiative. The participants then described the problem from their individual perspectives and agreed a state description. A systems map corresponding to that state description was constructed. A high level definition of the programme to implement the approach was also developed. The programme was signed off by the managing director and commenced immediately. The development was carried out over a period of 6 months. During the development the key transformations were identified and the post intervention systems maps were constructed. All the participants were involved in the development either directly in the programme or as part of its review process.

The development was followed by a development review workshop, in which the participants contributed their reflections in terms of the changes that had occurred and their experience of the process of change. They then applied the instrument post-intervention perspective and reflected upon the change in management and management challenge according to that instrument. This workshop also took place using web-conferencing and was recorded as before.

In the course of the development the researcher had compiled a deep description of the progress of development, in order to construct a review report, along with the record of the discussions in the development review, which was collated by the researcher in the form of a review report that captured the points raised during the discussion while maintaining the integrity of the shared description of the QDS developed in the workshops. The review report took approximately four weeks to construct and required the researcher to solicit clarifications from individual participants during the construction.

In a final workshop, (also using web-conferencing) the review report was presented and reviewed by the participants to ensure its validity. The review included reflection on key observations made in the review report which was then modified or extended to reflect participant views. This was also an opportunity for the participants to add or clarify observations for discussion and inclusion in the review report. The instrument was also reviewed and the change from the previous measurement discussed, explanations sought and reconciled.

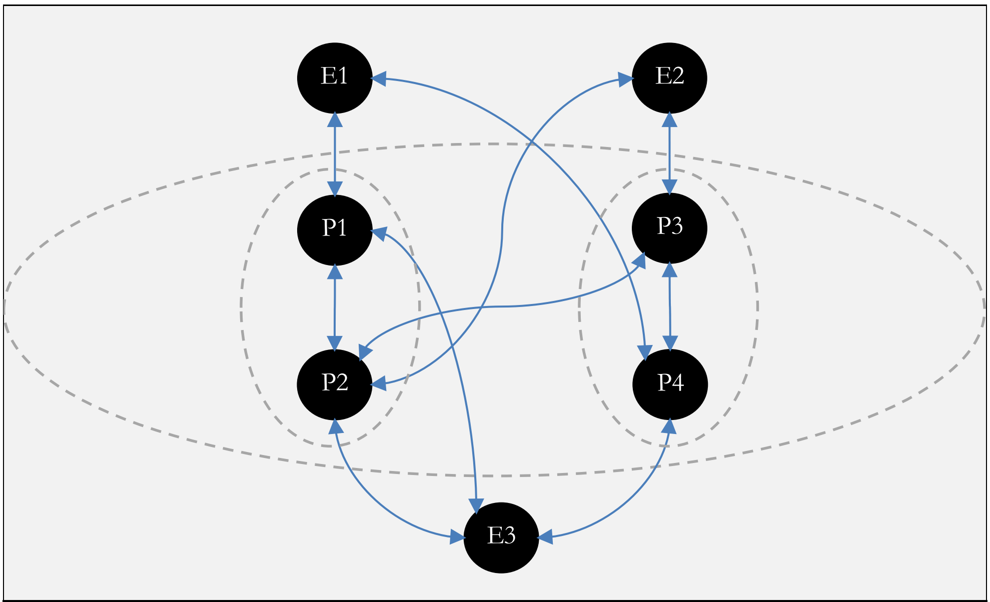
The participants signed off the amended review report as being representative of the QDS being reviewed. The points salient to this research were then abstracted out of the review report into this QDS investigation.

7.3 Problem Description

The advent and ubiquity of the mobile device, and more recently the smartphone, completely transformed the ecosystem which has since exploded in terms of scope of services, geographical distribution, kinds of players and regulatory interventions and the many complex interactions between all of these. As a direct consequence, the stable and predictable business processes of providing few, well defined services have begun to demonstrate the characteristics identified in Table 1: Regular v/s Knowledge Intensive Business Processes, and can no longer cope with the complexity of the ecosystem they must service. The dramatic changes occurring in the ecosystem present an opportunity to organisations like ST since they are far smaller than their competition and less invested in the past. However, the critical success factor is finding a way of managing its internal processes that is more appropriate to the unfolding complexity of the ecosystem (**H2)**.

Given this critical success factor, in order to achieve its goal ST must address several challenges: (a) Agility - ST must ensure that its processes are agile enough to adapt to these changing conditions at relatively low costs, (b) Scalability - ST requires being able to scale up its processes to handle multiple deliverables in parallel, (c) Throughput - ST requires ensuring that its processes are able to sustain high throughput without compromising quality or reliability, (d) Scope - ST needs navigating a complex ecosystem, seeking what is relevant where past history often influences the notion of relevance which calls for a completely different approach to the research process, and (e) Productivity - ST requires the capacity to address these challenges through greater productivity of limited existing resources while protecting the cost and risk of operation and the quality of the operation.

The system map pre-intervention is depicted in Figure 13.



Entities external to system	Processes internal to system
E1. Customers	P1. Agree Terms with customer
E2. Partners	P2. Agree Terms with Partners
E3. Accounting	P3. Deliver work
	P4. Collect fees

Figure 13: QDS Investigation 3 - ST - System map pre-intervention

The initial operating model was also very simple, consisting of only two business processes – Sales and Delivery, and their component processes. Issues arose in the delivery of engagements in the following major areas: (a) the speed of delivery, (b) the quality of the deliverables, and (c) the predictability of the process. Consequently, this led to considerable rework, delays, acrimony in the client and associate relationships and increasing cost and risk to ST.

7.4 Iteration 1: Process Maturity

7.4.1 Diagnosing

Explanations for these problems were examined in consultation with the practice lead and associates. These were: (a) Quality of sale, (b) Competence of the customer, (c) Competence of the practice lead, (d) Competence of the associates, (e) Quality of the process. The quality of the process itself seemed to be the most likely explanation for the problems.

ST focussed on improving process quality using the CMMI (2010) framework for improvement efforts, with the objective of moving the Digital Money practice to the Managed level in order to address the problems in the current engagement as well as future engagements of that kind.

7.4.2 Planning Action

As advocated by CMMI (2010), ST focussed on the following improvement areas (called improvement areas hereon): (a) CM - Configuration Management, (b) MA - Measurement and Analysis, (c) PPQA - Process and Product Quality Assurance, (d) REQM - Requirements Management, (e) SAM - Supplier Agreement Management, (f) SD - Service Delivery, (g) WMC - Work Monitoring and Control and (h) WP - Work Planning.

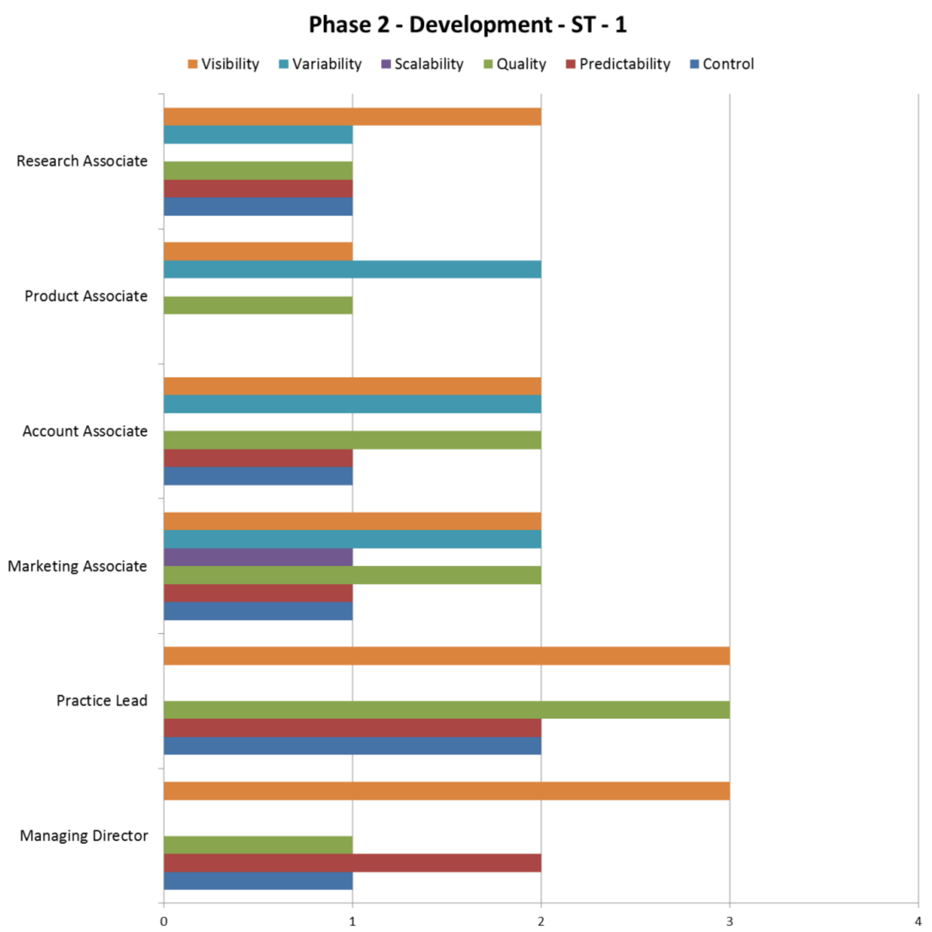
ST decided to limit the scope of the intervention in order to contain risk. The plan consisted of three steps: (1) Elaborate the business process to the appropriate extent, (2) Define and improvement strategy for each improvement area, and (3) Make improvements for each process and its activities impacted by the improvement areas.

7.4.3 Taking Action

While the structure of the business process was retained, each business process was elaborated with respect to processes and their activities within that business process. For each process area, certain strategies for improvement were identified and implemented. For each of the processes, the impacting improvement areas were identified.

7.4.4 Evaluating Action

As a consequence of the intervention, improvements were noted across all the problem areas: (a) The quality of deliverables and the conformance to the process improved considerably, (b) The speed of the business process also improved somewhat as did the predictability, and (c) This led to a reduction in rework and the consequent delays, eliminated the acrimony in the relationships through the transparency provided by the business process and consequently reduced the risk to ST. The resulting assessment of change in complexity is shown in Figure 14



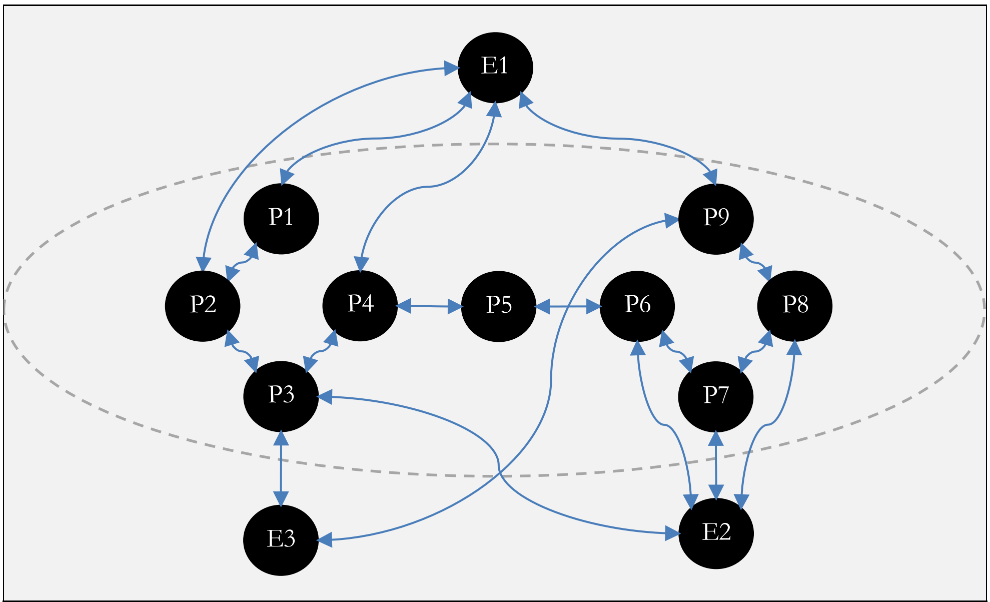
	Managing Director	Practice Lead	Marketing Associate	Account Associate	Product Associate	Research Associate
Visibility	3	3	2	2	1	2
Variability	0	0	2	2	2	1
Scalability	0	0	1	0	0	0
Quality	1	3	2	2	1	1
Predictability	2	2	1	1	0	1
Control	1	2	1	1	0	1

Figure 14: QDS Investigation 3/1 - ST - Change in Assessment

However, a number of problems became evident: (a) The overhead involved in the new operating model added to the cost of the engagement, (b) The practice lead practice lead's time was consumed in managing the operating model, instead of providing expertise, (c) Associates from the client team followed their own processes, and this often led to conflicts which needed resolution, (d) There was little reduction in the number of cycles required to agree requirements and complete deliverables, (e) While the predictability of individual processes did improve the predictability of the cost and duration of the business processes as a whole did not, (f) The operating model was not applicable across all engagements, (g) The scope of the intervention was insufficient to address complete engagements.

Consequently, while there were benefits from the intervention to that engagement, ST could not see this as a sustainable solution in the context of all its engagements. Consequently, despite the improvements made, success criterion (**SC**) was not met (**H4, H6)** with respect to the use of process maturity driven approaches.

The system map post Iteration 1 is depicted in Figure 15.



Entities external to system	**Processes internal to system**
E1. Customers E2. Associates E3. Accounting	P1. Identify customer P2. Define Engagement P3. Define and agree resourcing P4. Agree Terms with customer P5. Commence Engagement P6. Distribute work to associates P7. Execute work P8. Assemble and edit work P9. Deliver work and collect fees

Figure 15: QDS Investigation 3/1 - ST - System map

7.5 Iteration 2: Process Optimisation

7.5.1 Diagnosing

While the Digital Money practice could be considered to have moved to a Managed Level there were problems identified, concerning the ability of the practice to reliably deliver within acceptable quality, time and cost constraints, that needed addressing. The lack of quality of implementation was discounted as an explanation because the assessment was that depth and rigour was sufficient, perhaps overly so. The invalidity of the approach was discounted as an explanation as there were benefits due to better definition of the operating model.

Explanations for the improvements observed were also debated. Both, the improvement in the transparency and quality of interactions, and the reduction in variation of the quality of the deliverable could be ascribed to the learning effect and unfolding clarity, rather than the move to the Managed level. Also as opposed to process information, contextual information, which enabled a shared understanding of the requirement and consequently a context for the activity, was the major source of improvement and it was impacted more by unfolding clarity rather than the process itself.

The scope of intervention was found to be insufficient as there were dependencies in terms of resources, research and synchronisation from business processes in other parts of engagements. Engagements also differed, and a single common process model was not viable.

It was necessary to distinguish between production and delivery as separate business processes because: (a) Production involved interactions almost exclusively between ST and its associates while delivery involved interactions between ST and the customer, (b) Production and delivery operated on different cycle times, and (d) Production was far more under the control of ST while delivery was almost entirely determined by the customer once production was deemed complete.

7.5.2 Planning Action

Consequently, ST focussed on two goals, redefining the operating model to recognise and address the observations made and optimising it to address the problems identified. The approach agreed was to use the principles of lean to eliminate wastage, use agile to promote time-boxed iterations and adaptive planning between ST and its associates and to the Six Sigma DMAIC methodology as a framework to guide the work of optimisation.

The strategy had three key elements: (a) Moving from Process to Project Centricity - defining a common "meta" operating model template, and make only the minimum necessary modifications to the "meta" template processes as needed in order to deliver different engagements, (b) Scaling up of resources to meet demand, (c) Synchronising all processes and activities to a "heart-beat" set by the practice lead for all engagements, and (d) Capturing all contextual information in a document accompanying each work package.

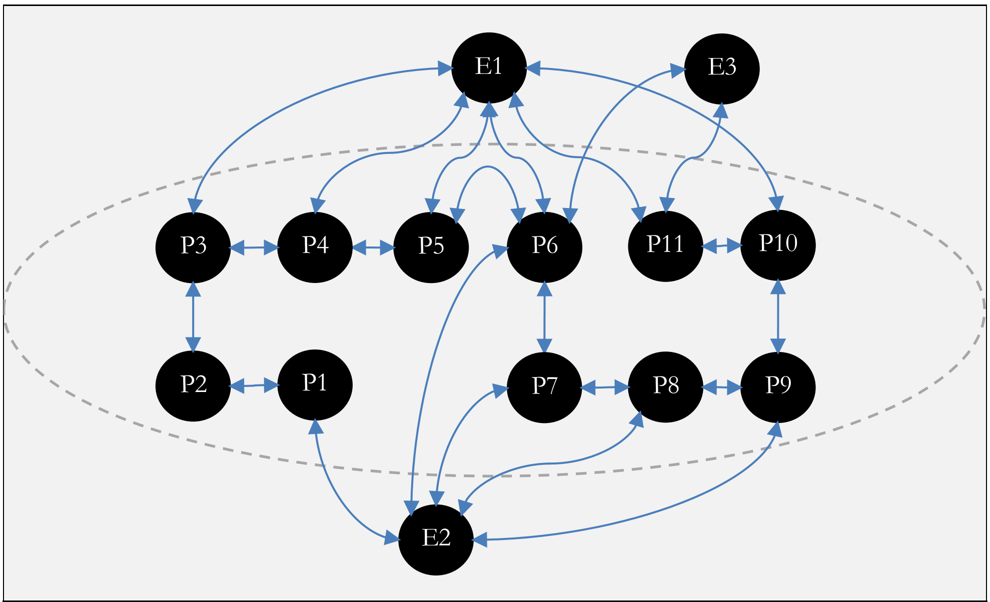
7.5.3 Taking Action

The operating model was modified to recognise activities involved in Marketing and Production. Business processes and strategies for improvement for each improvement area were identified and implemented, as were metrics to support analysis, improvement and on-going control of the process.

7.5.4 Evaluating Action

Most of what was measured did improve, particularly at the level of individual activities, although that did not necessarily translate into improvement at the process level. The system map is depicted in Figure 16.

However a number of problems arose: (a) as a consequence of becoming the synchronising agent and orchestrator for all engagements, the Practice Lead became the single point of failure, (b) a vital asset in terms of the Practice Lead's own knowledge and experience became unavailable, (c) the approach of scaling resources and work-packages in order to achieve synchronisation resulted in both, co-ordination effort and cost exploding, (d) this also led to major project overhead for relatively few activities; and a general feeling shared by the practice lead and the associates that the arrangement was "too complex", (e) due to the fragmentation and distribution of the work-packages, opportunities for synergies, time savings were now missed, and (f) there was little learning across engagements.

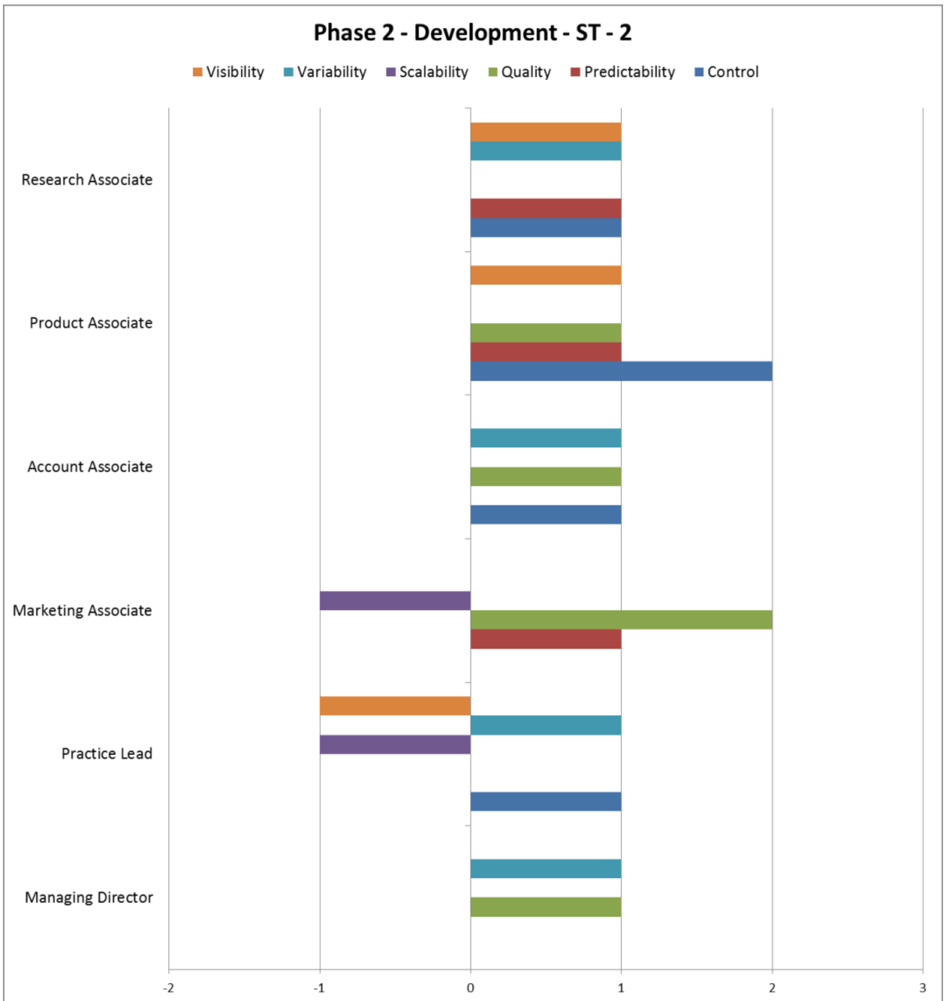


Entities external to system	Processes internal to system
E1. Customers E2. Associates E3. Accounting	P1. Select Conferences and Topics P2. Develop presentations, blogs, brochures P3. Make presentations, compile contacts P4. Qualify – Research and track contacts, determine interest, organise meeting and present credentials P5. Define Engagement – Determine requirements, Define deliverables, Construct proposition P6. Define and agree resourcing and agree terms with customer P7. Distribute work to associates P8. Execute work P9. Assemble and edit work P10. Compile and Present deliverable, Manage Changes P11. Signoff and collect fees

Figure 16: QDS Investigation 3/2 - ST – System map

Finally the strategy for capturing contextual information failed, because (a) the Practice Lead, who was responsible for processing the information did not have time to deal with it in addition to co-ordinating the engagements, (b) it was difficult to anticipate what would be contextually relevant without further conversations and the process of unfolding clarity, and (c) there was no framework to assimilate the various context documents produced so no value could be mined beyond the activity and they ended up being filed and forgotten.

Consequently, despite the improvements made, success criterion (**SC**) was not met (**H4, H6)** with respect to the use of process optimisation driven approaches. The resulting assessment of change in complexity is shown in Figure 17



	Managing Director	Practice Lead	Marketing Associate	Account Associate	Product Associate	Research Associate
Visibility	0	-1	0	0	1	1
Variability	1	1	0	1	0	1
Scalability	0	-1	-1	0	0	0
Quality	1	0	2	1	1	0
Predictability	0	0	1	0	1	1
Control	0	1	0	1	2	1

Figure 17: QDS Investigation 3/2 - ST – Change in Assessment

7.6 Iteration 3: Managing Constraints

7.6.1 Diagnosing

While the value of metrics and measurement was acknowledged, there was complete consensus that the intervention had made the process as a whole complex and unmanageable. This was in conflict with both, the established view of approaches such as Lean, Agile and Six Sigma, as well as ST experience of applying these in business environments. A peer review could find little to fault in the application of the techniques, or the combination of approaches adopted. Therefore, ST decided to directly understand and try to address the issue of complexity.

In trying to define complexity as it related to the process, no common definition could be agreed, but several process attributes were suggested and these were organised into four categories: (a) characteristics, (b) comprehensibility, (c) behaviour, and (d) consequences. This tends to support **H1**. In identifying complexity in the operating model, a key insight was that not all processes in the operating model were complex in terms of the attributes listed earlier. Therefore the following classification was adopted in describing processes: (a) Simple, (b) Complicated, (c) Complex, and (d) Chaotic.

In attempting to understand why complex processes deviated from their models and how that deviation affected the stability of the process, ST found that this occurred when (a) there were resource constraints e.g. when the same associate was attempting to simultaneously work on multiple work packages and prioritisation became necessary, (b) one associate waited upon research from another associate, and in order to maintain the flow of work, the associate would reprioritise and optimise a combination of work packages, (c) determining the knowledge context was itself a process of unfolding clarity. (ST identified three cases, which it called Information Case, Knowledge Case and Judgement Case)

In defining management of complexity, ST identified that the process instances were not just connected by the input and output dependencies defined by the model but were entangled in more subtle ways due to resource constraints, synchronisation issues and knowledge context inadequacies, and the management challenge was therefore correlated with the degree of entanglement which in turn represented the complexity of the process. The best way therefore to address the management challenge was to transform the complex processes to at best simple ones or at least complicated ones, by eliminating resource constraints, synchronising processes and removing the dynamic nature of the knowledge context. The business model dictated that the resource constraints could not be moved. However synchronisation could be achieved by identifying the constraining process and subordinating all remaining processes to it as advocated by the theory of constraints. This would also have the effect that the dynamism in the knowledge context of one instance would be contained within the constraining process and not cascaded.

7.6.2 Planning Action

Therefore, the intervention strategy was to apply the theory of constraints. In the context of the Digital Money practice, the operating model can be considered a system which is composed of a collection of processes. The strategy is therefore to apply the focussing steps to the operating model with the goal of maximising the throughput of the operating model by maximising the throughput of its constraining process. The steps were: (1) **Identify** the operating model's constraints, (2) Decide how to **Exploit** the operating model's constraints, (3) **Subordinate** everything else to above decision, (4) **Elevate** the operating model's constraints, and (5) If in the previous steps a constraint has been broken, go back to step 1.

7.6.3 Taking Action

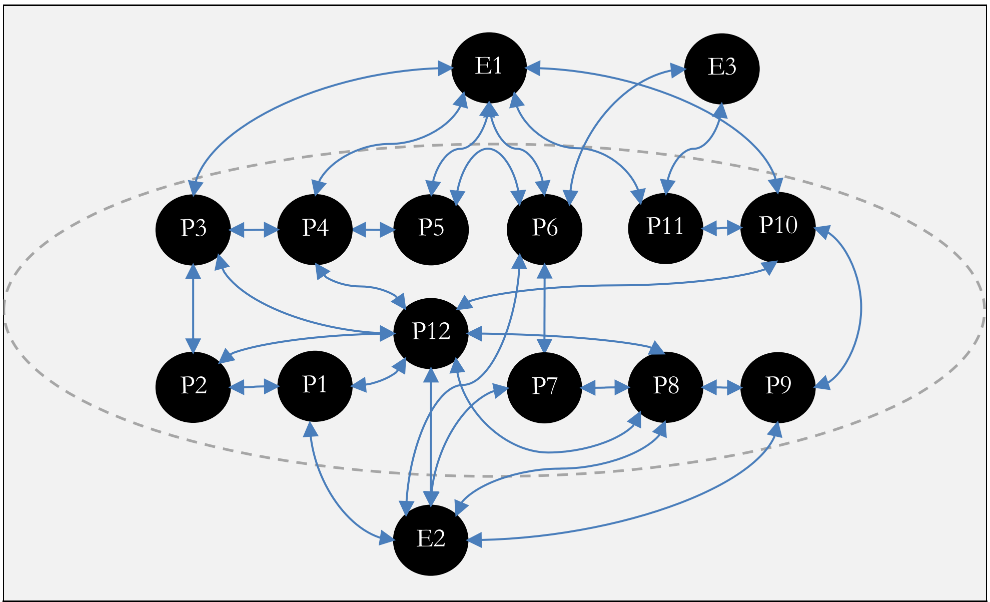
In Step 1- **Identify**: Research was identified as the constraining constraint, an undefined but key business process that was implicitly invoked by many of the processes and their activities, and carried out by almost all roles in the course of executing their work packages. In Step 2 - **Exploit**: Having identified all the contexts in which research needed to be carried out, a standardised process was created which could be applied in all of these contexts and provide appropriate tools provided. In Step 3 - Subordinate: The operating model was modified appropriately, the research business process was explicitly added to the operating model and research activities in all processes were changed to invocations of the research process with appropriate context document and interface. In Step 4 – **Elevate**, all the research capacity in terms of research associates was unified into a single, permanently available research "Capability" and all invocations for research from every process including itself was routed through a single "Pipeline" within which priority was controlled by the practice lead. This gave the practice lead clarity in terms of the research inventory, available research capacity and projected lead times, which helped the practice lead adjust priorities within the pipeline. Step 5 did not apply at this time.

7.6.4 Evaluating Action

There were several benefits to implementing this approach and these became apparent very quickly. First there was definite reduction in operating complexity as a consequence of less fragmentation, lower number of work products, fewer interfaces, fewer dependencies, greater visibility of work inventory and fewer control points to affect the flow of work. Second, as predicted by the theory of constraints, work did flow more freely. This resulted in reduced load on practice lead and reduced overall costs due to much more efficient utilisation of resources.

However there were some serious drawbacks and some of these were crippling to the business model. The nature of the consulting business is such that, within a reasonable range, engagements arrive at random intervals and are of random sizes and durations. While it is possible to predict average demand and therefore average capacity in the long term, it is impossible to do so in the short term. The consequence of this intervention resulted in the operating model being designed around a relatively fixed capacity whose throughput was maximised. This had several consequences: (a) the operating model was not flexible, in that it did not distinguish between short and long engagements and urgent and longer term deadlines, (b) the model was not easily scalable, in that it was not easy to flex capacity, (c) the model was also not agile, in that it was designed around a known set of topics, which determined the choice of associates based upon their knowledge and skills in specific areas and could not be easily extended, (d) the model did not improve predictability to the extent acceptable to customers, and (e) the model became inefficient because of continued duplication of work and synergies could not be exploited, despite standardised and shared context documents.

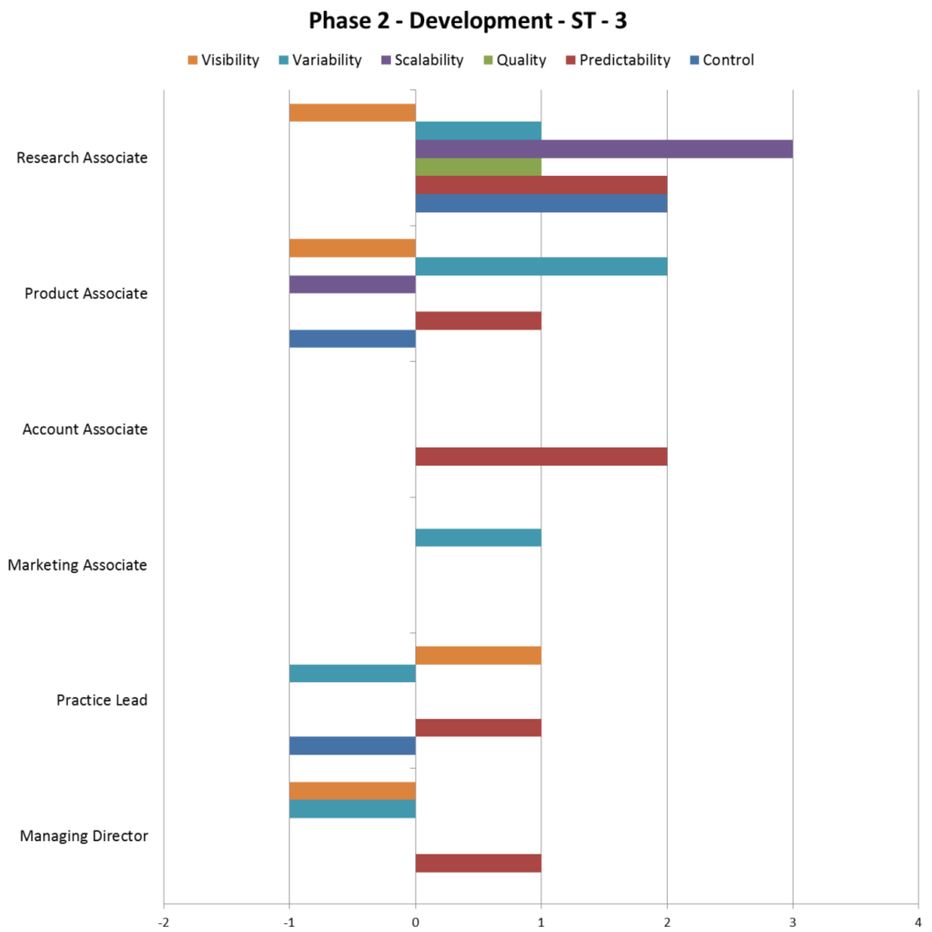
The system map is depicted in Figure 18.



Entities external to system	Processes internal to system
E1. Customers E2. Associates E3. Accounting	P1. Select Conferences and Topics P2. Develop presentations, blogs, brochures P3. Make presentations, compile contacts P4. Qualify – Research and track contacts, determine interest, organise meeting and present credentials P5. Define Engagement – Determine requirements, Define deliverables, Construct proposition P6. Define and agree resourcing and agree terms with customer P7. Distribute work to associates P8. Execute work P9. Assemble and edit work P10. Compile and Present deliverable, Manage Changes P11. Signoff and collect fees P12. Research – Scan, Process and Provide

Figure 18: QDS Investigation 3/3 - ST - System map

The resulting assessment of change in complexity is shown in Figure 19



	Managing Director	Practice Lead	Marketing Associate	Account Associate	Product Associate	Research Associate
Visibility	-1	1	0	0	-1	-1
Variability	-1	-1	1	0	2	1
Scalability	0	0	0	0	-1	3
Quality	0	0	0	0	0	1
Predictability	1	1	0	2	1	2
Control	0	-1	0	0	-1	2

Figure 19: QDS Investigation 3/3 - ST – Change in Assessment

In summary, the intervention had made the operating model somewhat more efficient for associates, more manageable for the practice lead, but ineffective for customers and ST. This of course made it unacceptable to ST. Consequently, despite the improvements made, success criterion (**SC**) was not met (**H4, H6)** with respect to the use of theory of constraints driven approaches.

7.7 Iteration 4: Managing Complexity

7.7.1 Diagnosing

A review of the intervention concluded that while TOC addressed management complexity, it did so by ignoring key realities. It focussed on resource utilisation by synchronising to research rather than customer needs. This moved the constraint to the sales process and obeying step 5 of the focussing steps advocated by the theory of constraints would have led back to the original model. Therefore it was evident that so long as both resource efficiency and agility were both goals, the current approach of synchronising operating cycles of all the processes was not viable[8].

One key observation was that the actual assembly and delivery of research, although significant and detailed had never contributed to complexity. The challenge that had given rise to the complexity was one of finding the right content available at the right time and editing it out of its original context. In other words, if research could anticipate need then the problem would be solved. Unfortunately this was not possible.

The whole point of ST research is to create knowledge relevant to the customer needs. Therefore the research process needed to produce knowledge that was simultaneously able to address several conflicting objectives: (a) Knowledge responsive to both, events and customer timelines, (b) Isolation of activity but integration of output, (c) In-process knowledge contribution but out-of-process knowledge consumption, (d) Knowledge standardised by vocabulary but referenced by perspective, and (e) Explicit information about entities but tacit knowledge relating entities

7.7.2 Planning Action

The way to address these conflicting objectives was to design a "buffer", containing all the information uncovered, to which information could be contributed as it became available, and from which information could be consumed as it was needed. If such a buffer could be created then the operational definition of the research component of a client engagement would translate to the "gap" in the "buffer" that needed to be filled in order to complete the engagement. Such a "buffer" had to support the following capabilities: (a) Multiple evolving entity classes, (b) Multiple evolving relationship classes, (c) Multiple evolving perspectives, (d) Multiple Knowledge contexts, (e)

Common Vocabulary (ontology), multiple synonyms, (f) Extensibility of entity and relationship classes, (g) Distributed, Federated and Versioned, and (h) Support for capturing related tacit knowledge. Since the "buffer" would become the base for an organised accumulation of information through experience, observation, communication or inference, which the associates could believe and value this buffer came to be called the Knowledge Base. This distinguished it from an information warehouse which was seen as a structured collection of facts.

The existence of such an "inventory" of knowledge, would allow the process of research to be more effectively disentangled from the other business processes by reducing synchronisation and resource dependencies. While this would reduce management complexity, it would result in moving the attributes of complexity as shown in Figure 41: Iteration 3 - Process Attributes of Complexity from the process to the knowledge base. Therefore the focus of managing complexity must shift from process and resource to the complexity of knowledge base itself.

The strategy devised for the intervention consisted of the following steps: (1) Design a knowledge framework to accommodate evolving ontologies (**H9**, **C3**), (2) Design a knowledge base infrastructure to support the digital money ontology and research ontologies (**H9**, **C3**), (3) Design an appropriate research process to contribute to the knowledge base (**H8**), (4) Design the operating model to consume from the knowledge base (**H8**), (5) Align associates, their roles and responsibilities, to the new operating model, and (6) Construct an initial knowledge base to get the process started

7.7.3 Taking Action

Step 1: Designing a knowledge framework: As no assumptions could be made about the kind of entities and relationships that the information structures would be required to support because of the evolving nature of the ecosystem, the solution was to define a "meta" structure using which structures could be defined in a standard way. If the assumptions that the supporting infrastructure made were restricted to the "meta" structure, then it should be able to support any new entities and relationships defined on the basis of that "meta" structure.

The meta structure was devised based upon the following concepts: (1) Information resource (iResource), a set of defined attributes with a unique identifier, (2) Information class descriptions (iClass) as information resources belonging to a special class that identified all the attributes applicable to a specific class, (3) Information attribute descriptions (iAttribute) as information resources, belonging to a special class that identified characteristics of the attributes (e.g. text, numeric, currency, Boolean etc.) and facets (e.g. length of text, precision of numbers etc.), (4) Relationships (iRelationship) as information resources that identified two other resources in a specific order which indicated the direction of the relationship, (5) Inheritance relationships between classes where classes are allowed to inherit attributes from other classes. It was implemented using relational databases and web technologies.

Such an approach enables the following: (a) Multiple, evolving and extensible entity and relationship classes can then be directly be supported in this scheme by letting classes be derived for iResource or iRelationship classes, (b) multiple evolving perspectives can also be supported as a set of nodes that constitute a starting point from which the exploration of the knowledge base can commence, (c) a perspective can map names of certain resources in the knowledge base through the use of aliasing thus supporting synonyms, (d) multiple evolving knowledge contexts can also be supported as a set of nodes that relate a work-package resource to a set of other resources, (e) a definition of the ontology of the knowledge base using the base names of current class structure and attributes and their aliases, (f) distributed concurrent access to a shared knowledge base, (g) federation through each resource having an identified owner, by default the creator, who can specify rights to this resource, (h) controlled access to the resource depending upon rights, (i) versioning and rollback of information resources, (j) capturing tacit knowledge by capturing observations, comments, action request, notes, warnings, guidance etc. as instances of classes derived from iRelationship that relate a user resource to a resource to which that knowledge applies, and (k) controlling change to the structure of the knowledge base and managing the content of federated resource.

Step 2: Designing the knowledge base infrastructure: The knowledge base infrastructure was constructed out of a set of core components to support: (a) Key Actions - including the ability to create new classes based on defined classes, attributes, instances of resources based upon defined classes, Instances of relationships based on defined relationship classes; the ability to modify the content of attributes for an information resource, attributes themselves, classes and their hierarchy; and delete content of attributes for an information resource, attributes in a class, classes themselves and their hierarchy; (b) Scanning topics - (information resources of class Topic) from sources such as periodicals, web searches, library searches and correspondence and tagging related information resources in knowledge base with and its source discovered in the scanning; and (c) Exploring the knowledge base starting with any information resource and following its relationships, keyword and standard searches, standard templates for referencing information etc.

Step 3: Designing an appropriate ST research process: The main difference in designing the research business process was a shift in the goal of the process from predictable fulfilment of specific requests within finite resource constraints to continuous enrichment of the knowledge base while providing access to that knowledge for different needs and at different times. The objective was to decouple the creation of knowledge from its consumption thus disentangling the research process from the other processes in the operating model. The target was to capture up to 90% of information needed for most engagements through this process, so that only the remaining information would require additional resources to fulfil. The business process was designed as a cycle consisting of five processes which was repeated at periodic intervals and on demand within those intervals. These processes are: (1) Monitoring Demand and consumption, (2) Scanning Sources, (3) Determining Significance, (4) Choosing Impacts and (5) Implementing Changes

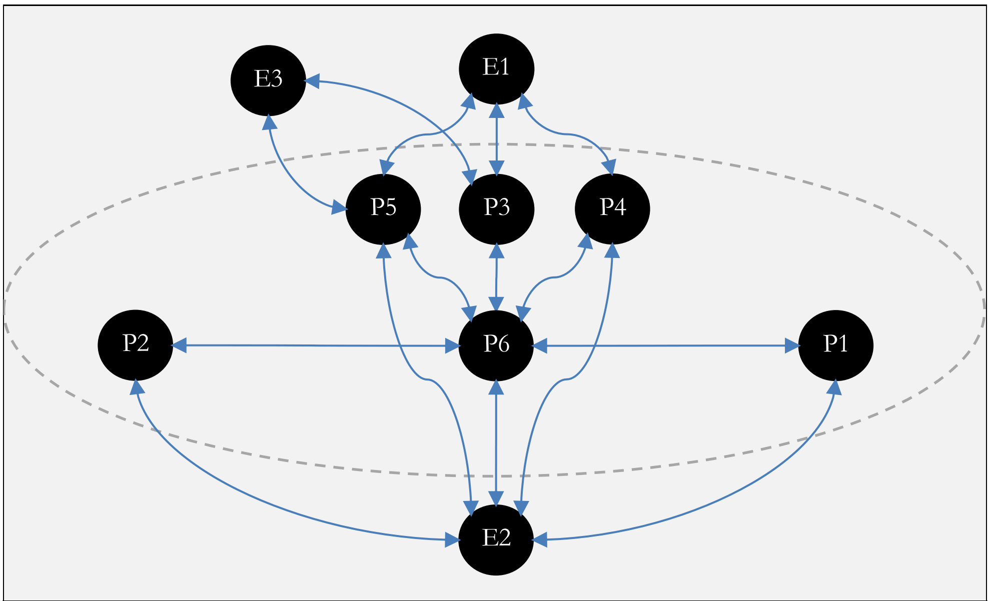
Step 4: Designing the operating model: The new design of the operating model is where the actual disentanglement of research from the other processes is achieved by: (a) Separating process information from ecosystem information and ensuring that all ecosystem information is maintained in the knowledge base, while process information continues to be transferred between processes through control documents or other means as before; (b) Providing capabilities within processes to contribute to or consume from the knowledge wherever appropriate and for whatever appropriate to the process; and (c) Making research a fully-fledged and independent business process and making each business process asynchronous from the others in terms of their operating cycle with synchronisation of work for a specific engagement managed through work packages communicated between interacting processes through prioritised queues.

Step 5: Realigning associates: As a consequence of this operating model, the roles and responsibilities of the associates needed to be realigned. Research associates were no longer responsible for construction of any of the deliverables; they were responsible only for executing steps 3 to 5 of the research process. All other activities were carried out by the practice lead supported by additional resources depending upon the load at that time.

Step 6: Seeding the knowledge base: The success of the approach depended upon having a viable knowledge base with enough information to be able to support the first few cycles of the research process. Recalling that there was considerable information produced, but lying unused in the context documents of earlier engagements, and beginning with a clean version of the knowledge base, each of these context documents were applied to the knowledge base. This led to the identification of a set of classes and a number of entities and relationships that could be seeded into the knowledge base. This proved sufficient to bootstrap the research process.

7.7.4 Evaluating Action

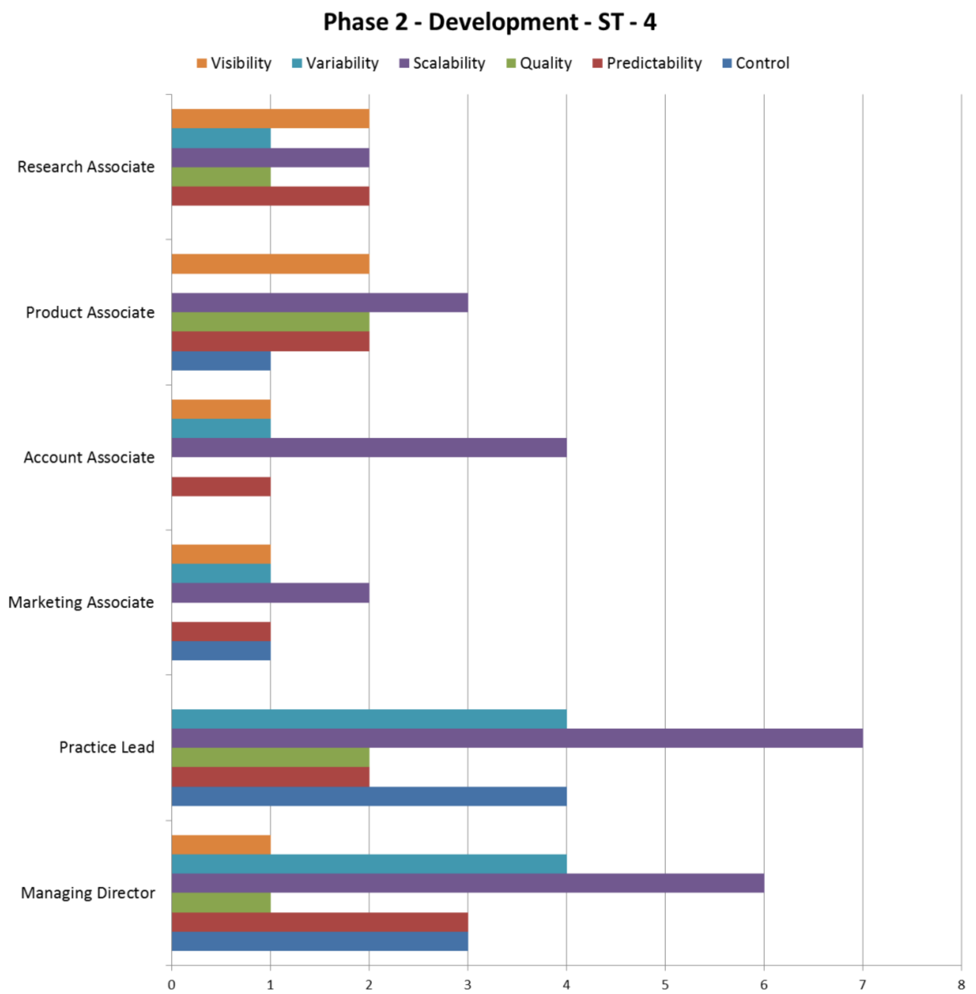
The final system map is depicted in Figure 20.



Entities external to system	Processes internal to system
E1. Customers E2. Associates E3. Accounting	P1. Research – Scan, Process and Provide P2. Marketing – Select Topics, Select Conferences, Develop Presentation, Write Blogs, Write Brochure, Make Presentation, Compile and Track Contacts P3. Sales – Research Contacts, Determine Interest, Organise Meeting, Present Credentials, Determine Requirements, Define Deliverables, Construct Proposition, Agree Terms P4. Production – Distribute, Execute, Assemble and Edit work and compile deliverable P5. Delivery P6. Knowledge Base Infrastructure

Figure 20: QDS Investigation 3/4 - ST - System map

As a consequence of implementing the process strategy the Digital Money practice in ST has witnessed significant positive impacts on (a) processes, (b) margins and cycle times, (c) resources and scalability, (d) management complexity and (e) growth of the knowledge base. There was also significant positive impact on the organisation challenges – Agility, Scalability, Throughput, Scope and Productivity. This is of course accompanied by a reduction in the management challenge on all the factors considered. Consequently, it is possible to conclude that the success criterion (**SC**) was met. The resulting change in assessment of management complexity is shown in Figure 21



	Managing Director	Practice Lead	Marketing Associate	Account Associate	Product Associate	Research Associate
Visibility	1	0	1	1	2	2
Variability	4	4	1	1	0	1
Scalability	6	7	2	4	3	2
Quality	1	2	0	0	2	1
Predictability	3	2	1	1	2	2
Control	3	4	1	0	1	0

Figure 21: QDS Investigation 3/4 - ST – Change in Assessment

There were a number of challenges encountered in implementing the plan and these are: (1) **Resistance to magnitude of change** – The implementation demanded major changes in the processes which had to be absorbed, along with considerable effort solely for the purpose of implementation which had to be undertaken while the practice lead and associates were already busy delivering existing work; (2) **Resistance to unfamiliar roles/activities** – Associates, used to greater latitude in terms of defining their outputs and the way they carried out their work, resisted the process which now constrained what was researched and how they could contribute; (3) **Resistance to unfamiliar tools and structures** – The concept of knowledge as a network of information resources was itself hard for the practice lead and associates to accept and the resulting scepticism led to resistance in implementation; (4) **Construction and stability of infrastructure** – As all of the infrastructure had to be created and implemented "in-flight" the development was iterative and stability took some time to establish. The lack of stability in the early versions also contributed to misgivings and resistance.

7.8 Reflections

It is evident that ST as a knowledge intensive business and the nature of its business model has driven its engagement into ever more complex business ecosystems, and will continue to do so. This has resulted in the complexity of the digital money practice also growing with the complexity of the digital money ecosystem[dd] (**H2, H3**)

A key insight provided by the discussion on complexity was that it was influenced by both, the number of elements in the process (activities and products) and the dependencies between these elements. This explained why fragmentation increased the complexity. While the *kinds* of elements remained the same, the number of elements and consequently the *number* of dependencies having to be managed increased dramatically (**H6**)

Another insight was that the nature of the dependency mattered significantly. Simple sequential dependencies between elements such as the flow between sequential activities in a process did not have anything like the impact that bi-directional dependencies, such as modifying a requirement did. Dependencies are just one kind of relationships and complexity seemed to depend upon both, the *nature* and the *number* of relationships between elements.

Complexity did matter, particularly to ST. From the operational perspective, it increased the cost and risk of delivery. It locked up key resources, which resulted in losing engagement opportunities and consequently brand and market share in a rapidly growing marketplace. But strategically, complexity prevented ST from

[dd] The knowledge base give ST the means to actively measure the complexity of the digital money ecosystem it tracks and that measurement now forms part of the positioning of its distinctive capability.

addressing the very challenges (Agility, Scalability, Throughput, Scope and Productivity) identified earlier that needed to be overcome if the business model of ST was to become successful.

ST developed a view of the digital money practice process as a complex system, over the first three iterations, the complexity arising for reasons discussed in the findings (**H4**). The participants were clear that it was the number, nature and dynamism of these that made the system complex (**H5**). The sub-processes were entangled from both, resource and knowledge perspectives, and this made the process as a whole challenging to manage (**H5**).

The first three iterations could be interpreted as taking a mechanistic view of the process, and as the change assessment instruments show, did not succeed in addressing complexity (**H4**). The final iteration focussed on identifying and managing the entangling knowledge contexts, and the resulting 'knowledge base' is essentially a set of information fragments connected together in the form of a network (**H7, H8**). The participants clearly identified that this was complex because of the nature of relationships between the information fragments.

ST implemented their approach by developing an 'information architecture' (framework), a 'digital money practice process' (process), and the 'knowledge base' application (toolset). They took particular care to take into account several attributes in the design of the framework, process and toolset to make these extensible to other domains and adjacent processes (**H9**, **C3**).

As a consequence of the resistance encountered in the final iteration, the approach to change, which was based upon logic and motivation, now needed to depend upon faith in leadership and formal power, a style which was distinctly uncomfortable for ST management. This leads to the recognition that the **Approach** may seem counter-intuitive, and will need conviction and strong management to see the implementation through.

ST also identified certain features not originally anticipated in the framework.

Traceability: A knowledge context consists of information fragments and relationships between the fragments. Therefore the information supporting a process or activity cannot be thought of as a single data record but as a subset of the complete knowledge context consisting of a set of related information fragments that are complete with respect to the process requirement. To achieve this sub-setting capability, the framework must support the ability to trace all the related information fragments, some of which may be more than one step away from the root fragment. This was particularly important to ST as most of the research work involved identifying all related information in support of specific customer requirements.

History: The information provided to a process as a subset of the knowledge context is at a given point in time. This means that the same process requesting the same information at different times may receive different information if the knowledge context was modified in the interim by other processes due to independent update cycles. There is often the need to evidence the information on the basis of which process decisions were taken. To support this requirements a history of changes to information fragments must be stored, in order to recreate the conditions for retrieval at a particular point in time. Again this was particularly important to KB as the reports it produced needed to be auditable with respect to information available at the time of production.

Thus, while this does support **C3**, the framework would need to be extended to accommodate these features.

Theoretical issues concerned with questioning the **Approach** are discussed below:

1. *Identify the complex business process and add to addressed business processes list* – ST formally carried out this step in the final iteration. It did so only after trying several more conventional means to address the process. In one sense, this was an act of desperation, rather than a logically derived strategy. It raises the question whether ST should have bypassed the earlier iterations and directly used the **Approach**. While this seems obvious in retrospect, at the start of the first iteration it was hard to see how the process in question was any different from other conventional processes.

2. *Identify the entangled processes associated with the complex process and add to the process ensemble list* – Again ST did formally carried out this step in the final iteration and the system map shows that their definition of the system did encompass the implicated processes as suggested by the **Approach**. In one sense, the first three iterations led up to making this step possible. This seems to suggest that the **Approach** should be applied only after more conventional approaches have been attempted (**H6**, **H7**).

3. *Identify entangled knowledge contexts* – ST formally carried out this step. Again it became possible because of the visibility generated by the earlier iterations.

4. *Create a shared knowledge context* – ST formally carried out this step resulting in a 'knowledge base'. The architecture they have created is generalizable and therefore extensible to other domains of application.

5. *Reorganise process ensemble to engage with the shared knowledge context* – ST formally carried out this step, and yet again the result matches the pattern of a hub and spoke architecture. However it is still not evident whether this is as consequence of the **Approach** or that the two are merely correlated.

6. *Manage the reorganised ensemble* – ST formally carries out this step, and has used the change assessment instrument to periodically survey the process ensemble. Such use was not part of the original **Approach**, but could be considered for inclusion.

In addition ST has identified more processes within the scope of this business process, and has addressed these using the **Approach**. Again this was largely possible due to the visibility generated in the previous iterations. ST has also identified other "adjacent" business processes, one of which will be addressed in the next QDS investigation. However, it is important to address only those "adjacent" processes that are entangled due to shared complex knowledge contexts, and not due to process information, resource or synchronisation entanglements.

Consequently, while this does support **C1**, it would be necessary to extend the **Approach** to take into account the additional steps that ST has identified.

7.9 Review of Development Phase

In the final iteration there was a significant positive change in the complexity assessment which equated to a significant reduction in the management challenge. This would tend to confirm that the **Approach** did have a beneficial impact on the QDSs investigated.

On the other hand, in the earlier iteration, the impact was mixed, far less pronounced on the positive side, and sometimes even negative. This would suggest that conventional approaches can tend to make the situation worse for such processes, an observation which resonates with the first two QDS investigations as well.

Although as a result of the last intervention there were clearly significant benefits for the Digital Money practice, the experience had raised several questions, which were debated with the practice lead and associates and are discussed below.

Was the problem unique to ST? In summary, the conclusion was that the problem did exist in all such research, but as long as it did not become an existential crisis, it was essentially disguised as a resource and efficiency issue and addressed accordingly. When the issue became significant enough the research team was simply disbanded and the capability outsourced. The practice had in fact applied their experience in adopting conventional approaches for the first three iterations. It was only when these did not work were they persuaded to adopt a novel approach.

Why did conventional approaches not work? The problem seems to have been twofold: (1) applying these approaches did not lead to an identification and resolution of the complexity problem, which needed a completely different perspective and approach to develop a novel solution, and (2) once the complexity was addressed the conventional approaches are seen to be effective again. It would appear that one indicator of complexity is the lack of efficacy of such conventional approaches (**H7**). Consequently, the approaches remained valid, except that they were applied by ST in the wrong order.

Why was the solution resisted so strongly? Consequently the consensus was that while the solution was necessary to address complexity, it was not sufficient to implement it. Additional factors like the size of the team and its ability to absorb change, the leadership, the size of the problem, and the speed of implementation were also extremely important to reduce the risk to implementation.

This approach to managing complexity creates several new opportunities for ST in terms of: (a) more products and services, (b) new business lines, (c) new application areas, and (d) a business model leveraging the knowledge base as an asset. However there are still several limitations in the implementation that relate to technology, process, information and functional coverage.

In summary, the QDS investigation in this chapter fleshed out the practical details of implementing the **Approach**, and identified a way of developing the framework, process and toolset that can be generalised and thus extended to support adjacent processes and other problem domains. Since the hypotheses and capabilities have been generally supported, and the **Approach** found to be valid (albeit needing to be extended) it was appropriate to attempt to validate the **Approach** by applying it in different problem domains. This is achieved through application of the approach to account management and fund administration domains as discussed in following chapter

Chapter 8: Validation Phase

The last chapter presented the QDS investigation for the development phase in terms of the problem, the four iterations of the action research cycle carried out, respectively applying process maturity, process optimisation, and theory of constraints approaches, followed by the application of the **Approach**. It discussed the implications of the QDS with respect to the hypotheses, the instrument, and the capabilities. It established that the **Approach** did in fact work where the more conventional approaches had failed.

This chapter describes the QDSs investigated in the validation phase at a greater level of detail. To recapitulate, the objectives of the validation phase are fourfold: **(1)** test the hypotheses; **(2)** test the **Approach**; **(3)** test the instrument to assess the management challenge; and **(4)** test the existence and need for an information framework, processes and tools.

The QDSs investigated cover two different problem domains (1) account management and (2) fund administration. The primary methods used are workshops for QDS discussion and review, coupled with the QDS investigation method. Actions are directed towards assessing the approach implementation and the consequent change in management challenge. The chapter concludes with a review of the validation phase.

8.1 Validation Phase – QDS Investigation 4 - ST

8.1.1 Background

ST is a management consultancy providing research, strategy and consultancy services in the digital money ecosystem and process, programme and systems management consultancy services in finance, insurance, services and retail sectors. This is an extremely knowledge intensive business, that deals with intangible products and offers advisory, and consulting covering a range of specialised knowledge based services.

A main competitive advantage for ST is its ability to maintain complex ecosystem models that enable multi perspective analysis. On the basis of this ability, ST is able to rapidly innovate specialised multi-perspective, multi-jurisdiction knowledge products, and to offer these in a number of different ways, including self-service portals, 'viewports' (which are essentially portals in a document form), analytic reports and consulting services.

ST has focussed on its Digital Money practice which models the highly complex digital money ecosystem and provides a range of products and services to organisations in that ecosystem.

ST is therefore familiar with complexity and has made progress in addressing the knowledge base and the knowledge management process underpinning the ability to model the ecosystem on a near current basis. . This process satisfied all of the characteristics outlined in Table 1: Regular v/s Knowledge Intensive Business Processes, prior to the initiative. Having been involved in the process improvement initiative, the researcher is therefore trusted and familiar with the context. In his role as the managing director, the researcher is therefore familiar with the context through involvement in the improvement efforts.

8.1.2 Procedures

Bearing in mind the need to involve participants from several perspectives and at different levels, the following participants were selected.

Table 21: QDS Investigation 4 - ST - List of Participants

Participant	Role	Selected To Provide
P1	Managing Director	Strategic Perspective
P2	Practice Lead	Operational Complexity Perspective
P3	Marketing Associate	Marketing Perspective
P4	Account Associate	Account Research Perspective
P5	Product Associate	Product Management Perspective
P6	Research Associate	Research Process Perspective

The objectives of the implementation initiation workshop were to: (a) build a description of the problem to be solved, (b) confirm the roles and agreement of the participants for the investigation, and (c) obtain a baseline assessment of complexity.

The implementation initiation was conducted over one workshop, which was held at one of ST's offices over web-conference. The workshop was recorded using the web-conference capability and the recording was used by the researcher for further analysis

In the implementation initiation workshop, the researcher reviewed with the participants their experience of addressing complexity in their earlier initiative and the concepts and insights they could leverage for the current initiative. The participants then described the problem from their individual perspectives and agreed a state description. A systems map corresponding to that state description was constructed. A high level definition of the programme to implement the approach was also developed.

The programme was signed off by the board and commenced immediately. The implementation was carried out over a period of 6 weeks. During the implementation the key transformations were identified and the post intervention systems map was constructed. All the participants were involved in the implementation either directly in the programme or as part of its review process.

The implementation was followed by an implementation review workshop, in which the participants contributed their reflections in terms of the changes that had occurred and their experience of the process of change. They then applied the instrument post-intervention perspective and reflected upon the change in management and management challenge according to that instrument. This workshop also took place using web-conferencing and was recorded as before.

The record of the discussions was collated by the researcher in the form of a review report that captured the points raised during the discussion while maintaining the integrity of the shared description of the QDS developed in the workshops. This review report took approximately one weeks to construct and required the researcher to solicit clarifications from individual participants during the construction.

In a final workshop, (also using web-conferencing) the review report was presented and reviewed by the participants to ensure its validity. The review included reflection on key observations made in the QDS description and these were then modified or extended to reflect participant views. This was also an opportunity for the participants to add or clarify observations for discussion and inclusion in the QDS description. The instrument was also reviewed and the change from the previous measurement discussed, explanations sought and reconciled.

The participants signed off the amended review report as being representative of the QDS being reviewed. The points salient to this research were then abstracted out of the review report into this QDS description.

8.1.3 Problem description

ST is seen as a trusted authority in the area of Digital Money, and its reputation is maintained through references from key industry figures for the quality and reliability of its services. ST's strategy is based upon providing a few trusted associates access to its knowledge base, and leveraging their capabilities in providing targeted products and services to customers through its account management process. This depends upon carefully selecting prospects and winning business through propositions crafted for them

Complexity arises because (a) the selection of prospects depends upon the research of people and events occurring in the ecosystem, (b) the development of propositions depends upon the research of initiatives and requirements in the ecosystem, and products available with ST (c) the development of products is affected by the propositions and prospects, (d) prioritising and scheduling is affected by events and initiatives (e) associates take on different roles in the process at different times and for different scopes depending upon their availability, (f) associates are geographically dispersed, and (f) opportunities must be responded to very quickly and iteratively. The interdependencies between the sub-processes and the dynamism in the process elements drive complexity, and demonstrate the characteristics identified in Table 1: Regular v/s Knowledge Intensive Business Processes.

As a result of its success in developing and applying the **Approach** in addressing its knowledge management complexity, ST identified Account Management as an adjacent process because (a) it shared many of the key entities of the knowledge management process, and (b) much of the research involved was being carried out as part of the knowledge research process. Therefore it made sense to leverage the content of the knowledge base instead of recreating the same knowledge and then ensuring its consistency.

8.1.4 Findings

At the heart of the problem was the fact that the identity, structure and priority of accounts was constantly changing as (a) people moved between accounts, or changed roles within accounts, (b) accounts started or stopped initiatives, (c) merged or separated from other accounts, and (d) ecosystem events impacted decision making, prioritisation and funding within accounts.

There had been many attempts to improve the process. These can be classified into (a) *restructuring* – reassigning ownership of funds to different fund administrators and resources. (b) *reorganisation* – specialising and rationalising work descriptions, roles and responsibilities within the process, (c) *automation* - document management, systems integration between application involved, and (e) *outsourcing* the whole process.

A key realisation from its earlier experience in addressing the complexity of the knowledge management process was that an account could be conceived as just another perspective of the knowledge base, provided that the information requirements of the account management processes could be integrated into the knowledge base. Taking this approach would automatically leverage the research processes in the knowledge management process and the existing research in the knowledge base. It would also enable the knowledge management processes to leverage account management through the enrichment of the knowledge base.

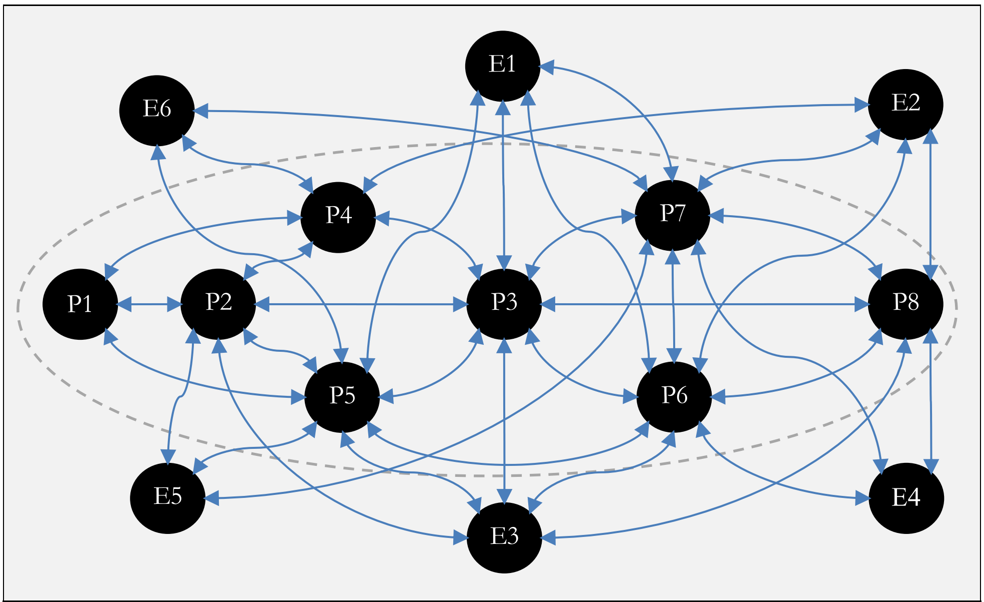
The challenge lay in maintaining a model of the account that remained consistent from several perspectives at any point in time. Over the lifecycle of the account, the integrity of that model was threatened because (a) the identity, structure and priority and information content of the accounts were dynamic, and (b) different associates, in different roles would work asynchronously on the same account, leading to inconsistencies and rework.

Most of the information exchanged between the processes and external entities relate to the state of the specific element of the account in question. However, development of context involves keeping track of and processing the dependencies that exist between the elements of the account at any given point in time. The focus of the intervention was therefore the management of the information associated with the account as a whole, and in particular, keeping track of the information related to the relationships between the elements of the account in an integrated and consistent way (**H5**, **H6).**

The system map pre-intervention is depicted in Figure 22.

This required the creation of an account architecture that could model any account structure, coupled with a knowledge management infrastructure that could address the acquisition/storage/retrieval and integration issues in applying that account architecture.

The account architecture is essentially an extension of the existing 'knowledge base' and takes the form of a network where the entities are modelled as nodes, and relationships between them are arcs. Thus people, events, initiatives, requirements etc. are all entities, related to each other within the account structure. Thus all manner of new accounts can be modelled as collections of related existing entities (and/or existing accounts), the relationships carrying information such as proportion of ownership, roles, status etc. (**C3)**.



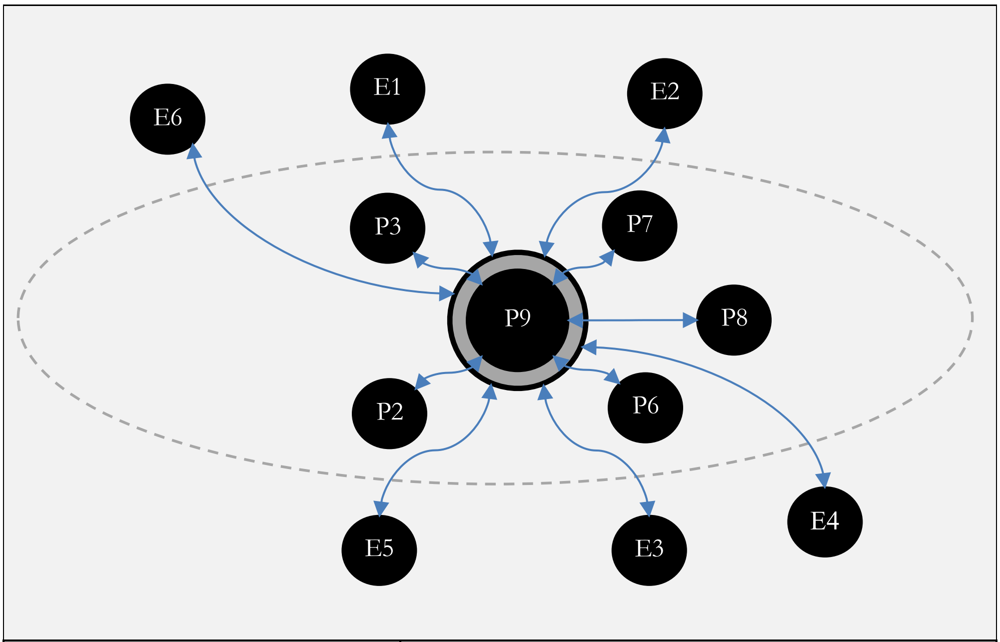
Entities external to system	Processes internal to system
E1. Marketing	P1. Prospect Identification
E2. Sales	P2. Prospect Qualification
E3. Strategic Planning	P3. Account Research
E4. Product Management	P4. People Tracking
E5. Consulting	P5. Events Tracking
E6. Customers	P6. Initiatives Tracking
	P7. Requirements Tracking
	P8. Proposition Development

Figure 22: QDS Investigation 4 - ST - System map pre-intervention

The dynamism in the structure is then managed by the ability to introduce, remove or change both entities and relationships. Documents related to such changes are also held as entities, linking to the actual document repository. The account structure at a specific point in time is called the account configuration (**H9)**.

Each entity or relationship must belong to class. The class determines what information will be held for that entity or relationship. The set of classes itself is organised as a hierarchy where child classes inherit the information requirements of their parent classes. This allows for extensibility, through the creation of new classes of entities for innovative fund structures.

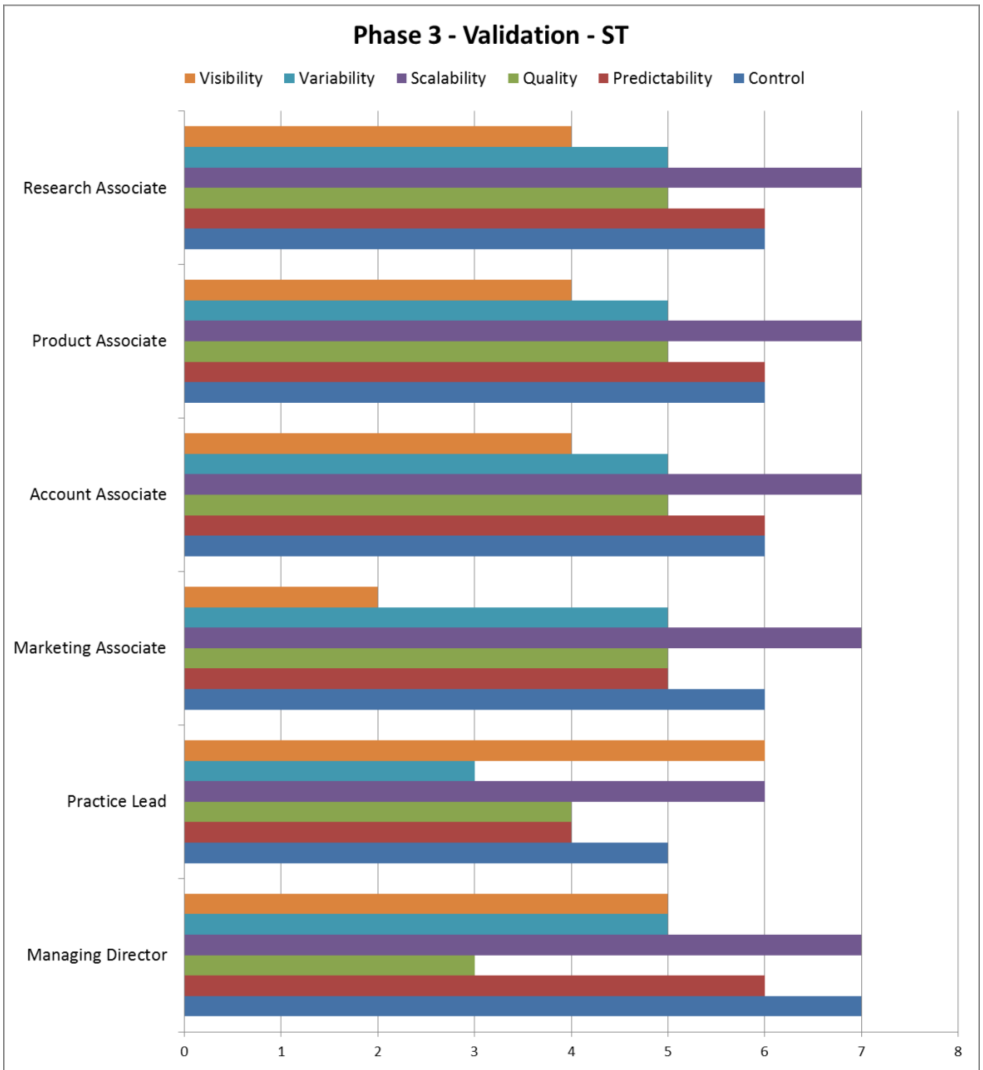
Having put the architecture and the management infrastructure in place, the processes were reorganised to exchange only notifications, the context being provided by the (newly introduced) account knowledge management process infrastructure (called the 'account knowledge base') (**H8**). The new system map is depicted in Figure 23.



Entities external to system	Processes internal to system
E1. Marketing	~~P1. Prospect Identification~~ (leverages KM process)
E2. Sales	P2. Prospect Qualification
E3. Strategic Planning	P3. Account Research
E4. Product Management	~~P4. People Tracking~~ (leverages KM process)
E5. Consulting	~~P5. Events Tracking~~ (leverages KM process)
E6. Customers	P6. Initiatives Tracking
	P7. Requirements Tracking
	P8. Proposition Development
	P9. Account Knowledge Management

Figure 23: QDS Investigation 4 - ST - System map post-intervention

The overall process shows a significant positive change in the complexity assessment factors depicted in Figure 24, with the complexity of the new account configuration process more than compensated for by the reduction in complexity across the whole system (**C2)**. Since the process goals were also met it is possible to conclude that the success criterion for the intervention was met.



	Managing Director	Practice Lead	Marketing Associate	Account Associate	Product Associate	Research Associate
Visibility	5	6	2	4	4	4
Variability	5	3	5	5	5	5
Scalability	7	6	7	7	7	7
Quality	3	4	5	5	5	5
Predictability	6	4	5	6	6	6
Control	7	5	6	6	6	6

Figure 24: QDS Investigation 4 - ST - Change in Assessment

8.1.5 Reflections

From the description of the problem it is evident that ST as a knowledge intensive business has engaged in ever more complex digital money ecosystems, and will need to continue to do so. This has resulted in the complexity of the account management process also growing with the complexity of the ecosystems (**H2**, **H3**). ST identified the account management process as a complex system, the complexity arising for reasons discussed in the findings (**H4**). The sub-processes were entangled from both, resource and knowledge perspectives, and this made the process as a whole challenging to manage. The earlier attempts to improve the process could be interpreted as taking a mechanistic view of the process and clearly did not lead to any real reduction in management challenge (**H7)**.

Two additional features not anticipated in the framework also came to light and these are discussed below.

Traceability: A knowledge context consists of information fragments and relationships between the fragments. Therefore the information supporting a process or activity cannot be thought of as a single data record but as a subset of the complete knowledge context consisting of a set of related information fragments that are complete with respect to the process requirement. To achieve this sub-setting capability, the framework must support the ability to trace all the related information fragments, some of which may be more than one step away from the root fragment.

History: The information provided to a process as a subset of the knowledge context is at a given point in time. This means that the same process requesting the same information at different times may receive different information if the knowledge context was modified in the interim by other processes due to independent update cycles. There is often the need to evidence the information on the basis of which process decisions were taken. To support this requirements a history of changes to information fragments must be stored, in order to recreate the conditions for retrieval at a particular point in time.

Thus, while this does support **C3**, the framework would need to be extended to accommodate these features.

In determining how the **Approach** was applied by ST the steps in the **Approach** are analysed below:

1. *Identify the complex business process and add to addressed business processes list* – ST formally carried out this step, using its experience of addressing complexity through the 'Knowledge Management Process' to conclude that the account management process had similar characteristics and could benefit from the approach.

2. *Identify the entangled processes associated with the complex process and add to process ensemble list* – ST formally carried out this step, and in doing so discovered several implicated processes they had not considered before, as the activities involved were carried out by geographically dispersed associates, sometimes as part of other processes.

3. *Identify entangled knowledge contexts* – ST formally carried out this step, and used it as the basis for deriving the architecture for the account knowledge base.

4. *Create a shared knowledge context* – ST formally carried out this step resulting in an 'account knowledge base'. ST's approach to addressing the complexity of the process focussed on identifying and managing the entangling knowledge contexts and the resulting 'account knowledge base' (framework) is essentially a set of information fragments connected together in the form of a network. ST implemented their approach through a 'account configuration process' (process), and the 'SAGE' application (toolset).

5. *Reorganise process ensemble to engage with the shared knowledge context* – ST formally carried out this step, resulting in leveraging existing processes in another area, reduced interfaces and interactions between sub-processes and the creation of a new 'account configuration management process'.

6. *Manage the reorganised ensemble* – ST formally continues to carry out this step and have launched process improvement and re-tooling initiatives to address sub-processes (requirements management).

In addition ST carried out some further steps. As noted in step 2, ST discovered sub-processes and have followed the **Approach** in addressing such sub-processes. Also ST identified the account management process as 'adjacent' business process as the final step of the earlier initiative. They have currently identified more adjacent ecosystems and their attendant knowledge management processes as adjacent business process, which they intend to address using the **Approach**. Consequently, while this does validate **C1**, it would be necessary to extend the **Approach** to take into account the additional steps that ST has identified.

8.2 Validation Phase – QDS Investigation 5 - AB

8.2.1 Background

AB is an international merchant bank providing private banking, wealth management, and trust/fund administration services to its customers for over a 100 years. Over its long history it has acquired, merged with and been acquired by several entities and has grown in terms of asset managed, products and services offered, geographical distributions and lines of business. The common thread has been the brand which is highly recognised and respected.

This is an extremely knowledge intensive business, that deals with intangible assets, and products and offers advisory, trust and fiduciary arrangements covering a range of specialised knowledge based services.

A key competitive advantage for AB is its rapid innovation of specialised multi-asset, multi-jurisdiction products, and ability to offer these through a multitude of wrapper arrangements. Along with the many mergers and acquisitions in its history, this has led to a complex product and service set in a complex operating environment.

AB is therefore familiar with complexity and has already made progress in addressing the complexity of product advisory area that owns the product / service configuration processes through an initiative that the researcher was involved with. The researcher is therefore trusted and familiar with the context through involvement in the improvement efforts.

The focus of this section is AB's implementation of the **Approach** to address complexity in the fund administration process. . This process satisfied all of the characteristics outlined in Table 1: Regular v/s Knowledge Intensive Business Processes, prior to the initiative. Having been involved in the process improvement initiative, the researcher is therefore trusted and familiar with the context. This is part of its Corporate Fiduciary service offering and a major revenue earner for AB.

8.2.2 Procedures

Bearing in mind the need to involve participants from several perspectives and at different levels, the following participants were selected.

Table 22: QDS Investigation 5 - AB - List of Participants

Participant	Role	Selected To Provide
P1	Divisional Director	Strategic Perspective
P2	Chief Operating Officer	Operational Complexity Perspective
P3	Programme Director	Change Delivery Perspective
P4	Process Owner	Process Resourcing, Goals, Outcomes
P5	Process Administrator	Process Complexity Perspective
P6	Client Relationship Manager	Process (Internal) Client Perspective

The objectives of the implementation initiation workshop were to: (a) build a description of the problem to be solved, (b) review complexity concepts and the **Approach**, (c) confirm the roles and agreement of the participants for the investigation, and (c) obtain a baseline assessment of complexity.

The implementation initiation was conducted over two workshops, which were held at one of AB's offices. During the workshops, the Divisional Director's personal assistant also attended and kept a record of discussions for the researcher.

In the implementation initiation workshops, the researcher reviewed with the participants the basic concepts of complexity, systems thinking, process management, process maturity and change, in order to develop a common understanding and vocabulary of the concepts and approaches among participants. The participants then described the problem from their individual perspectives and agreed a state description. A systems map corresponding to that state description was constructed. A high level definition of the programme to implement the approach was also developed.

The programme was signed off by the board and commenced 6 weeks later. The implementation was carried out over a period of 4 months. During the implementation the key transformations were identified and the post intervention systems map was constructed. All the participants were involved in the implementation either directly in the programme or as part of its review board.

The implementation was followed by two implementation review workshops, in which the participants contributed their reflections in terms of the changes that had occurred and their experience of the process of change. They then applied the instrument post-intervention perspective and reflected upon the change in management and management challenge according to that instrument.

The record of the discussions was collated by the researcher in the form of a review report that captured the points raised during the discussion while maintaining the integrity of the shared description of the QDS developed in the workshops. This review report took approximately four weeks to construct and required the researcher to solicit clarifications from individual participants during the construction.

In a final workshop, the review report was presented and reviewed by the participants to ensure its validity. The review included reflection on key observations made in the QDS description and these were then modified or extended to reflect participant views. This was also an opportunity for the participants to add or clarify observations for discussion and inclusion in the QDS description. The instrument was also reviewed and the change from the previous measurement discussed, explanations sought and reconciled.

The participants signed off the amended review report as being representative of the QDS being reviewed. The points salient to this research were then abstracted out of the review report into this QDS description.

8.2.3 Problem description

AB specialises in the construction of specialised corporate funds and special purpose vehicles, typically administered offshore and covering multiple jurisdictions and asset classes. Investors into such funds (members) can be individuals, partnerships, trusts, corporates and other entities, with diverse nationalities and domiciles. They may have special tax provisions, currency, investment class, asset class preferences. They may also have specific reporting preferences and banking arrangements.

A fund is structured and mandated by the financial solutions group to meet specific goals. It is registered in a specific jurisdiction and assigned to a fund manager. Members then join the fund and the pooled resources are then invested according to the mandate for the fund. Members may continue to join or leave during the lifetime of the fund and may change their structures, preferences and arrangements at any time.

Contributions are collected from members through a 'Call' process, where the members' contribution is proportionate to their investment commitment. Similarly proceeds are distributed through a 'Distribution' process; again the member's contribution is proportionate to their investment commitment.

Process complexity, with characteristics identified in Table 1: Regular v/s Knowledge Intensive Business Processes, arises because (a) the 'Call' requires two phases, every member must agree the call before any funds can be collected, (b) 'Calls' and 'Distributions' must complete within statutory time constraints, (c) completion takes place through complex multi-currency transactions per member, (d) members participate in the same fund through multiple and dynamic arrangements (d) members expect to have their transaction and reporting consolidated, (e) this is an extensively regulated activity requiring considerable documentation and traceability, and (f) investment windows of opportunity are usually small. Fund administration is the key to successful fund management and must grapple with these complexities.

This was a very lucrative, high growth, high margin, but highly fragmented market consisting of several fund administration companies, each managing a few funds. As the fund administration process was similar, AB had reasoned that consolidating the administration of a large number of funds through a common infrastructure would provide both high volumes and high margins through economies of scale. It therefore acquired several of these fund administration companies and attempted to standardise the process.

In doing so, AB made some key discoveries: (a) while *activities* were similar the *processes* differed according to the structure of the funds they were set up to administer, (b) whereas *activities* could be documented, process orchestration relied upon the competence of each fund administrator, (c) fund administrators had a limited band-width and could not be easily scaled or replaced, (d) there was considerable overhead in ensuring no leakage of information between funds, (e) statutory reporting overhead seemed to grow out of proportion to the number of funds, (f) investment, call and distribution cycles could simply not be synchronised, and (g) problems in any one fund cascaded across all funds due to the resource sharing.

As a result, after several failed attempts at re-engineering the process, the business continued to grow increasingly unprofitable (**H6)**. AB had therefore to (a) find a way to make the process both scalable and profitable, (b) operate the process as individual funds, making it un-competitive, or (c) sell of the business while the market was still growing. AB chose to trial the **Approach** in order to achieve option (a).

8.2.4 Findings

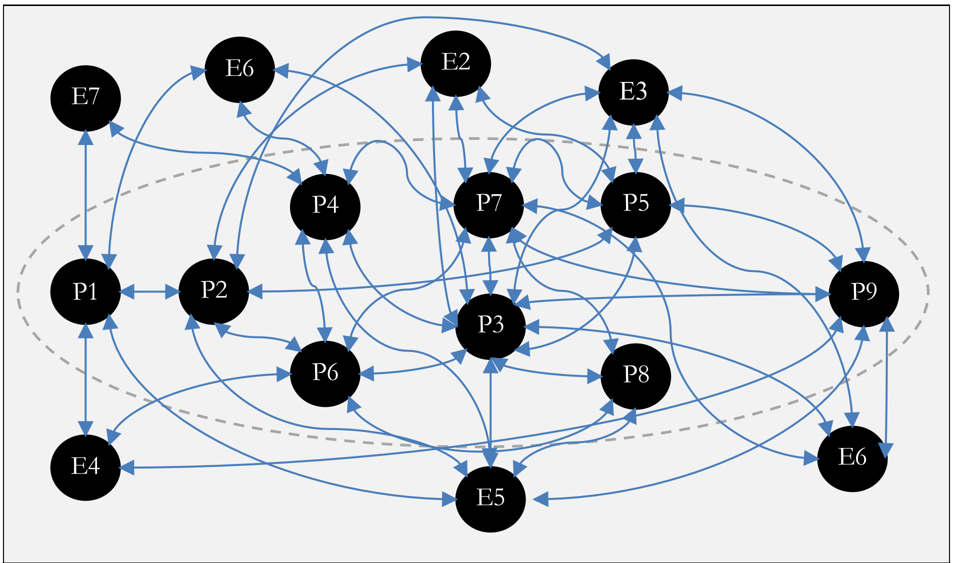
At the heart of the problem was the complexity and dynamism in the structure of each fund. Integrating this into a standard process has been complex and challenging and not always successful and has resulted in a complex and expensive infrastructure.

There had been many attempts to improve the process. These can be classified as (a) restructuring – reassigning ownership of funds to different fund administrators and resources. (b) reorganisation – specialising and rationalising work descriptions, roles and responsibilities within the process, (c) process re-engineering – particularly using six sigma methodology, (d) document management, automation and systems integration between application involved, and (e) outsourcing the whole process (**H6)**.

The challenge lay in maintaining a model of the fund that remained consistent from several perspectives (each corresponding to a stakeholder) at any point in time. Over the lifecycle of the fund, the integrity of that model was threatened because of (a) the form of the model – the financial solutions group described the fund in the form of a document, relevant parts of which were copied by individual functions; consequently changes to the structure could never be consistently applied, (b) the dynamism of the model – not just due to member turnover and preference change, but also due to regulatory, mandate, investment class and asset class changes (**C3)**.

All information exchange between processes, whether related to state, action or context, took the form of documents. While in theory, therefore, actions could be linked to defined events, these had to be separately notified to all concerned through documents, and the appropriate context rediscovered. In practice, such notification quickly became informal, and hard to track.

The system map pre-intervention is depicted in Figure 25.



Entities external to system	**Processes internal to system**
E1. Fund Managers	P1. Fund Setup
E2. Fund Clients	P2. Client Management
E3. Client Relationship Managers	P3. Call and Distribution
E4. Regulatory Agencies	P4. Investment and Divestment
E5. Compliance and Audit	P5. Client Accounting and Reporting
E6. Finance and Accounting	P6. Regulatory Reporting
E7. Financial Solutions Group	P7. Payments and Collections
	P8. Foreign Exchange Management
	P9. Fund Closedown

Figure 25: QDS Investigation 5 - AB - System map pre-intervention

Most of the information exchanged between the processes and external entities relate to the state of the specific element of the fund in question. However, development of context involves keeping track of and processing the dependencies that exist between the elements of the fund at any given point in time.

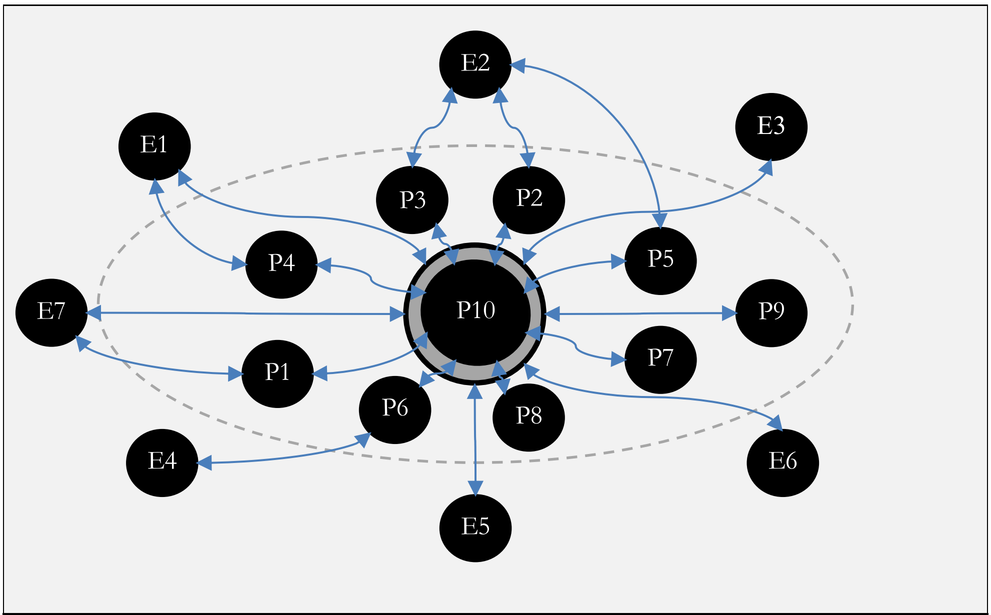
The focus of the intervention was therefore the management of the information associated with the fund as a whole, and in particular, keeping track of the information related to the relationships between the elements of the fund in an integrated and consistent way (**H8)**.

This required the creation of a fund architecture that could model any fund structure, coupled with a knowledge management infrastructure that could address the acquisition/storage/retrieval and integration issues in applying that fund architecture (**C3)**.

The fund architecture takes the form of a network where the entities are modelled as nodes, and relationships between them are arcs. Thus all manner of new entities can be modelled as collections of related existing entities, the relationships carrying information such as proportion of ownership, obligations, etc. Thus members, regulatory bodies, banking institutions, asset classes, investment classes, currencies etc. are all entities, related to each other according to the fund structure. The dynamism in the structure is then managed by the ability to introduce, remove or change both entities and relationships. Documents related to such changes are also held as entities, linking to the actual document repository. The fund structure at a specific point in time is called the fund configuration (**C3)**.

Each entity or relationship must belong to class. The class determines what information will be held for that entity or relationship. The set of classes itself is organised as a hierarchy where child classes inherit the information requirements of their parent classes. This allows for extensibility, through the creation of new classes of entities for innovative fund structures.

Having put the architecture and the management infrastructure in place, the processes were reorganised to exchange only notifications, the context being provided by the (newly introduced) fund configuration process infrastructure (called the 'fund configuration'). The new system map is depicted in Figure 26 (**H8**).

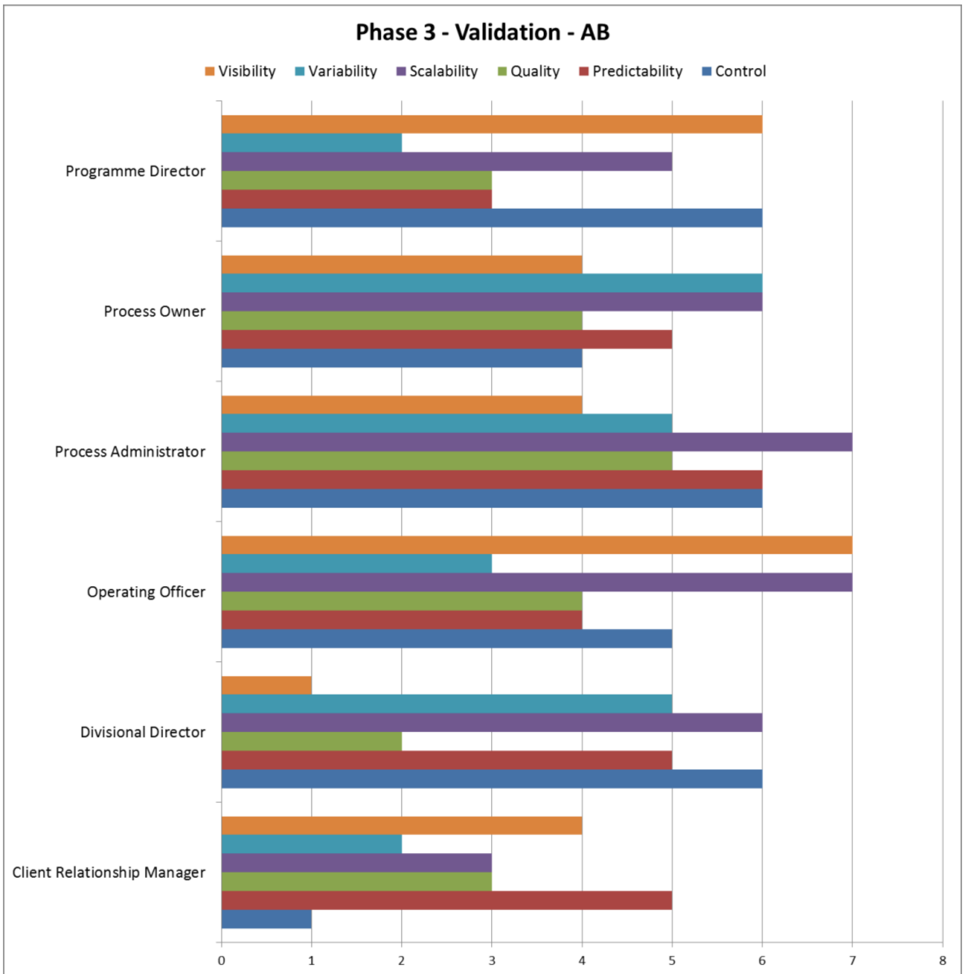


Entities external to system	Processes internal to system
E1. Fund Managers	P1. Fund Setup
E2. Fund Clients	P2. Client Management
E3. Client Relationship Managers	P3. Call and Distribution
E4. Regulatory Agencies	P4. Investment and Divestment
E5. Compliance and Audit	P5. Client Accounting and Reporting
E6. Finance and Accounting	P6. Regulatory Reporting
E7. Financial Solutions Group	P7. Payments and Collections
	P8. Foreign Exchange Management
	P9. Fund Closedown
	P10. Fund Configuration Management

Figure 26: QDS Investigation 5 - AB - System map post-intervention

The overall process shows a significant positive change in the complexity assessment factors depicted in Figure 27, with the complexity of the new fund configuration management process more than compensated for by the reduction in complexity across the whole system (**H5, H8**). Since the process goals were also met it is possible to conclude that the success criterion for the intervention was met.

AB have now embarked upon a strategy of selective outsourcing for P5 and P7, coupled with six sigma driven process improvements for P2, P3 and P8. Early results appear promising (**H7**).



	Client Relationship Manager	Divisional Director	Operating Officer	Process Administrator	Process Owner	Programme Director
Visibility	4	1	7	4	4	6
Variability	2	5	3	5	6	2
Scalability	3	6	7	7	6	5
Quality	3	2	4	5	4	3
Predictability	5	5	4	6	5	3
Control	1	6	5	6	4	6

Figure 27: QDS Investigation 5 - AB - Change in Complexity Assessment

8.2.5 Reflections

From the description of the problem it is evident that AB as a knowledge intensive business has engaged in ever more complex fund ecosystems, and will need to continue to do so. This has resulted in the complexity of the fund administration also growing with the complexity of the ecosystems (**H2)**.

AB identified the fund administration process as a complex system, the complexity arising for reasons discussed in the findings. The sub-processes were entangled from both, resource and knowledge perspectives, and this made the process as a whole challenging to manage (**H4, H5)**.

The earlier attempts to improve the fund administration process could be interpreted as taking a mechanistic view of the process and clearly did not succeed in addressing complexity as the efforts to improve resource efficiency and scheduling consistency were defeated by the need for agility in meeting dynamic demands (**H4)**.

Two additional features not anticipated in the framework also came to light and these are discussed below.

Access to existing Knowledge: The information used in business processes is often available in existing applications and databases. It is not recommended as a design practice to replicate this information in a knowledge context since that would create issues of redundancy, information currency, primacy and conflicts. Therefore the framework must support the ability to define the information fragment centrally but access the content from other sources.

Implication: The semantics of the knowledge context may define certain constraints. When modifying information fragments, the framework must ensure that these constraints are respected. It is therefore necessary to support the evaluation of implications of changing an information fragment in order to assure that the constraints are not violated or to notify/refuse the change.

Thus, while this does support **C3**, the framework would need to be extended to accommodate these features.

In determining how the **Approach** was applied by AB the steps in the **Approach** are analysed below:

1. *Identify the complex business process and add to addressed business processes list* – While AB did not formally carry out this step, in practice it used its appreciation of complexity concepts, the assessment instrument and its experience of addressing complexity through the 'Product House' to conclude that the fund administration process had similar characteristics and could benefit from the approach. The participants reported that they are already assessing other processes in the organisation in line with this step.

2. *Identify the entangled processes associated with the complex process and add to process ensemble list* – AB formally carried out this step, and in doing so discovered several implicated processes they had not considered before.

3. *Identify entangled knowledge contexts* – AB formally carried out this step, and used it as the basis for deriving the architecture for the fund configuration.

4. *Create a shared knowledge context* – AB formally carried out this step resulting in a 'fund configuration'. AB's approach to addressing the complexity of the process focussed on identifying and managing the entangling knowledge contexts, and the resulting 'fund configuration' (framework) is essentially a set of information fragments connected together in the form of a network. AB implemented their approach through a 'product configuration process' (process), and the 'fund configuration application' (toolset).

5. *Reorganise process ensemble to engage with the shared knowledge context* – AB formally carried out this step, resulting in reduced interfaces and interactions between sub-processes and the creation of a new 'product configuration management process'.

6. *Manage the reorganised ensemble* – AB formally continue to carry out this step and have launched process improvement initiatives to address sub-processes (collection and payment, statutory reporting) using six sigma methodologies.

Participants report that AB continues to discover sub-processes as they get triggered by events related to specific funds. They have followed the **Approach** in addressing such sub-processes, leading to changes in the fund configuration. In addition, participants report that AB has identified investment management and regulatory reporting as adjacent business processes. Consequently, while this does validate **C1**, it would be necessary to extend the **Approach** to take into account the additional steps that ST has identified.

8.3 Review of Validation Phase

In both the QDSs investigated in the validation phase, there was a significant positive change in the complexity assessment which equated to a significant reduction in the management challenge. This would tend to confirm that the **Approach** did have a beneficial impact on the QDSs investigated.

In both QDSs there had been a history of conventional approaches being unsuccessfully applied. This would suggest that conventional approaches can tend to make the situation worse for such processes, an observation which resonates with all three previous QDS investigations as well. Also, the two QDSs investigated in this phase used completely different technologies to implement the approach, which suggests that a particular technology in not a determinant to success. However both benefited from having a pattern to follow in creating the framework and toolset and also managing the resistance to change.

Yet again one can observe that the resulting architecture followed the hub and spoke pattern, despite this not being a conscious design strategy. However, this is still not sufficient evidence to make such a pattern a recommendation.

This chapter described the QDSs investigated in the validation phase at a greater level of detail. To recapitulate, the objectives of the validation phase were to test (1) the validity of the criteria for assessment of management challenge, (2) the validity of the hypotheses, (3) the existence of the hypothesised capabilities and (4) the validity of the **Approach**. The QDSs investigated covered two different problem domains (1) account management and (2) fund administration. In summary, the QDS investigations confirmed the applicability of the **Approach** in general terms, albeit using completely different technologies with respect to its implementation.

The next chapter discusses the results of the research in the context of the research question and objectives and the theoretical framework developed earlier. It concludes by assessing the possible contribution to knowledge made by this thesis.

Chapter 9: Discussion and Conclusions

The central purpose of this research was to develop an **Approach** to manage the complexity of knowledge intensive business processes. This was formulated in terms of the main research question.

Q1: How can organisations manage the complexity of their knowledge intensive business processes?

The answer to this question led to the development of the **Approach**. In summary, the answer then is that organisations can managed the complexity of their cKIBP's by first following the **Approach** to reduce knowledge entanglements and then applying more conventional approaches to process improvement. This question however led to two secondary questions:

Q1.a: What does "business process complexity" mean?

The answer to this question led to the concept of "entanglement" in general and the concept of "entangled knowledge contexts" in particular when related to cKIBP's (see 4.2 – **H5**). From the perspective of this thesis then, complexity of KIBP's due to knowledge entanglements arises out of entangled knowledge contexts.

Q1.b: What does it mean to "manage business process complexity"?

The answer to this question led to the concept of assessing such complexity in terms of its "management challenge", the development of an assessment instrument, and the concept of an "agile knowledge context" accompanied by a framework, process and toolset to manage such complexity (see 4.2).

The review of the literature (chapter 2-3) concluded that while there is clearly considerable literature that discusses complexity, complex systems, the use of complexity theories in organisation, ways of measuring complexity, complex knowledge intensive business processes and knowledge management, the literature does not seem to address research questions directly. It also does not meet the researcher objectives with respect to knowledge intensive business processes, of (a) understanding the nature of complexity as it relates to business processes in order to explain why the current paradigm does not always seem to work, and (b) providing practicing managers with a pragmatic way of recognising complexity and managing complex business processes

Therefore a theoretical framework based upon the literature reviewed earlier was developed in chapter 4, which proposed an **Approach** to addressing complex business processes, as well as discussing the issues in operationalizing its testing, development and validation in terms of the research design and conduct of the research.

A research methodology was developed (chapter 5), which was a variant of action research, and QDS investigation. Five QDSs were researched (chapters 6-8), two as QDS investigations in the pilot phase, one in the development phase consisting of four action research cycles presented as a single QDS investigation, and two more as QDS investigations in the validation phase. These QDS investigations covered three knowledge intensive organisations in different areas and covering very different problem domains, and assessed the intervention against the change in management challenge factors from chapter 5. The broad conclusion was that all factors showed improvement in all cases when the **Approach** was applied.

This final chapter includes: (a) a comparison of the evidence uncovered through the research relating the central arguments back to the literature review; (b) a critical review of the work carried out, covering the **Approach** itself, the assessment criteria, and the conceptual framework that was developed; (c) the limitations of this research and its findings; and (d) outstanding issues for further research. The chapter concludes by assessing the possible contribution to knowledge made by this thesis.

As summarised in Table 23, the QDS investigations confirmed the applicability of the **Approach** in general terms, albeit using different technologies with respect to its implementation in individual QDSs. They helped flesh out the **Approach** in terms of practical considerations and recommendations. They also provided insights with regard to the role of conventional approaches in addressing complex business processes with knowledge entanglements, and the softer aspects of resistance to change when implementing the **Approach**. The findings are further discussed below.

Table 23: Summary analysis of QDS Investigations

	QDS 1	QDS 2	QDS 3	QDS 4	QDS 5
Phase	Pilot		Development	Validation	
Research Methodology	QDS Investigation	QDS Investigation	Action Research	QDS Investigation	QDS Investigation
Organisation	**AB**: Respected merchant bank	**MN**: International IT provider	**ST**: Management consultancy	**ST:** Management consultancy	**AB**: Respected merchant bank
Problem Domain	Product / Service Configuration	Programme Management	Knowledge Management	Account Management	Fund Administration
Comparison of findings with Literature	Complexity and Complex systems – Consistent with Literature Organisations as Complex Systems – Consistent with Literature Business Processes – Consistent with Literature Knowledge Management - Consistent with Literature				
Review of Hypothesis	H1 - H4 validated H5 – H7: Partially validated H8 – H9 validated				
Review of Approach	Validated		Validated Extension Required	Validated Extension Required	Validated
Review of Framework Implementation	Shared Knowledge Context		**Agile** Knowledge Context New Features discovered	**Agile** Knowledge Context	Shared Knowledge Context New Features discovered
Review of Assessment Criteria	Generally effective and reflective of attributes of complexity **Exceptions** Visibility – more useful as a *prerequisite* rather than an *indicator* Extensibility – reflects quality of implementation, not the **Approach** itself				

9.1 Comparison of findings with Literature

While not disputed by the participants, not all the insights drawn from the review of literature were seen as relevant by the participants to their particular problem areas. Some of the insights, however, had particularly strong resonance and these are discussed below.

In regard to complexity as a term and a field of study, the research confirmed that business process complexity is hard to define (Gershenson & Heylighen, 2005) and measure (Moldoveanu, 2005), but participants were able to identify characteristics (Cilliers P. , 1998) and indicative properties exhibited by such processes as shown in Table 24.

In regard to complexity and complex systems the research found that in all the QDSs the managers already (intuitively) regarded the business process as a complex system, and had in fact used traditional tools to control or manage it, and these worked well in QDSs that did not involve entanglements due to complex knowledge contexts. This is consistent with Hiett's (2001) view that, "… through years of experience and sensitivity to situations, various abilities, techniques, and ideas have been developed that seem to work."

In regard to organisations as complex systems the research found that the view of organization as complex adaptive systems that coevolve with the environment through the self-organizing behaviour of agents navigating "fitness landscapes" of market opportunities and competitive dynamics (Kauffman, 1995), was widely (though not universally) accepted amongst participants in a metaphorical sense. The exceptions were predominantly those participants who took a mechanistic view of the system.

In regard to business processes the research found that there were indeed several definitions of business process, all of which tended towards the ontology of goal-oriented "ensemble of co-ordinated activities" (Smith & Fingar, 2003), "sequences of events" (Van de Ven, 1992), "software program like system" (Cardoso, Mendling, Neumann, & Reijers, 2006), or "interdependent constituents that construct the enterprise" (Melão & Pidd, 2000). Participants also tended to classify these in varied ways, which was often a source of conflict[ee]. The business processes had been analysed and modelled with many and varied techniques, but all of these had stumbled over dynamism and the

[ee] The researcher was advised by participants to eliminate the definition of business process from the Approach because of the conflict it could create. A comment from one very senior participant was "You are dealing with process experts. We know what we mean. Don't teach us to suck eggs".

impact of complexity on the understandability of models. There was also agreement that the change model of "unfreezing, transition, and refreezing" did not work because of such dynamism.

In regard to business knowledge management the research found that in all the QDSs the absence of a unifying, semantically developed and contextualised structure to represent knowledge was the common theme that gave rise to the management challenge (Raghu & Vinze, 2007). The processes studied were all (a) knowledge intensive, (b) hard to predict, (c) varied in almost every instance of the process, and (d) conventional approaches had been attempted unsuccessfully. The result of the intervention was in fact a transformation of the process from being activity centric to being information centric (Kumaran, Liu, & Wu, 2008).

9.2 Review of the Hypotheses

The research found that the in all the QDSs the hypotheses articulated in chapter 4 were at the very least weakly validated. Crucially none of them were invalidated, provided they were appropriately reworded. These are discussed in more detail below:

H1: *"Complexity" is hard to define in a way that is acceptable to all perspectives and is largely used as a metaphor, which makes it at best a partial description and difficult for traditional management to adopt*

This hypothesis was tested in all the QDSs investigated. Its metaphorical use (Lissack, 1999; Stacey R. D., 2001; Burnes, 2005) was evident in the workshops and it was usually discussed by way of analogy. The differences in perception (Richardson K. A., 2005; Cilliers P. , 2005), occurred across levels of management, across functions (Davenport & Short, 1990), and across disciplines (Smith & Fingar, 2003), and this variance in perceptions (Richardson K. A., 2005) led to conflict both in terms of the definition (Casti, 2003; Gershenson & Heylighen, 2005; Whitt & Maylor, 2008), of the problem and the solution to be adopted. There was agreement, however, that complexity exhibited certain attributes and that the presence of complexity made the problem "hard" to solve, and sometimes labelling a process as "complex" was short-hand for saying that the process was intractable. This made management wary of "complexity". Therefore this hypothesis can be considered to be validated.

H2: *Engaging in complex ecosystems implicitly or explicitly impacts the complexity of the business processes of knowledge intensive organisations and creates significant challenges for them*

In all the QDSs investigated, there was a clear pattern where an initially simpler process grew increasingly complex as it needed to cope with more factors within its environment (Axelrod & Cohen, 2000). The need arose out of (a) strategic decisions e.g. engaging in new/extended/related markets or geographies (Galbraith, 1982); (b) structural decisions e.g. acquisitions and re-organisations (Moore, 1996); (c) addressing constraints or competitive pressures e.g. cost, scale, cycle-time (Axelrod & Cohen, 2000); or (d) change arising out of product or process innovation (Cohen M. , 1999). Therefore this hypothesis can be considered to be validated.

H3: *Management of cKIBP's will get increasingly more challenging as the rate of evolution, proliferation and integration of the processes being managed keeps increasing*

Again in all the QDSs investigated, there was evidence of increasing dynamism in the strategic direction (Anderson, 1999; Mason, 2007) and consequently the objectives, configuration and deployment of business processes, which made the processes increasing difficult to manage. The management focus was shifting from "how to control the process" (Lissack, 1999) - i.e. a focus on stability - to "how to control its change" (Uhl-Bien, Marion, & McKelvey, 2007; Klijn, 2007) – i.e. a focus on agility. Therefore this hypothesis can be considered to be validated.

H4: *(1) An ensemble of business processes can be regarded as a complex system, but (2) the mechanistic view of business processes does not sufficiently capture the complexity since it obscures the role of relationships*

In all the QDSs investigated, there was agreement amongst the participants that the process could be considered to be a complex system (Boulding, 1956; Bertalanffy, 1968; Capra, The Web of Life, 1996). However, in all the QDSs investigated, the existing modelling approaches had taken a mechanistic view

(Lindsay, Downs, & Lunn, 2003), excluding all information that could not be modelled through a structured interface. Most of the relationships (Senge, 1990) subsequently discovered to exist could be traced back to such excluded information. Therefore this hypothesis can be considered to be validated.

H5: *(1) Complexity arises because of entanglements between processes and (2) addressing complexity requires reduction or removal of such entanglements*

In all the QDSs investigated, it was evident that the management challenge arose out of the existence of such entanglements (Gell-Mann, 1995/96). The participants referred to entanglements variously as "dependencies", "endless loops", "deadlocks", "sticking points" etc., (Berwanger, Grädel, Kaiser, & Rabinovich, 2012) but they had no difficulty in recognising these as entanglements once the term was introduced to them. The intervention essentially focussed on reducing or removing such entanglements (Baader & Voronkov, 2005) and the assessment showed a reduction in management challenge sufficient to satisfy the success criteria.

However, while this evidence would validate the fact that management challenge (as a surrogate for complexity) was reduced through the removal of such entanglements, it does not justify a claim that no approach other than the removal of such entanglements would have worked (even though other conventional approaches had been attempted and failed). Consequently the hypothesis in its present form can only be considered to be partially validated and requires to be rephrased as **H5**: *Complexity arises because of entanglements between processes and one way of addressing complexity is the reduction or removal of such entanglements* in order for it to be considered fully valid.

H6: *(1) The level of entanglement correlates with the management challenge in managing the process, and, (2) while effective in addressing complicated processes, conventional approaches are less effective in addressing complex processes with knowledge entanglements*

In all the QDSs investigated, the assessment of the management challenge (Lissack, 1999) showed a reduction in management challenge (Moldoveanu, 2005; Biemans, Lankhorst, Teeuw, & Wetering, 2001; Melão & Pidd, 2000; Checkland P. B., 1972; Galliers, 1994; Patching, 1995; Chan & Choi, 1997;

Perona & Miragliotta, 2004), when knowledge entanglements were removed. In that sense there is a correlation between removal of entanglements and reduction in management challenge. However, the research did not have the opportunity to assess the change in management challenge related to the removal of *individual* entanglements. Doing so would not have made sense as in all the QDSs investigated the individual entanglements were related to each other in some way and the solution required their collective removal. Therefore the first part of the hypothesis can be considered to be only weakly validated.

On the other hand, in all these QDSs conventional approaches, far from being effective in addressing knowledge entanglements, had not even detected the presence of knowledge entanglements, as they assume a deterministic model (Lindsay, Downs, & Lunn, 2003; Melão & Pidd, 2000; Morgan, 1997; Falconer, 2005; Alonso, Dadam, & Rosemann, 2007; Indulska, Recker, Rosemann, & Green, 2009), and thus do not include that concept and have no tools for addressing it. Therefore the second part of the hypothesis can be considered to be validated.

H7: *(1) Once knowledge entanglements are reduced or removed, conventional approaches once again become effective on the reorganised process ensemble, and therefore, (2) one indicator of knowledge entanglements is the ineffectiveness of conventional approaches in resolving the problems*

The first part of the hypothesis could only be confirmed for the QDSs in the pilot phase, where the organisations had actually embarked upon process improvements using conventional approaches (Smith & Fingar, 2003) on the reorganised process ensemble and obtained good results (Reynolds, 2011). This could not be confirmed within the scope of this research for the other QDSs, although in all of these QDSs the organisation immediately planned/embarked upon process improvement using conventional methods. Therefore this part of the hypothesis can be considered to be at least weakly validated.

As regards the second part of the hypothesis, in all the QDSs investigated conventional approaches had been applied and were ineffective while knowledge entanglements existed. Therefore this part of the hypothesis can be considered validated. However that cannot be taken to mean that conventional approaches would fail in ***all*** cases, and ***only*** because of the existence of knowledge entanglements. Consequently, in the researcher's view this confirms that the failure of conventional approaches is at best an indicative rather than a conclusive test.

H8: *(1) Knowledge sharing entanglements arise when the information flow contains entangled complex knowledge contexts, and (2) can be resolved by reorganising the process ensemble to contribute and consume from a set of integrated knowledge contexts*

The first part of the hypothesis was observed in all the QDS investigated (Raghu & Vinze, 2007), although the entanglements themselves had to be discovered as they were not initially modelled. Therefore this part can be considered to be validated.

As regards the second part of the hypothesis, in all the QDSs the solution did consist essentially of reorganising the process ensemble to contribute to and consume from a set of integrated knowledge contexts (Bhattacharya, et al., 2005; Bhattacharya, Gerede, Hull, Liu, & Su, 2007; Bhattacharya, Caswell, Kumaran, Nigam, & Wu, 2007; Liu, Bhattacharya, & Wu, 2007), and the solution met the success criteria. Where there were exceptions these were of detail not of principle. Therefore this part of the hypothesis can also be considered to be validated.

H9: *While knowledge sharing entanglements can be addressed through a shared knowledge context, creating and managing a complex shared agile knowledge context requires an information framework, processes and tools*

In the QDSs investigated in the development and validation phases, a framework, process and toolset were indeed created (strong in the case of ST (Kumaran, Liu, & Wu, 2008) and weak in the case of AB), in order to address agility (Putnik & Putnik, 2012), although they were not necessarily identified as such. Also the problems identified with the **Approach** in the pilot phase QDS investigations could be traced back to the absence of these elements (Chang & Li, 2007; Sun, 2010; Allameh, Zare, & Davoodi, 2011; Pinho, Rego, & Cunha, 2012). While this could be taken as evidence supporting the *benefit* of an information framework, process and toolset, it cannot be taken as evidence of these being a *requirement*, particularly considering that despite the insufficiency of these elements, even the QDSs in the pilot phase did succeed in reducing the management challenge. Therefore this hypothesis can be considered valid only if rephrased as: **H9**: *Creating and managing a complex shared agile knowledge context can benefit from a framework, processes and tools*

The evidence in support of the hypotheses leads to the conclusion that the perspective on complexity as it applies to complex knowledge intensive business process which was developed in 4.2 is valid

9.3 Review of the Approach

The research indicates that in all the QDSs investigated all the steps in the **Approach** were carried out in principle, either implicitly or explicitly, although, of course, for the QDSs in the pilot phase, they were not so identified, as the **Approach** did not exist at the time of the intervention.

However, during the application of the **Approach**, various practical weaknesses were identified. Most of them reflected unfamiliarity with the concepts of the approach and lack of experience in implementing the **Approach**. This is consistent with the view that Biemans et al. (2001) take in arguing that business process "architecting" is more an art than a science; consequently, experience is very important. These are discussed below.

1. *Identify the complex business process and add to addressed business processes list*

The first practical problem related to the definition of "Business Process". As discussed in the literature review, there can be several descriptions of the term "Business Process", following different ontologies but largely identifying the similar characteristics (Davenport & Short, 1990; Hammer & Champy, 1993; Raghu & Vinze, 2007; Davenport T. H., 1993; Ould, 1995; Zairi, 1997; Slack, Chambers, Johnston, & Betts, 2006). However the definition of the specific business process depends upon the perspective, and interest of the person providing that definition. This is not unexpected, as, in common with any system description, the contents and boundary are determined by the observer (Mitleton-Kelly, 1998; Anderson, 1999; Houchin & MacLean, 2005; Hutchins, 1995; Gershenson & Heylighen, 2005; Stacey R. O., 1995; Simon H. , 1996; Phelan, 1998).

This is not a problem for the **Approach**, because once the target business process is identified, the process of working through it to identify the entangled knowledge contexts would lead to a model with the entangled processes falling within the system boundary. The model can then act as the definition of that specific process.

The issue arises because valuable time is lost in the workshops while participants try to agree terminology. The problem was resolved by encouraging the participants to agree a name for the process being discussed and concentrate on its description rather than try and agree the definition of the term "business process". A second similar problem arose with the term "complex" (Gershenson & Heylighen, 2005; Richardson K. A., 2005; Cilliers P. , 2005; Heylighen, 1999; Havel, 1995). This was resolved by introducing terms that could be used to describe complexity, and encouraging participants to focus on processes that would fit those descriptors rather than attempt to define complexity. These descriptors were seeded from the review of the literature and extended through the workshops and discussions in the course of the research as shown in Table 24.

Table 24: Descriptors of Complexity

Characteristics	Comprehensibility	Behaviours	Consequences
Interrelated Convoluted Not Simple Complicated Too many moving parts	Hard to understand Opaque Unclear Intricate Confusing Ambiguous	Surprising Unpredictable Unstable	Uncontrollable Fragile Unmanageable Intractable Difficult to modify Difficult to extend

A third problem related to participants questioning the need to maintain a separate list of business processes addressed using the **Approach**. The rationale, of course, is that these complex processes are special cases and need to be distinguished from other processes amenable to standard approaches.

2. *Identify the entangled processes associated with the complex process and add to process ensemble list.*

In a similar vein, the distinction between the term "Business Process", "sub-processes" and "activities" led to conflicting opinions during workshops and added no value to the development of the **Approach**. The researcher adopted the strategy of recommending the use of organisations' standard process methodology where available and where this did not exist, adopting the convention to refer to the complex business process being addressed as the "Business Process" and sub-processes and activities contained within it as "processes".

3. *Identify entangled knowledge contexts*

While the concepts of "entanglement" and "entangled knowledge context" were quickly understood in principle, applying these turned out to be quite difficult in the pilot and development phases. On the other hand, in the validation phase, where the participants had experienced the **Approach**, there was no such difficulty. It was generally agreed that the use of examples would be productive and these were easy to identify for that *particular* problem domain *after* the **Approach** had been applied. However it was hard to find general enough examples *a priori* that would fit *all* problem domains.

4. *Create a shared knowledge context*

Because the **Approach** did not specify how this was to be achieved, the recommendation was to use the existing organisational practices in the areas of information architecture and systems design in integrating individual knowledge contexts and sharing them between the entangled processes

5. *Reorganise process ensemble to engage with the shared knowledge context*

Again, because the **Approach** did not specify how this was to be achieved the recommendation was to use the existing organisational practices in the areas of process architecture and engineering in achieving this step.

6. *Manage the reorganised ensemble*

Again, because the **Approach** did not specify how this was to be achieved, the recommendation was to use the existing organisational practices in the areas of process lifecycle management in achieving this step.

Extended Approach

However in the course of the development and validation phases, after applying these steps, more processes that fit within the scope of the identified complex business process, and have knowledge entanglements with the current process ensemble were discovered. Such discovery is consistent with the "emergence" characteristic (Cilliers P. , 2005) of complex systems discussed in section 2.3.1. Indeed, an important objective of step 6 is to look out for exactly such processes. This led to creation of an additional step of enhancement of the process ensemble to include the newly discovered processes and a loop back to step 3 of the core approach.

Even if all the processes associated with the identified complex business are discovered, it is possible that other business processes are identified that may or may not be complex in their own right, but have knowledge entanglements with the identified business processes, or would benefit from sharing the knowledge context. This clearly happened for the ST QDS investigation in the validation phase. This leads to an additional step of identifying such "adjacent" business processes and a loop back to step 2 of the core approach.

This **extended Approach,** then consists of the **Approach** extended by the following steps:

7. If more processes within the scope of the identified complex business process are discovered, extend the process ensemble list associated with the complex process and go to step 3.

8. If more "adjacent" business processes are identified, extend the list of addressed business processes and go to step 2.

In the researcher's view, the need to extend the **Approach** does not invalidate the **Approach**, as the **Approach** did meet its success criteria. In other words applying the **Approach** does lead to reducing the Management challenge of cKIBP's. What, then, can one make of the **extended Approach**? It can be argued that from the CMMI (2010) perspective, the **Approach** corresponds to a capability step while the extended **Approach** corresponds to a maturity step. In other words the core **Approach** addresses the question "How can this organisation address *one* of its cKIBP's?" while the **extended Approach** addresses the question "How can this organisation address its cKIBP's *in a repeatable and sustainable way that can be leveraged?*"

9.4 Review of the Framework

In general the elements of the proposed framework were considered to be necessary and appropriate and were used in the design and implementation of their Knowledge Base by ST, and the Fund Configuration by AB. However additional necessary features were discovered in the validation phase and these are discussed below.

Access to existing Knowledge: The information used in business processes is often available in existing applications and databases. It is not recommended as a design practice to replicate this information in a knowledge context since that would create issues of information currency, primacy and conflicts. Therefore the framework must support the ability to define the information fragment centrally but access the content from sources other than the framework itself.

Traceability: A knowledge context consists of information fragments and relationships between the fragments. Therefore the information supporting a process or activity cannot be thought of as a single data record but as a subset of the complete knowledge context consisting of a set of related information fragments that are complete with respect to the process requirement. To achieve this sub-setting capability, the framework must support the ability to trace all the related information fragments, some of which may be more than one step away from the root fragment.

History: The information provided to a process as a subset of the knowledge context is at a given point in time. This means that the same process requesting the same information at different times may receive different information if the knowledge context was modified in the interim by other processes due to independent update cycles. There is often the need to evidence the information on the basis of which process decisions were taken. To support this requirements a history of changes to information fragments must be stored, in order to recreate the conditions for retrieval at a particular point in time.

Implication: The semantics of the knowledge context may define certain constraints. When modifying information fragments, the framework must ensure that these constraints are respected. It is therefore necessary to support the evaluation of implications of changing an information fragment in order to assure that the constraints are not violated or to notify/refuse the change.

While ST did develop what could be considered a viable information framework for aKC's and both ST and AB exploited it successfully in terms of reducing the management challenge and increasing the agility of the process as a whole, an examination of the information framework itself is beyond the scope of this thesis.

However, two interesting points can be made as regards its implementation. (1) ST and AB used quite different technologies to implement the elements of the framework in very different problem domains. This provides comfort that the framework elements are general enough to be applied to different problem domains and implemented using different technologies; (2) at least in the case of ST, the resulting Knowledge Base led to a dramatically more ambitious business model, where, as an asset, the Knowledge Base could be leveraged and extended in many dimensions. This demonstrates the potency of such intervention and the scale, level and range of the impacts it can have.

9.5 Review of the Assessment Criteria

The change instrument was found to be generally effective and reflective of the attributes of complexity in the experience of participants. None of the existing factors were disputed and most of the additional factors proposed were commensurable with the existing factors, with two exceptions.

The first exception was with regard to the role of "visibility". The problem was that an improvement in visibility was noted both with conventional approaches and with the **Approach**. It makes sense that a process with greater visibility is easier to manage, and one would expect more process mature organisations to have greater visibility of their processes usually through applying some of the conventional approaches. Therefore visibility as a factor is more useful not so much an *indicator* of management challenge in itself as much as it is a *prerequisite* to addressing complexity and thus reducing management challenge. Therefore the researcher proposes defining visibility as part of process maturity to be a prerequisite in order to apply the **Approach**, and dropping it as a factor from the instrument assessing the management challenge.

The other exception was "extensibility" which was proposed as a separate factor by several participants. Extensibility was discussed in two senses (1) as a process design goal, or (2) as an indicator of the quality of the process. In neither of these senses, however, does it impact upon either the hypotheses or the **Approach**. Moreover, as in the case of ST, they could readily extend their existing infrastructure to cope with a different (albeit related) process because of the quality of the framework, process and toolset they implemented in order to manage their Knowledge Base, the design of which was dictated by the process goals. Therefore it makes more sense to view extensibility as an attribute of the quality of implementation of the framework, process and toolset, rather than affecting the development of the **Approach**.

9.6 Reflections

The researcher began the research with a number of assumptions, including a limited scope consisting of literature in the area of Business Process Complexity, and that directly relevant sources would be easily available, generally in agreement with each other and would be plentiful given the hype around BPM at the time the research commenced. The researcher also assumed that there would be at best answers or at worst approaches to answering what he believed to be clear questions being asked.

However, the scope of the literature review turned out to be large and the process turned out to be iterative, making the literature review essentially concurrent with all the phases of the research and simultaneously informing and being directed by activities in those phases. The research itself was carried out over a long period, during which Business Process Management as a concept and as a discipline had moved on as well. Thus literature review turned out to be an on-going exercise. Balancing the multiple roles played by the researcher also proved challenging.

The action research approach normally implies a transmission of learning and reflection between a preceding and a succeeding QDS/cycle. However, in practice, in every case, it became necessary to revisit the findings from all the previous QDSs, sometimes necessitating discussions between participants across QDSs. This is illustrated in Figure 28, where the solid arrows show the normal flow of learning and the dashed arrows show the modified flow.

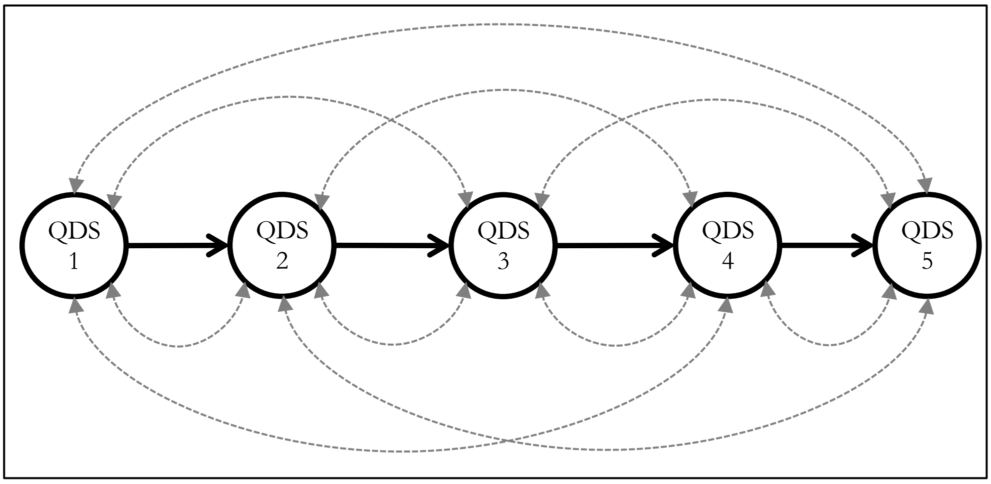


Figure 28: Reflection between QDSs

9.7 Limitations of the Research

Reservations and limitations could arise out of the, exclusion of tacit knowledge, exclusion of the political dimension and possibility of investigator bias.

9.7.1 Excluding tacit knowledge

In developing and applying the **Approach**, tacit knowledge is not explicitly addressed. This exclusion could be seen as a limitation because tacit knowledge is often a characteristic of knowledge intensive business processes when discussing knowledge creation (Nonaka, Toyama, & Konno, 2000).

However the researcher believes that this is not a significant limitation because of two reasons. Firstly, explicitly addressing tacit knowledge may lead to a better approach but does not invalidate this **Approach**. Secondly, one of the findings was that in several cases what was considered tacit knowledge was actually knowledge that lacked a structure to help make it explicit.

9.7.2 Excluding the political dimension

The political dimension was specifically excluded from the scope of this research as discussed at the end of section 2.4.1. Several participants alluded to organisational politics as a factor in increasing the management challenge of a business process. However the researcher believes this was not a significant limitation because, in the QDSs investigated, politics influenced priorities and resource allocation rather than the design of the process and knowledge infrastructure, and the **Approach** was seen as successful despite the politics.

9.7.3 Possibility of Investigator bias

Investigator bias is perhaps an inherent limitation in qualitative theses and is a possibility here because the researcher was connected to all of the QDS investigations, either due to past involvement (QDS Investigation 1-2), in the role of Managing Director – the person ultimately responsible for the decision to apply the **Approach**, as well as the systems architect (QDS Investigation 3), and in the role of consultant, and systems architect (QDS Investigation 4-5).

However the researcher believes this was not a significant factor for three reasons. Firstly, the research method adopted explicitly provided opportunities for the QDS investigations and findings to be reviewed by all the participants.

Secondly, the developed **Approach** needed to be applied to his own organisation, so there was nothing to gain for him in prematurely declaring the **Approach** valid. Thirdly, the outcomes were measured in each QDS by participants independently of the researcher and showed no significant divergence.

9.7.4 Implications of limitations

What then is the likely impact of the above limitations on the findings? As explained in the previous sections, there are no grounds to believe that investigator bias, and exclusions significantly impacted on the findings. The major implication therefore is that while the **Approach** has been tested in concept, the development of the **Approach** is not yet completed, and needs further work and validation in other cases, beyond the restrictions imposed by a doctoral thesis.

9.8 Implications of the Research

The research has several implications, particularly for the management of knowledge intensive firms, and practitioners of business process improvement. As the research has discovered, in the presence of entangled processes, applying conventional process improvement approaches tends only to worsen the situation. Therefore, management must consciously (Lissack, 1999) change the way it thinks about such processes and practitioners must change the way they approach process improvement. Such change is in three parts, the mind-set, the tool-set and the technology-set. In terms of the mind-set, this involves a paradigm shift (Kuhn, 1962) away from the mechanistic mode of thinking (Axley & McMahon, 2006) towards agility (Areta & Giachetti, 2004). In terms of the tool-set, this involves integrating the **Approach** with the conventional approaches coupled with a shift away from activity centric to information centric approaches to modelling business processes (Bhattacharya, Gerede, Hull, Liu, & Su, 2007). Finally in terms of the technology-set, this involves developing technologies supporting the life cycle of information centric business processes and agile knowledge contexts (Jung, Choi, & Song, 2007) and the identification and management of entanglements. While all change is difficult, a simultaneous, three-part change would appear to be particularly challenging.

9.9 Future Directions

Based on the QDS investigations completed to date, the researcher argues, that the **Approach** can be implemented, with reasonable assurance of obtaining some useful outcomes. However, in the researcher's view there is the potential to test, modify and extend the **Approach**. In terms of theory, there is the need to include tacit knowledge and the political dimension to form a more general **Approach**. In terms of capability, there is the need to provide tool support to implementing the **Approach**, as well as tools to support the framework. In terms of scope, there is the need to test the application of the **Approach** in other problems domains, including other ecosystems, strategic and operational alignment, regulatory compliance, agent networks and distribution models.

9.10 Contribution to Knowledge

In conclusion, the researcher believes this thesis has made a contribution to knowledge both in terms of the practice and the theory.

The contribution to theory is twofold

1. The theoretical framework (with its concepts of management challenge, entanglement, agile knowledge contexts, and the classification framework), supported by the evidence provided through the analysis of the empirical data

2. The perspective developed in 4.2 which links complexity with knowledge intensive business processes and provides both an explanation as to why business process complexity arises and a strategy for managing such processes.

Together, these have broad application to the complex knowledge intensive business processes.

The contribution to the practice includes

1. Providing a pragmatic way to understand the nature of complexity as it relates to business processes,

2. Providing an explanation as to why the current paradigm of activity centric approaches to process management do not always seem to work,

3. Identifying the key role of knowledge contexts in the management of complex business processes, and

4. Developing a viable **Approach** to managing complex knowledge contexts through a framework and process.

Reviewing those elements (as well as other minor innovations noted in earlier chapters) it is not unreasonable to claim that this thesis has fulfilled the requirement of an original contribution to knowledge

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APPENDIX

AN APPROACH TO MANAGING THE
COMPLEXITY OF KNOWLEDGE INTENSIVE
BUSINESS PROCESSES

PADMAKAR OAK

Appendix to a thesis submitted in partial fulfilment of the requirements of the University of West of England, Bristol for the degree of PhD

Faculty of Business and Law, University of West of England, Bristol

March 2013

Appendix I. QDS Investigation 3 - Review Report

I.1 Background

ST is an organisation with the mission of creating shifts in thinking. Founded in 2003, ST helps businesses understand and manage complexity through crucial thinking and simple actions.

The motivation in founding ST was based upon the experience of the founder through several large scale programme and process management initiatives and the resulting conversations with senior business executives on the causes and challenges of complexity.

This experience led to the observation that in the perception of senior executives, complexity exists when

- The more they grew the business, the less they seemed able to grow it further
- The more systems they put in place the less systematic their business seemed to become
- While they felt it should be a simple business, running it seemed to get ever more complex
- While they wanted to make the business work in synergy, the business seemed to want to break up even more
- They knew they needed to change but did not know where to begin

Such senior executives were looking for a way to:

- Synthesize many views into one coherent picture

- Understand how to fit together the many parts and manage them as a whole
- Distil the various management theories to fit their particular circumstances
- Build their own business capability rather than depend on external resources

Consequently such senior executives needed advise and support that

- Covered the width of their business scope
- Stretched from concept to delivery
- Went across the people, process and technology perspectives
- Was relevant over the lifecycle of their business

A key issue for such senior executives was to have access to such advice and support on demand, or for specific, short term assignments, investments they could justify even under tight budget constraints, and which could be resourced internally through transfer of skills and knowledge. The usual sources of such advice and support were large consulting firms whose business models were predicated upon expensive advice or free advice coupled with resource intensive long term engagements, which created a conflict of interest between these firms and their customers, and an opportunity for ST. ST is therefore designed to support these needs, through focus on strategy as a means of articulating direction, programmes as vehicles for transformation and processes as means of internal capability building. It supports these needs by providing a number of services shown in Figure 29: ST Services.

Service	Content of Service	Benefits to customers
Strategy Development	• Business Strategy • Process Strategy • IT Strategy • Product Strategy • Marketing Strategy • Outsourcing Strategy	• Wide coverage in developing strategy • Integrated strategy development process • Cohesive and consistent end result
Capability Development	• Structure using Enterprise Architecture Frameworks • Strategic Alignment using Balanced Scorecards, Structural Tension Theories • Process excellence using CMMI, Lean, Six Sigma, TOC and BPM methods	• Development of internal resources • Development of structures, policies and governance • Development of processes and metrics
Change Management	• Defining What to Change, and What to Change to • Creating Strategy for Change, Change Structure and Change Process • Managing and Evaluating Change	• Clearly formulated specification and motivation • Construction of change capability • Full lifecycle management of change • Embedding and evaluation of change
Programme Management	• Defining Problems and Constraints, Goals and Outcomes • Designing Outcome Maps, Programmes • Aligning Projects • Sustaining Direction	• Full lifecycle programme coverage • Focused on delivering business outcomes • Initiative reuse through project alignment • Continuous visibility of risks and benefits
Software Product Management	• Product Positioning • Product Lifecycle • Application Development Lifecycle	• Building SPM capability • Feature Prioritisation Framework • Issue Management Framework • Product Portfolio Architecture
Application Rationalisation	• Application Portfolio Analysis • Function Distribution Strategy • Application Portfolio Strategy	• Building Application Management capability • Function Configuration and Distribution • Issue Management Framework • Application Portfolio Architecture

Figure 29: ST Services

In offering these services, ST differentiates itself through

- Focused, time-boxed role execution

- Bounded cost, defined outcomes
- Knowledge transfer and embedding
- Seamless induction and hand-offs

In line with its mission, it is natural for ST to be involved in advising organisations managing complex business ecosystems. One such ecosystem is digital money.

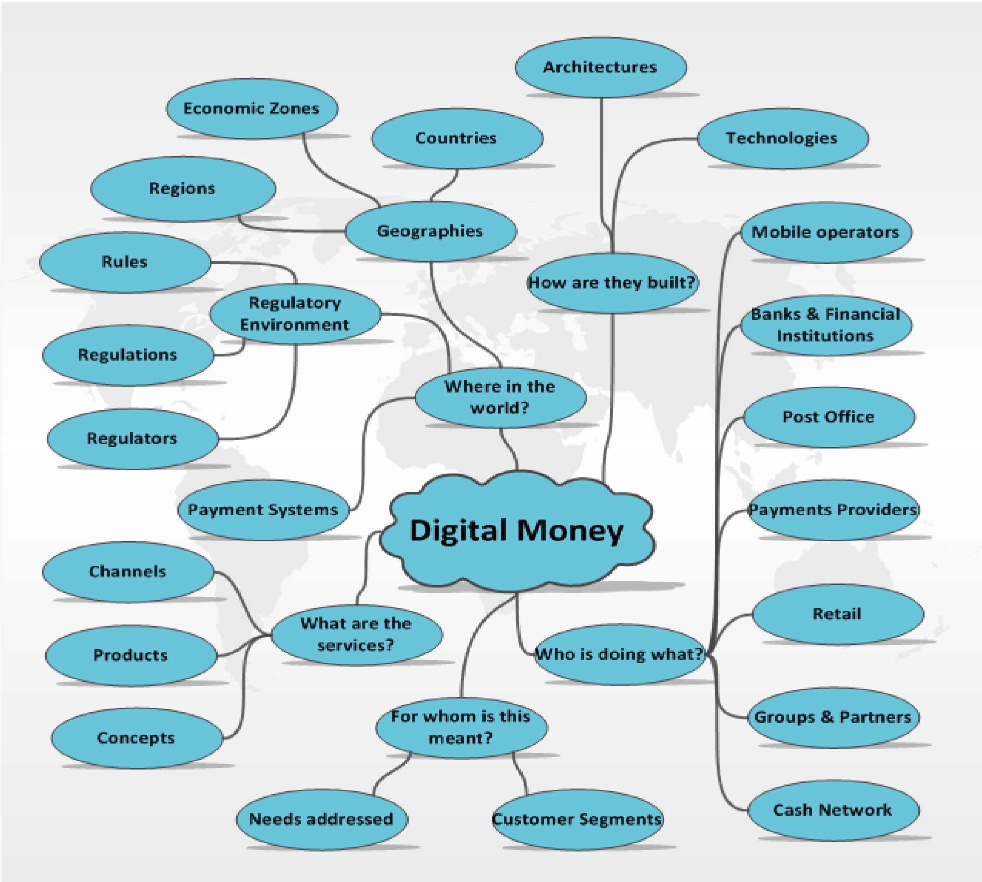

Figure 30: Key Elements of the Digital Money Ecosystem

This is a dynamic ecosystem with a size of over one trillion and a growth rate as high as 54% in some sectors, with a global reach, and a highly knowledge intensive character, which places it right in the sweet spot for ST. This includes all transactions involving value transfer in dematerialised form and includes the dematerialisation, transmission, transformation, storage, accounting, control, security and re-materialisation across organisation and state boundaries. Figure 30: Key Elements of the Digital Money Ecosystem captures key elements of this ecosystem.

1.1.1 The Opportunity

As a knowledge intensive business ST provides consulting and analytic reporting services to players in this ecosystem. When the organisation started tracking this ecosystem in 2003, if was a simpler ecosystem with very few players, mainly banks and money transfer operators, providing a few well defined services in the mature economies. The process involved in delivering these services was relatively straightforward, with well-defined sources of information, fairly stable research requirements and a stable customer base.

The advent and ubiquity of the mobile device, and more recently the smartphone, completely transformed the ecosystem which has since exploded in terms of scope of services, geographical distribution, kinds of players and regulatory interventions and the many complex interactions between all of these. As a direct consequence, the stable and predictable business processes of providing few, well defined services has been seriously impacted and can no longer cope with the complexity of the ecosystem they must service.

This is because of many factors including:

- The explosion in the number of players and their interaction
- The explosion in the number of services and their interaction
- The explosion in the infrastructures that enable inter and intra border transactions

- The explosion of regulatory changes, both local and global with the consequent conflicts

- The growth and ubiquity of mobiles and other innovative payment channels, technologies, mechanisms, interfaces and platforms

Finding a way to survive and prosper is becoming an existential necessity for ST customers in this space and constitutes a major opportunity for ST to engage in the forefront of this ever-growing, complex ecosystem.

A key catalyst in exploiting this opportunity was the arrival of the Marketing Director, a successful entrepreneur with extensive experience over 25 years of creating and delivering solutions of the Digital Money Market across functions including market development, business development, marketing, sales, product development, and technical architecture. She brought an integrated perspective across marketing, strategy and technology, having contributed to the global development of digital money through the leading money transfer company Western Union, a leading bank (Royal Bank of Scotland), a global mobile operator (Orange France Telecom), LogicaCMG (the pioneer in SMS), Smart Stream Reconciliations and Wipro a leading IT provider.

The Marketing Director articulated the opportunity, developed the business case and took on the role of the Practice Lead in the creation of the Digital Money practice with the goal of growing ST into a global brand providing information, and strategy to stakeholders in the digital money space.

A key element of the business case was that the dramatic changes occurring in the ecosystem present an opportunity to organisations like ST since they are far smaller than their competition and less invested in the past. However, the critical success factor is finding a way of managing its internal processes that is more appropriate to the unfolding complexity of the ecosystem.

1.1.2 The Challenges

Given this critical success factor, in order to achieve its goal ST must address several challenges.

- **Agility**: As discussed earlier, the ecosystem is rapidly changing. Therefore there is increasingly variability in the kind and quantum of knowledge to be researched, the vocabularies in use, the sources of information, the frequency of update, the kinds of questions that need to be addressed, and the responsiveness and depth of the reporting and the variation in reporting cycles for the customers. ST must ensure that its processes are agile enough to adapt to these changing conditions at relatively low costs.

- **Scalability**: The original requirements were for defined and commissioned deliverables which could be strictly sequenced. There is growing demand for low cost off-the-shelf reports on current topics which can be numerous. This requires ST to be able to scale up its processes to handle multiple deliverables in parallel.

- **Throughput**: Because the ecosystem is evolving so rapidly, there is growing pressure on players to take rapid decisions, which translates to significantly higher pressures on organisations like ST to provide high quality data and analysis in shorter and shorter time cycles. This requires ST to ensure that its processes are able to sustain high throughput without compromising quality or reliability.

- **Scope**: The scope of research is hugely impacted as the complexity of interactions within the ecosystem grows. Whereas in the past it was sufficient to research information directly related to a well-defined topic, now the lines are blurred between several topics and matters of relevance often cross topics and must be considered. As opposed to the earlier strategy of searching for well-defined data within well-known structured data-sets, it is now a matter of navigating a complex ecosystem, seeking what is relevant where past history often influences the notion of relevance. This calls for a completely different approach to the research process in ST.

- **Productivity**: ST has a completely organic growth strategy and does not have recourse to external funding. Therefore the capacity to address these challenges must be created from within, through greater productivity of existing resources which are extremely limited. In doing so, the cost and risk of operation and the quality of the output must be protected as they define respectively the sustainability and the brand of ST.

1.1.3 The Initial Business Model

<table>
<tr>
<td rowspan="2"><u>Key Partners</u>
• Based upon Optimisation / Economy of scale
• Associates by skill
• Associates in knowledge area
• Associates by geography</td>
<td><u>Key Activities</u>
• Based upon Problem Solving for customers
• Consulting Engagements
• Custom Reports</td>
<td rowspan="2" colspan="2"><u>Value Propositions</u>
• Customisation
• Price
• Cost Reduction
• Acceleration</td>
<td><u>Customer Relationships</u>
• Personal assistance to customers
• Regular contact with Practice Lead</td>
<td rowspan="2" colspan="2"><u>Customer Segments</u>
• Niche Market composed of
• Practice Lead Contacts</td>
</tr>
<tr>
<td><u>Key Resources</u>
Intellectual
• Access to information on internet
• Knowledge built by Practice Lead
Human
• Practice Lead</td>
<td><u>Channels</u>
• Sales Force consisting of
• Practice Lead</td>
</tr>
<tr>
<td colspan="3"><u>Cost Structure</u></td>
<td colspan="4"><u>Revenue Streams</u></td>
</tr>
<tr>
<td>Value-Driven</td>
<td colspan="2">Fixed Costs
• Practice Lead Salary
• Infrastructure
• Marketing
Variable Costs
• Costs related to consulting engagements</td>
<td colspan="3">Asset Sale consisting of
• Consultant Time
• Contract value for deliverable</td>
<td></td>
</tr>
</table>

Figure 31: The Initial Business Model

The practice was set up with a very simple business model, centred upon and maximising the value of the Practice Lead's knowledge, experience and contacts. The model is captured in Figure 31: The Initial Business Model

The target market was the contacts made by the Practice Lead, with the value proposition based upon customised consulting engagements and reports, lower prices with consequent cost reductions for customers and an acceleration of value through the skill and experience of the Practice Lead. Economies of scale were to be achieved by engaging key partners for their specific skills or knowledge to deliver specified components of the engagement. In the light of the new practice the service offering was enhanced with the following service:

Service	Content of Service	Benefits to customers
Digital Money Market Entry Strategy	• Country Selection • Business Case • Partner Selection • Market Segment Analysis • Product Definition	• Across Digital Money, not just mobile money • Offers deep insight into global innovative payment services • Analysis is based upon multi-perspective knowledge integration tools • Focussed and responsive deliverables

1.1.4 The Initial Operating Model

The initial operating model was also very simple, consisting of only two business processes – Sales and Delivery, and their component processes. This is captured in the Figure 32: The Initial Operating Model

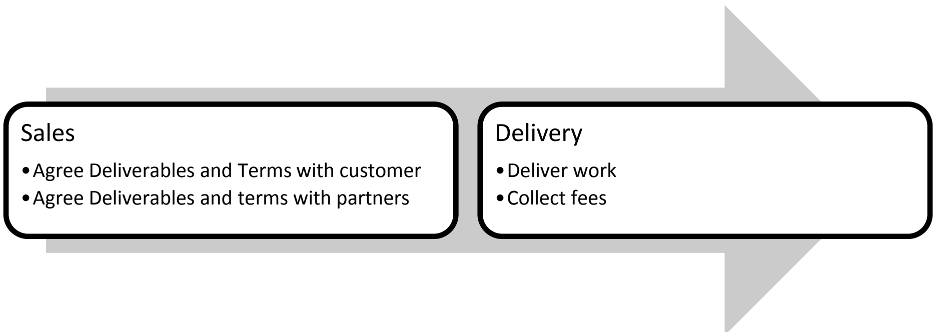

Figure 32: The Initial Operating Model

I.1.5 The Initial Implementation

The practice commenced with an initial engagement based upon contacts made by the practice lead. The client was another consulting firm focussed on the mobile industry, and was attempting to enter the digital money research space. The client had been long established and had built a strong reputation for their expertise in the mobile industry. They also had mature processes in terms of conducting research, producing standard reports, organising conferences and delivering strategic consulting engagements to their own clients. A reason for the attraction of that engagement to ST was an opportunity to learn from the client in terms of process and deliverable quality.

The engagement consisted of two separate strands: delivering specific strategic analysis and recommendations in collaboration with the client's internal and external partners, and delivering presentations on Digital Money at the client's various international conferences in order to support the client's credentials in that space.

Delivering these strands led to the assessment of the gaps in capability within ST at that time. These were identified to be specific knowledge areas and the need for editorial support. Associates were identified and retained to plug these gaps in capability and a simple operating framework was established.

Issues arose almost immediately in the delivery of the engagement in the following major areas: the speed of delivery, the quality of the deliverables, and the predictability of the process. Consequently, this led to considerable rework, delays, acrimony in the client and associate relationships and increasing cost and risk to ST.

I.2 Initiation

Through a workshop, the researcher discussed with the participants the basic concepts of complexity, process management, process maturity and change. The objective of the workshop was to develop a common understanding of the concepts and approaches among potential participants and to create a description of the problem to be solved. The initiation workshop also introduced the action research methodology and confirmed the roles and agreement of the participants. The instrument was also applied at this stage.

I.3 Iteration 1: Process Maturity

I.3.1 Diagnosing

Several explanations for these problems were examined in consultation with the practice lead and associates. These were:

Quality of sale: This related to clarity of customer expectations, understanding of work content and feasibility of producing the deliverables, estimation of effort and risk, cost and margin assessments and feasibility of the timeline. All of these were discounted because these were not issues when seen independently, and both the practice lead and the partners had experience of delivering such engagements before.

Competence of the customer: This related to the question of whether the client understood their requirements, clearly defined and stood by the deliverable and was able to assess and absorb the deliverables, and do all of these in a predictable and reliable way. This too was discounted as an explanation, because there was little evidence of instability of requirements or definition of deliverables, and the quality issues raised were justified. Also, the client itself had considerable experience, capabilities and mature processes around exactly such engagements, which ST in fact wanted to learn from.

Competence of the practice lead: One explanation considered was the ability of the practice lead to manage such an engagement. This too was discounted because the practice lead had a track record of managing much larger and far more challenging engagements in the various large organisations, and there was nothing novel about this particular engagement.

Competence of the associates: Yet another explanation considered was the ability of the associates to deliver their specific pieces of work. This too was discounted because the associates had been engaged precisely for their track record of competence in their specific areas, and there was no evidence to suggest that there were issues with their contribution when seen individually.

Quality of the process: Upon deeper examination, it became evident that most of the issues originated in the following areas: clarity regarding state and expectations for each activity, transfer of information between the client, ST and the associates, the co-ordination of activities and the management of change all of which related to the quality of the process. Therefore the quality of the process itself seemed to be the most likely explanation for the problems.

Consequently, ST focussed on improving process quality. CMMI (2010) was chosen as a framework for improvement efforts, as CMMI models provide guidance for developing or improving processes that meet the business goals of an organization and a CMMI model may also be used as a framework for appraising the process maturity of an organization. Additionally, ST was very familiar with CMMI having implemented it in software engineering and service delivery contexts for its clients.

CMMI defines five levels of maturity: Initial, Managed, Defined, Quantitatively Managed and Optimizing. It was evident that the Digital Money practice was at the Initial level, and it was agreed that it was necessary to focus on and achieve the Managed level and it would be sufficient for the practice to remain at the Defined level.

Therefore the objective of the intervention was to move the Digital Money practice to the Managed level with the goal of addressing the problems in the current engagement as well as future engagements of that kind.

1.3.2 Planning Action

CMMI (2010) advocates that, in order to achieve the Managed level, process improvement efforts should focus on the following process areas (called improvement areas hereon):

- **CM** - Configuration Management
- **MA** - Measurement and Analysis
- **PPQA** - Process and Product Quality Assurance
- **REQM** - Requirements Management
- **SAM** - Supplier Agreement Management
- **SD** - Service Delivery
- **WMC** - Work Monitoring and Control
- **WP** - Work Planning

In order to improve these process areas, it was first necessary to elaborate the business processes to the extent that the relationship of these improvement areas to the processes of the business processes and their activities could be identified. A decision was taken to limit the intervention to the business processes supporting the first strand of the engagement in order to contain risk. Taking this into account the plan for the intervention was:

1. Elaborate the business process to the appropriate extent

2. Define and improvement strategy for each improvement area

3. Make improvements for each process and its activities impacted by the improvement areas

The results of the intervention would then be evaluated collectively with the practice lead and associates. In agreement with the practice lead and associates, this plan was put into action.

I.3.3 Taking Action

I.3.3.1 Elaborating the business processes

While the structure of the business process was retained, each business process was elaborated in terms of the processes and their activities within that business process. The revised operating model is captured in Figure 33: Iteration 1 - Operating Model

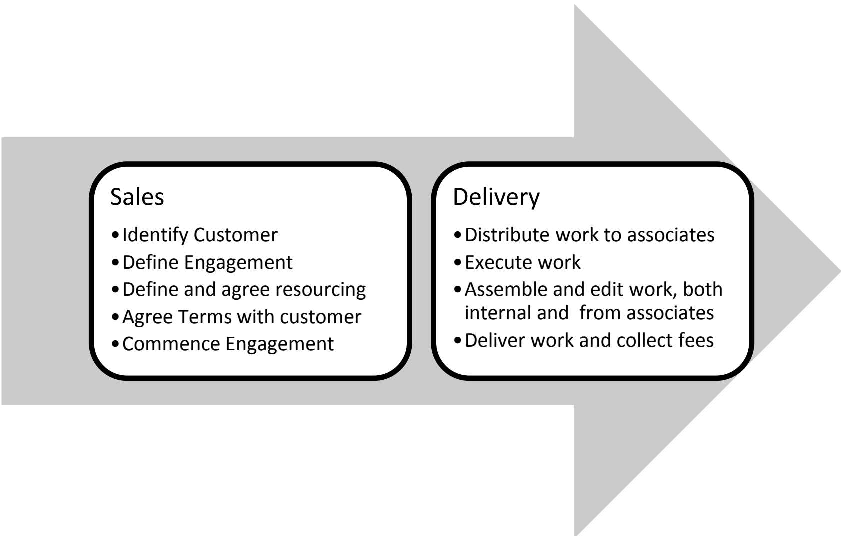

Figure 33: Iteration 1 - Operating Model

I.3.3.2 Strategies for improvement

For each process area certain strategies for improvement were identified and implemented. These are described in Figure 34: Iteration 1 - Improvement Area and Strategies.

Improvement Area	Improvement Strategies
CM: Configuration Management	Create common library of knowledge artefacts for all processes Create consistent naming standards Implement version control
MA: Measurement and Analysis	Identify measures for process / activity Verify measure for each activity upon completion
PPQA: Process and Product Quality Assurance	Define standards for each deliverable Define standards for each interface Agree compliance and exception management Agree escalation and remediation process
REQM: Requirements Management	Define requirement template Define requirement change process Create consistent referencing standards Reference requirement appropriately in each deliverable
SAM: Supplier Agreement Management	Define Agreement template Create consistent referencing standards Reference agreement terms appropriately for each activity / deliverable
SD: Service Delivery	Embed templates into processes and ensure adherence Provide tool support for communications Provide tool support for documentation

Figure 34: Iteration 1 - Improvement Area and Strategies

I.3.3.3 Making Improvements

For each of the processes, the impacting improvement areas were identified. These are reflected in Figure 35: Iteration 1 - Improvements by Process.

Process	Improvements by Improvement Area
Identify Customer	**CM**: Maintain single prospect list with status in common library **MA**: Qualify prospect list by suitability, likelihood and value
Define Engagement	**CM**: Maintain all engagement documents in common library with consistent naming conventions **MA**: Include standards and measures for engagement in agreement and verified upon delivery **REQM**: Include requirements documentation standards and change process in agreement
Define and agree resourcing	**CM**: Maintain resource list with status in the common library **MA**: Include standards and measures for engagement in associate agreement and verified upon delivery **PPQA** : Included standards for each deliverable and interface, compliance and exception management, escalation and remediation process in associate agreement **REQM**: Define and apply standard requirement template, requirement change process and consistent referencing standards. Reference relevant requirement appropriately in each deliverable **SAM** : Reference Agreement template, consistent referencing standards defined and relevant agreement terms appropriately for each activity / deliverable
Agree Terms with customer	**CM** : Maintain Client agreement in common library **SAM** : Verify that agreement follows agreement template
Commence Engagement	**CM**: Maintain key engagement documents in common library with version control checkpoint **SD**: Implement and test templates, document standards, communication standards tools and processes
Distribute work to associates	**CM**: Maintain work packages on common library under version control **MA**: Confirm standards and measures at issue of work package **PPQA**: Confirm compliance, exception, escalation and remediation at issue of work package **REQM**: Confirm that all requirements are covered in work packages and current version of requirement referenced in work package **SAM**: Reference relevant agreement terms in work package **SD**: Reference templates, document standards, communication standards tools and processes in work package
Execute work	**CM**: Maintain interim work products in common library with version control **MA**: Monitor and record progress in course of work **REQM**: Reference work products relevant requirement and route changes in requirement as changes in work packages

Process	Improvements by Improvement Area
	SAM: reference relevant agreement terms in work products **SD**: Monitor work products to adhere to relevant templates, document and communication standards
Assemble and edit work, both internal and from associates	**CM**: Maintain deliverables corresponding to work packages in common library with version control checkpoint **MA**: Verify standards and measures at receipt of deliverable and final deliverables **REQM**: Verify that all requirements are addressed through deliverables **SAM**: Verify that deliverables reference relevant agreement terms **SD**: Verify that deliverables adhere to relevant templates, document and communication standards
Deliver work and collect/pay fees	**CM**: Maintain final deliverable in common library under version control checkpoint **REQM**: Verify that all requirements are addressed through final deliverables and current version of requirement referenced in relevant deliverable **SAM**: Verify that closing documents reference agreement terms

Figure 35: Iteration 1 - Improvements by Process

I.3.4 Evaluating Action

As a consequence of the intervention, improvements were noted across all the problem areas. The quality of deliverables and the conformance to the process improved considerably. The speed of the business process also improved somewhat as did the predictability. This led to a reduction in rework and the consequent delays, eliminated the acrimony in the relationships through the transparency provided by the business process and consequently reduced the risk to ST.

The engagement closed uneventfully and was considered a success. However, even before the engagement closed, a number of problems became evident.

- The overhead involved in the new operating model added to the cost of the engagement.

- It took almost all the practice lead's time to manage the operating model, so that more work needed to be passed on to associates, further adding to both the cost and the overhead, and reducing the valuable input earlier provided by the practice lead.

- Associates from the client team followed their own processes, and this often led to conflicts which needed resolution.

- There was little reduction in the number of cycles required to agree requirements and complete deliverables as the duration of the process allowed for requirement changes. While some of the costs could be passed back to the customer, it did take away the opportunity for the practice lead to win more business.

- While the predictability of individual processes did improve the predictability of the cost and duration of the business processes as a whole did not.

- Several more engagement opportunities arose that did not seem to follow this particular operating model and it made no sense to undertake a similar exercise per engagement.

- While the intervention addressed the first strand of the engagement i.e. delivering specific strategic analysis and recommendations in collaboration with the client's internal and external partners, it did not address the second strand i.e. delivering presentations on Digital Money at the client's various international conferences in order to support the client's credentials in that space. While that was a considered decision, based on the assumption that the two strands were isolated from each other, it became clear that there were overlaps due to sharing the practice lead's time, the need for research to support the presentations and the need to synchronise the second strand with the first. These overlaps gave rise to several issues related to control of the business processes and delivery time and quality.

Consequently, while there were benefits from the intervention to that engagement, ST could not see this as a sustainable solution in the context of all its engagements.

I.4 Iteration 2: Process Optimisation

I.4.1 Diagnosing

While the Digital Money practice could be considered to have moved to a Managed Level there were problems identified, concerning the ability of the practice to reliably deliver within acceptable quality, time and cost constraints, that needed addressing. Several explanations for these problems were examined in consultation with the practice lead and associates. These were:

Quality of implementation: This related to the question whether ST had implemented the move to the Managed level with depth and rigour that was both sufficient and appropriate. Given that ST already had considerable knowledge and experience through its work on capability development with several large and small organisations, the assessment was that depth and rigour was sufficient, perhaps overly so. This explanation was therefore discounted.

Validity of the approach: This raised the question whether ST should have pursued the CMMI (2010) model in the first place. It was agreed that there were benefits due to better definition of the operating model. However, other explanations for the benefits observed were debated.

- **Learning effect**: While there was clear improvement in the transparency and quality of interactions, this could also be explained by the growing familiarity with the business processes, templates and protocols that arose through the many cycles. Therefore it could be argued that the improvement was not so much because of the quality of the operating model, and more to do with the fact that it existed and was repeated.

- **Unfolding clarity**: Another explanation for the improvement was that as the engagement progressed, the collective understanding of ST and its associates grew and this was the biggest contributor to the improvement. This explanation was supported by the observation that another parallel engagement also showed much the same pattern of improvement despite being managed from inception under the new process.

- **Variation**: While the variation in the quality of deliverable and adherence to the process structure was considerably reduced, there was no impact on the variation in the duration of activities and cycle time. Where there was improvement, it was explained more in terms of unfolding clarity rather than process quality.

Process Information v/s Contextual Information: A key observation was that there seemed to be two distinct kinds of information exchanged. Process Information consisted of the status and sequencing of activities and structure and state of deliverables. While this contributed to the visibility of the process it did little to improve the process. Contextual information, on the other hand, was that which enabled a shared understanding of the requirement and consequently a context for the activity. It was the latter which was the major source of improvement and it was impacted more by unfolding clarity rather than the process itself.

Impact of Marketing: While the second strand of the engagement was initially assumed to be isolated from the first, it became evident that there were dependencies in terms of resources, research and synchronisation. More importantly it became evident that the second strand also contributed to ST marketing in terms of contacts and knowledge and needed to be recognised as a business process in its own right.

Distinguishing production and delivery: While the operating model did not distinguish between production and delivery as separate business processes, important differences became evident:

- Production involved interactions almost exclusively between ST and its associates while delivery involved interactions between ST and the customer.
- Production and delivery operated on different cycle times.
- Production was far more under the control of ST while delivery was almost entirely determined by the customer once production was deemed complete.

Consequently, ST focussed on two goals, redefining the operating model to recognise and address the observations made and optimising it to address the problems identified.

There was considerable debate regarding the approach to take. Options considered included Lean, Agile and Six Sigma, all of which were very familiar to ST through its work in capability development in several organisations. While Six Sigma was seen as a more complete methodology, it was more appropriate for processes that addressed a large number of similar cases where quantitative measures were available or could be easily obtained. Agile, on the other hand was more appropriate to evolving the same case over multiple iterations. Lean focussed on eliminating waste.

The approach agreed was to use appropriate elements of each of the methodologies, the choice being guided by the goals of the intervention.

I.4.2 Planning Action

The "Lean" approach identifies several kinds of waste. The relevant kinds of waste and their interpretation as applied to the intervention are provided in Figure 36: Iteration 2 - Interpretations of Lean Waste in intervention.

Waste	Interpretation for the intervention
Transport	Communicating work products that are not actually required to perform the processing
Inventory	Number of work products incomplete but not currently being processed
Motion	Reformatting or Refactoring of work products and repositioning in the common library hierarchy
Waiting	Associates waiting on work products to commence production
Overproduction	Creation of work products not contributing to deliverables
Over Processing	Unnecessary steps and effort required to produce work products
Defects	The effort involved in inspecting for and fixing defects
Misalignment	Producing work products that do not meet client specifications
Unused Talent	Relevant associate knowledge available but not recognised or utilised

Figure 36: Iteration 2 - Interpretations of Lean Waste in intervention

The Six Sigma approach defines DMAIC as the project methodology for improving business processes. The DMAIC project methodology has five phases:

- **Define** the problem, the voice of the customer, and the project goals, specifically.

- **Measure** key aspects of the current process and collect relevant data.

- **Analyse** the data to investigate and verify cause-and-effect relationships. Determine what the relationships are, and attempt to ensure that all factors have been considered. Seek out root cause of the defect under investigation.

- **Improve** or optimize the current process based upon data analysis using techniques such as design of experiments, poka yoke or mistake proofing, and standard work to create a new, future state process. Set up pilot runs to establish process capability.

- **Control** the future state process to ensure that any deviations from target are corrected before they result in defects. Implement control systems such as statistical process control, production boards, visual workplaces, and continuously monitor the process.

Agile is a conceptual framework that promotes foreseen interactions throughout the development cycle and is based on iterative and incremental development, where requirements and solutions evolve through collaboration between self-organizing, cross-functional teams. It promotes adaptive planning, evolutionary development and delivery, a time-boxed iterative approach and a rapid and flexible response to change.

In optimising the operating model, the strategy was to use the principles of lean to eliminate wastage, use agile to promote time-boxed iterations and adaptive planning between ST and its associates and to the Six Sigma DMAIC methodology as a framework to guide the work of optimisation.

1.4.2.1 Process to Project Centricity

One problem that needed to be addressed was the fact that there were now multiple engagements that did not easily fit into this process model. But it was clear from the first iteration that it was not practical to design individual processes for each engagement. Therefore the approach taken was to define a common “meta” operating model template, and make only the minimum necessary modifications to the “meta” template processes as needed in order to deliver different engagements. In effect this re-oriented the Digital Money practice from being process-centric to being project-centric. However resources continued to be shared between the projects as the practice lead still managed all the projects and the associates remained essentially the same.

I.4.2.2 Scaling of resources

In order to address the speed of the overall operating model, it was decided to scale up the resources in terms of associates depending upon demand. While this was challenging, it was felt that the additional effort and cost would be compensated through a shorter lead time to delivery, more flexibility and reduced risk.

I.4.2.3 Synchronisation

While scaling of resources would partly address the synchronisation problems, it was necessary to ensure a means of synchronisation for all processes and activities. It was agreed that the practice lead would set the pace or "heart-beat" for each engagement and orchestrate the commencement and completion of each activity becoming in effect the synchronising agent for the whole engagement.

I.4.2.4 Contextual Information

In order to address the need to manage contextual information, it was agreed to minute hand-off conversations and that the work-package would be accompanied by a context document which captured the necessary contextual information and would be updated in the course of executing work.

1.4.3 Taking Action

1.4.3.1 Modified operating model

The first action undertaken was to modify the operating model to recognise activities involved in Marketing and Production business processes, as shown in Figure 37: Iteration 2 - Operating Model.

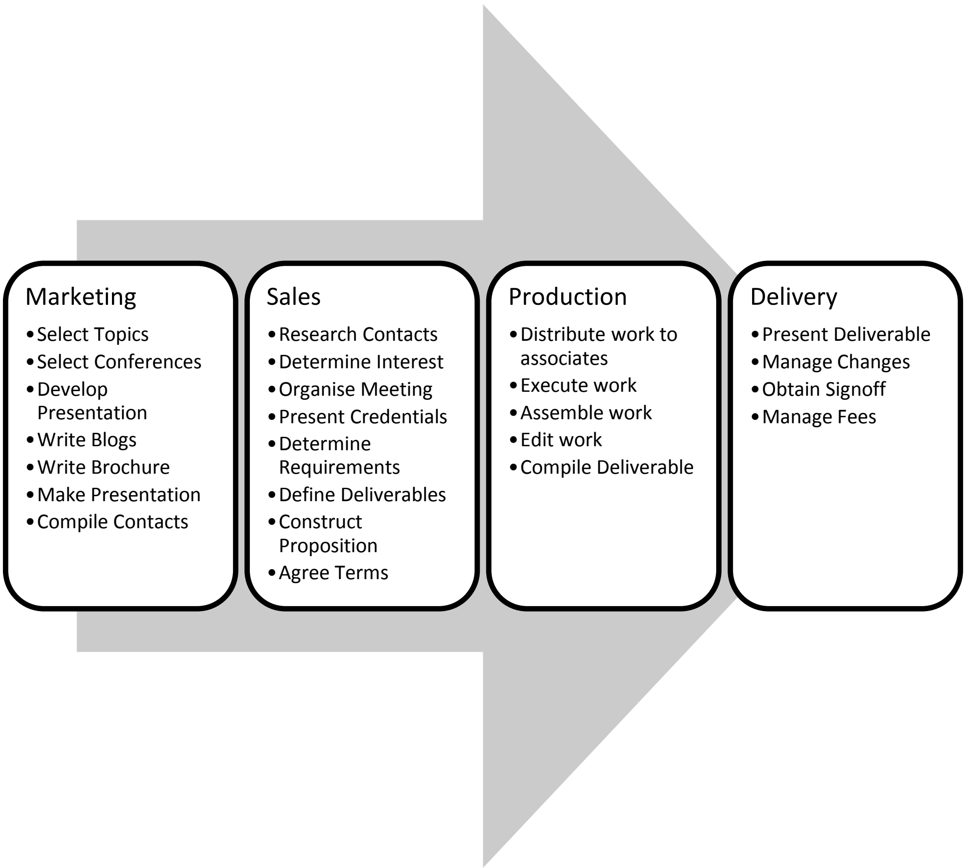

Figure 37: Iteration 2 - Operating Model

I.4.3.2 Strategies for improvement

For each improvement area certain strategies for improvement were identified and implemented. These are described in Figure 38: Iteration 2 - Improvement Strategies.

Improvement Area	Improvement Strategies
Lean	
Transport	Minimise communications to only those absolutely necessary in each hand-off
Inventory	Issue work packages only when: all necessary inputs are available AND all necessary resources are available
Motion	Pre-form most work products and design intermediate work-products to avoid need for refactoring of work products Pre-define positioning in the common library hierarchy
Waiting	Activate associates only on issue of work package
Overproduction	Construct "manifest" of work products when defining deliverables Check manifest for superfluous work products
Over Processing	In each activity, eliminate unnecessary steps and effort required to produce work products
Defects	Institute a "Verify inputs" step at the start of each activity
Misalignment	Check manifest for misaligned work products
Unused Talent	Create a remarks section in each work product Encourage associates to add relevant knowledge to that section
Agile	
Time Boxed Iterations	Break the "Execute Work" activity into time boxed iterations Institute a short review at each iteration to detect defects, misalignment
Adaptive Planning	Define plan in "Distribute Work Package" activity Adapt plan at each iteration
Six Sigma	
DMA	Applied for each sub-process / activity
DM	Applied to process as a whole

Figure 38: Iteration 2 - Improvement Strategies

A key component of the DMAIC is the identification of metrics to support analysis, improvement and on-going control of the process. For each of the process groups metrics identified are reflected in Figure 39: Iteration 2 - Metrics Identified by Process Group.

Process Group	Metrics
Marketing	Presentation Development Time
Sales	Conversion Rate, Cycle Time, Average Price
Production	Standard Report Time, Custom Report Time
Delivery	Closure Cycles, Closure Time

Figure 39: Iteration 2 - Metrics Identified by Process Group

I.4.3.3 Making Improvements

For each of the sub-processes and activities, improvements effected are reflected in Figure 40: Iteration 2 - Improvements by Process

Process	Improvement
Select Topics	**Lean**: Motion, Misalignment, Unused Talent **Agile**: Time Boxed Iterations Six Sigma: DMA
Select Conferences	**Lean**: Motion, Misalignment, Unused Talent **Agile**: Time Boxed Iterations Six Sigma: DMA
Develop Presentation	**Lean**: Motion, Waiting, Over Production, Over Processing, Defects, Misalignment, Unused Talent **Agile**: Time Boxed Iterations, Adaptive planning Six Sigma: DMA
Write Blogs	**Lean**: Motion, Waiting, Over Production, Over Processing, Defects, Misalignment, Unused Talent **Agile**: Time Boxed Iterations, Adaptive planning Six Sigma: DMA
Write Brochure	**Lean**: Motion, Defects, Misalignment, Unused Talent **Agile**: Time Boxed Iterations, Adaptive planning Six Sigma: DMA
Make Presentation	**Lean**: Transport, Misalignment, Unused Talent **Agile**: Adaptive planning Six Sigma: DMA
Compile Contacts	**Lean**: Transport, Inventory, Motion, Waiting **Agile**: Time Boxed Iterations Six Sigma: DMA
Research Contacts	**Lean**: Transport, Motion, Waiting, Over Production, Over Processing, Defects, Misalignment, Unused Talent **Agile**: Time Boxed Iterations, Adaptive planning Six Sigma: DMA
Determine Interest	**Lean**: Over Production, Over Processing, Misalignment, Unused Talent **Agile**: Adaptive planning Six Sigma: DMA
Organise Meeting	**Lean**: Transport, Misalignment **Agile**: Adaptive planning Six Sigma: DMA
Present Credentials	**Lean**: Waiting, Over Production, Over Processing, Misalignment **Agile**: Time Boxed Iterations, Adaptive planning

Process	**Improvement**
	Six Sigma: DMA
Determine Requirements	**Lean**: Transport, Inventory, Motion, Waiting, Over Production, Over Processing, Defects, Misalignment **Agile**: Time Boxed Iterations, Adaptive planning Six Sigma: DMA
Define Deliverables	**Lean**: Transport, Inventory, Motion, Waiting, Over Production, Over Processing, Defects, Misalignment **Agile**: Time Boxed Iterations, Adaptive planning Six Sigma: DMA
Construct Proposition	**Lean**: Transport, Motion, Over Production, Defects, Misalignment **Agile**: Time Boxed Iterations, Adaptive planning Six Sigma: DMA
Agree Terms	**Lean**: Transport, Inventory, Motion, Waiting, Over Production, Over Processing, Defects, Misalignment **Agile**: Time Boxed Iterations, Adaptive planning Six Sigma: DMA
Distribute work to associates	**Lean**: Transport, Inventory, Motion, Waiting, Defects, Misalignment **Agile**: Adaptive planning Six Sigma: DMA
Execute work	**Lean**: Transport, Inventory, Motion, Waiting, Over Production, Over Processing, Defects, Misalignment, Unused Talent **Agile**: Time Boxed Iterations, Adaptive planning Six Sigma: DMA
Assemble work	**Lean**: Transport, Inventory, Motion **Agile**: Adaptive planning Six Sigma: DMA
Edit work	**Lean**: Transport, Inventory, Motion **Agile**: Time Boxed Iterations, Adaptive planning Six Sigma: DMA
Compile Deliverable	**Lean**: Transport, Inventory, Motion **Agile**: Time Boxed Iterations, Adaptive planning Six Sigma: DMA
Present Deliverable	**Lean**: Defects, Misalignment **Agile**: Adaptive planning Six Sigma: DMA
Manage Changes	**Lean**: Transport, Inventory, Motion, Waiting, Over Production, Over Processing, Defects, Misalignment **Agile**: Time Boxed Iterations, Adaptive planning Six Sigma: DMA
Obtain Signoff	**Lean**: Transport, Defects, Misalignment **Agile**: Adaptive planning

Process	Improvement
	Six Sigma: DMA
Manage Fees	**Lean**: Transport, Motion, Defects, Misalignment **Agile**: Adaptive planning Six Sigma: DMA

Figure 40: Iteration 2 - Improvements by Process

I.4.4 Evaluating Action

As a consequence of the intervention, it became evident that most of what was measured did improve, particularly at the level of individual activities, although that did not necessarily translate into improvement at the process level. For instance, there was no significant impact on the customer in terms of cycle time or cost, although there was some improvement in the signoff due to most of the defects being addressed through multiple iterations.

As a consequence of becoming the synchronising agent and orchestrator for all engagements, the Practice Lead became the single point of failure as a consequence became overloaded and highly stressed. Also, a vital asset in terms of the Practice Lead's own knowledge and experience became unavailable.

The approach of scaling resources and work-packages in order to achieve synchronisation resulted in both, co-ordination effort and cost exploding.

This also led to major project overhead for relatively few activities; a number of project level processes to develop and maintain; significant increase in status reporting for each work-package and iteration; and too many dependencies due to the fragmented nature of work being delivered by the same set of resources. The general feeling shared by the practice lead and the associates was that the arrangement was "It's too complex".

Due to the fragmentation and distribution of the work-packages, opportunities for synergies, time savings, which usually arose when the same associate was attached continuously, were now missed. Since each engagement was treated as a separate project and associates worked on different work-packages on different projects, there was little learning across engagements.

It had been expected that the introduction of a "Remarks" section in each work product, in which associates could capture relevant observations, would compensate for the problems of fragmentation. However this did not happen for two reasons:

- While associates did try to contribute through the "Remarks" section, the Practice Lead, who was responsible for processing the remarks simply did not have time to deal with them in addition to co-ordinating the engagements.

- When examined, it was not readily apparent what the remarks meant without recourse to a conversation with the associate, which meant further time lost. There was no structure to the contributions, and there was no framework into which these contributions could be assimilated.

It had been expected that minutes of hand-off conversations and the accompanying context document would accelerate work execution. This too did not happen for the following reasons:

- The creation of minutes added more load on the Practice Lead and necessitated further conversation to clarify points which was happening earlier in any case.

- While context documents were provided, it was difficult to anticipate what would be contextually relevant without further conversations and the process of unfolding clarity. This again added to the Practice Lead's load.

- Finally, there was no framework to assimilate the various context documents produced so no value could be mined beyond the activity and they ended up being filed and forgotten.

I.5 Iteration 3: Managing Constraints

I.5.1 Diagnosing

While the value of metrics and measurement was acknowledged, there was complete consensus that the intervention had made the process as a whole complex and unmanageable. In contrast to the goal of the intervention, instead of reducing waste by eliminating unnecessary activities and work products, there seemed to be even more activities, conversations and wasted effort. This led to the whole approach being called into question as it made what both the practice lead and the associates felt should be a simple process they were all familiar with into something unnecessarily complex, particularly as the organisation continued to grow.

This was in conflict with both, the established view of approaches such as Lean, Agile and Six Sigma, as well as ST experience of applying these in business environments. A peer review could find little to fault in the application of the techniques. While the application of the approaches in combination was questioned, it was difficult to see how the situation would have been different if they were applied in isolation.

Since increasing "complexity" had been the constant refrain through all the interventions, and given the recognition that growth had inevitably resulted in the need for internal reconfiguration whose complexity reflected that of the ecosystem with which the organisation needed to engage, it was decided to directly understand and try to address the issue of complexity.

1.5.1.1 Understanding Complexity

First, the practice lead and the associates made an attempt to arrive at a common definition of complexity as it related to the process. While no precise definition could be agreed upon, several process attributes were suggested and these were organised into four categories: characteristics, comprehensibility, behaviour and consequences. This is shown in Figure 41: Iteration 3 - Process Attributes of Complexity.

Characteristics	Comprehensibility	Behaviours	Consequences
Interrelated	Hard to understand	Surprising	Uncontrollable
Convoluted	Opaque	Unpredictable	Fragile
Not Simple	Unclear	Unstable	Unmanageable
Complicated	Intricate		Intractable
Too many moving parts	Confusing		Difficult to modify
	Ambiguous		Difficult to extend

Figure 41: Iteration 3 - Process Attributes of Complexity

A key insight provided by the discussion on complexity was that it was influenced by both, the number of elements in the process (activities and products) and the dependencies between these elements. This explained why fragmentation increased the complexity. While the *kinds* of elements remained the same, the number of elements and consequently the *number* of dependencies having to be managed increased dramatically.

Another insight was that the nature of the dependency mattered significantly. Simple sequential dependencies between elements such as the flow between sequential activities in a process did not have anything like the impact that bi-directional dependencies, such as modifying a requirement did. Dependencies are just one kind of relationships and complexity seemed to depend upon both, the *nature* and the *number* of relationships between elements.

But did complexity matter, particularly to ST? Operationally, it increased the cost and risk of delivery. It locked up key resources, which resulted in losing engagement opportunities and consequently brand and market share in a rapidly growing marketplace. But strategically, it failed to address the very challenges (Agility, Scalability, Throughput, Scope and Productivity) identified earlier that needed to be overcome if the business model of ST was to become successful.

Since complexity mattered so much, the next step was to identify complexity in the operating model. A key insight in doing so was that not all processes in the operating model were complex in terms of the attributes listed earlier. For instance:

- A sequence of activities, with clear and structured interfaces, to be carried out in order by the same associate tended to be simple from the management point of view even if individual activities required considerable effort

- Processes which involved such simple sequences coupled with hand-offs, decision points and loops, were still entirely predictable and therefore manageable with a little more effort, provided the interfaces remained clear and structured as they could be modelled and the model enforced.

- Where the process could not be modelled with any confidence, it was left to the ability of the particular associate to deliver with best efforts. The question of management did not arise, as the process accepted whatever was offered

- It was in situations where the model could not be enforced without negative consequences that the challenges arose. The reasons were usually to do with availability of resource or the clarity of information required.

Therefore the classification shown in Figure 42: Iteration 3 - Process Classification was adopted in describing processes:

Type	Description
Simple	Linear sequences of activities where interfaces are clear and structured and no hand-offs are necessary (the same resource executes the whole sequence). These can be easily modelled and the model easily enforced
Complicated	Hand-offs, decisions and loops are now involved but the interfaces remain clear and structured. While more difficult to do so, these can still be modelled and the model enforced.
Complex	Complicated processes which can be modelled but regularly deviate from the model. Enforcing the model can have negative consequences
Chaotic	Processes which cannot be modelled with any confidence

Figure 42: Iteration 3 - Process Classification

I.5.1.2 Drivers of complexity

The next step was to attempt to understand why complex processes deviated from their models and how that deviation affected the stability of the process.

This usually occurred when there were resource constraints e.g. when the same associate was attempting to simultaneously work on multiple work packages and prioritisation became necessary. In that case the associate attempted to optimise the combination of work packages in order to minimise the impact on time to deliver for those work packages. To do otherwise would have meant inefficient utilisation of the associate and delays that could have been avoided. Therefore the existence of resource constraints within interdependent processes was one driver.

This also occurred when one associate waited upon research from another associate. Again, in order to maintain the flow of work, the associate would reprioritise and optimise a combination of work packages. Again to do so otherwise would have meant idle time and interrupted flow of work. Unfortunately, this meant that frequently the associate could not immediately pick up the necessary research when it became available, and consequently the effect cascaded to other processes. Therefore the lack of synchronisation between process instances was another driver.

There was also another situation where the stability of the process was affected. The commissioning of a work package assumed that the context document accompanying the work package would provide the knowledge context required to process. However there were frequent instances where determining the knowledge context was itself a process of unfolding clarity. In other words it required iterated interactions to develop the context and this sometimes meant commissioning more work packages. This happened in three cases.

In the case where the gap in the context related to additional information for entities in the context, this did not have a significant impact. This was called the Information Case.

In the more frequent second case, other entities that were related to those already in the context needed to be discovered and added to the context in a recursive fashion and this entire web of related elements and information about them needed to be ascertained before the process could be continued. This was called the Knowledge Case. While this did have a more significant impact, so long as the context determined which relationships to look for and how deep to recurse, the impact could be limited.

However it was the third case, where the search was open-ended and it was left to the associate to determine what to look for and how deep to go, that the impact was the greatest. This was called the Judgement Case. This also happened to be the most frequent, and such searches were frequently duplicated by different associates, or by the same associate for different work packages.

I.5.1.3 Defining management of complexity

Essentially, this meant that the process instances were not just connected by the input and output dependencies defined by the model but were entangled in more subtle ways due to resource constraints, synchronisation issues and knowledge context inadequacies. Such entanglement required close and constant management because of the cascading effects and the consequent cost and risks, but there logical way to address these, and it was left to the practice lead's judgement to take the right decision in a given context. The management challenge was therefore correlated with the degree of entanglement which in turn represented the complexity of the process.

From the above argument it followed that the key difference between complicated and complex processes was the presence of entanglement and the best way therefore to address the management challenge was to transform the complex processes to at best simple ones or at least complicated ones. In effect this meant eliminating resource constraints, synchronising processes and removing the dynamic nature of the knowledge context[9].

1.5.1.4 Synchronisation the key issue

The business model dictated that the resource constraints could not be moved. However synchronisation could be achieved by identifying the constraining process and subordinating all remaining processes to it as advocated by the theory of constraints. This would also have the effect that the dynamism in the knowledge context of one instance would be contained within the constraining process and not cascaded.

1.5.2 Planning Action

The intervention strategy was therefore to apply the theory of constraints a summary of which is provided below.

1.5.2.1 Applying TOC

Theory of constraints is based on the premise that the rate of goal achievement by a goal-oriented system (i.e., the system's throughput) is limited by at least one constraint. This premise is often argued by reductio-ad-absurdum is as follows: If there was nothing preventing a system from achieving higher throughput (i.e., more goal units in a unit of time), its throughput would be infinite — which is impossible in a real-life system. Only by increasing flow through the constraint can overall throughput be increased.

The key concept here is the notion of a constraint, which is anything that prevents the system from achieving more of its goal. There are many ways that constraints can show up, but a core principle within TOC is that there is at least one and at most a few in any given system.

Constraints can be internal or external to the system. An internal constraint becomes evident when the market demands more from the system than it can deliver. If this is the case, then the focus of the organization should be on discovering that constraint and following the five focusing steps to reduce it (and potentially remove it). An external constraint exists when the system can produce more than the market will bear. If this is the case, then the organization should focus on mechanisms to create more demand for its products or services.

The five focusing steps aim to ensure on-going improvement efforts are centred on the system's constraint(s) and are crucial to the application of TOC. In the TOC literature, this is referred to as the process of on-going improvement (POOGI). Assuming the goal of a system has been articulated and its measurements defined, the steps are:

1. Identify the system's constraint(s) (that which prevents the organization from obtaining more of the goal in a unit of time)

2. Decide how to exploit the system's constraint(s) (how to get the most out of the constraint)

3. Subordinate everything else to above decision (align the whole system or organization to support the decision made above)

4. Elevate the system's constraint(s) (make other major changes needed to break the constraint)

5. Warning!!!! If in the previous steps a constraint has been broken, go back to step 1, but do not allow inertia to cause a system's constraint (because changing the constraint could result in a different part of the system now becoming a new constraint).

In the context of the Digital Money practice, the operating model can be considered a system which is composed of a collection of processes. The strategy is therefore to apply the focussing steps to the operating model with the goal of maximising the throughput of the operating model by maximising the throughput of its constraining process.

I.5.3 Taking Action

I.5.3.1 Step 1- Identify: Research the constraining business process

The constraint was recognised as research, an undefined but key business process that was implicitly invoked by many of the processes and their activities, and carried out by almost all roles in the course of executing their work packages, as shown in Figure 43: Iteration 3 - Research Involved

Process	Research Involved
Select Topics	Determining current topics of interest from internet, news, correspondence and documents existing in library
Select Conferences	Determining current conferences of interest from internet, news, correspondence and documents existing in library
Develop Presentation	Determining information related to current topics of interest from internet, news, correspondence and documents existing in library
Write Blogs	Determining information related to current topics of interest from internet, news, correspondence and documents existing in library
Research Contacts	Determining background of contacts from internet, news, correspondence and documents existing in library
Execute work	Determining information related to work package from internet, news, correspondence and documents existing in library
Assemble work	Verify information related to work package from internet, news, correspondence and documents existing in library
Edit work	Verify information related to work package from internet, news, correspondence and documents existing in library
Manage Changes	Determining information related to requested changes from internet, news, correspondence and documents existing in library

Figure 43: Iteration 3 - Research Involved

I.5.3.2 Step 2 - Exploit: Standardise research and provide appropriate tools

Having identified all the contexts in which research needed to be carried out, a standardised process was created which could be applied in all of these contexts. To address the issue of dynamic knowledge contexts, past cases were examined and the standard context document enhanced to attempt to minimise the incidence of Judgement cases. Tools like standard searches and feeds, common topic lists, and content management capabilities were provided in order to create a searchable library of past document contexts and research.

I.5.3.3 Step 3 - Subordinate: Modified operating model

The research business process was explicitly added to the operating model and research activities in all processes were changed to invocations of the research process with appropriate context document and interface. The interface defined the kind of research expected and the accompanying context document followed the standard context document associated with the kind of research expected.

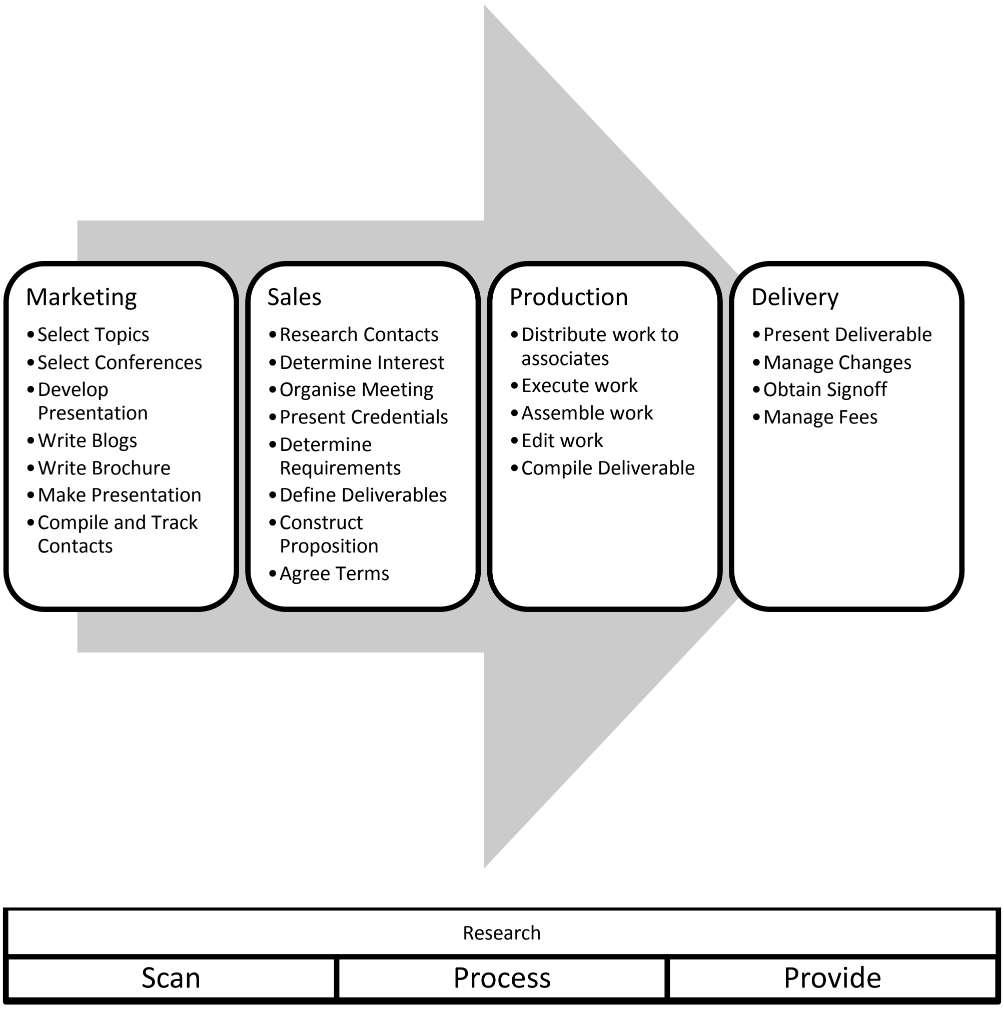

Figure 44: Iteration 3 - Operating Model

Invocations were accompanied by due date, but these were used only as guidance by the practice lead in prioritising work, rather than targets to be met by the process. The modified operating model is shown in Figure 44: Iteration 3 - Operating Model.

I.5.3.4 Step 4 – Elevate: The Research Capability and "Pipeline"

Having established research as a business process, all the research capacity in terms of research associates was unified into a single, permanently available research "Capability" and all invocations for research from every process including itself was routed through a single "Pipeline" within which priority was controlled by the practice lead. This gave the practice lead clarity in terms of the research inventory, available research capacity and projected lead times, which helped the practice lead adjust priorities within the pipeline.

I.5.4 Evaluating Action

There were several benefits to implementing this approach and these became apparent very quickly. First there was definite reduction in operating complexity as a consequence of less fragmentation, lower number of work products, fewer interfaces, fewer dependencies, greater visibility of work inventory and fewer control points to affect the flow of work. Second, as predicted by the theory of constraints, work did flow more freely. This resulted in reduced load on practice lead and reduced overall costs due to much more efficient utilisation of resources.

However there were some serious drawbacks and some of these were crippling to the business model. The nature of the consulting business is such that, within a reasonable range, engagements arrive at random intervals and are of random sizes and durations. While it is possible to predict average demand and therefore average capacity in the long term, it is impossible to do so in the short term. The consequence of this intervention resulted in the operating model being designed around a relatively fixed capacity whose throughput was maximised. This had several consequences.

The operating model was not flexible, in that it did not distinguish between short and long engagements and urgent and longer term deadlines. The only way to control this was to prioritise the pipeline, which had undesirable effects on efficiencies or on other schedules. There was no way to isolate an engagement and treat it differently so it was difficult to predict completion reliably. This, quite understandably, was not acceptable to customers, particularly because such reliable, customised delivery was part of the proposition offered by the Digital Money practice.

The model was not easily scalable, in that it was not easy to flex capacity. The research process was optimised around a capacity that was permanently available. While demand exceeded capacity, increasing the capacity could be justified, but as discussed earlier the nature of the consulting business meant that there was no guarantee that the demand would always exceed capacity. In those circumstances, permanently increasing capacity would expose ST to unacceptable risk. The other reason for permanence was to take advantage of the learning curve through exposing the same set of associates to multiple iterations and interactions. Bringing associates temporarily on board was possible, but would mean time and effort for integration, a period of familiarity mismatch, and lost knowledge when these associates were stood down.

The model was also not agile, in that it was designed around a known set of topics, which determined the choice of associates based upon their knowledge and skills in specific areas. However, the Digital Money ecosystem is characterised by its diversity and innovation which implies a constant churn in the kind of research topics that emerged. The ability to keep abreast of such a dynamic ecosystem was meant to be a key differentiator for the Digital Money practice, but the model could not support this claim.

A key design driver for the model was to make it predictable. It was expected that containing dynamism within the research process and controlling the process through the pipeline and priority would achieve predictability. What was not anticipated was the effect of the research work generated from within the research process itself. As discussed earlier such work was added back to the pipeline and it made sense to automatically accord it the highest priority, since work depending upon it was already in process and dependent upon it completing. However this had the effect of changing priorities of other work scheduled by the practice lead in the pipeline. It therefore became necessary to either route such work through the practice lead, which meant delay, or for the practice lead to override automatic priorities in the pipeline. The latter proved very difficult to manage as the implications of change were not easy to determine in the midst of so many moving priorities. The net effect was that the model did not improve predictability to the extent acceptable to customers.

It was expected that standardised context documents and research available to all associates in a searchable content management system would lead to considerable reuse and reduction in duplication of effort, since they could reuse similar patterns of searches and identify material already available. However experience showed that while the patterns were similar, key information was missing, or the search was not sufficiently deep or the terminology of the research reflected the perspective of the researcher who carried it out and would need to be semantically mapped to the current researcher's perspective. Most associates were of the view that it was easier to do the research again rather than try and identify all the pieces of relevant research already done. This meant that the model became inefficient because of continued duplication of work and synergies could not be exploited.

In summary, the intervention had made the operating model somewhat more efficient for associates, more manageable for the practice lead, but ineffective for customers and ST. This of course made it unacceptable to ST.

I.6 Iteration 4: Managing Complexity

I.6.1 Diagnosing

A review of the intervention concluded that while TOC addressed management complexity, it did so by ignoring key realities.

It focussed on resource utilisation by synchronising to research rather than customer needs. This moved the constraint to the sales process and obeying step 5 of the focussing steps advocated by the theory of constraints would have led back to the original model. Therefore it was evident that so long as both resource efficiency and agility were both goals, the current approach of synchronising operating cycles of all the processes was not viable.

One key observation was that the actual assembly and delivery of research, although significant and detailed had never contributed to complexity. It had always been the challenge of finding the right content available at the right time and editing it out of its original context that had given rise to the complexity. In other words, if research could anticipate need then the problem would be solved. Unfortunately this was not possible.

The whole point of research is to create knowledge relevant to the customer needs. Therefore the research process needed to produce knowledge that was simultaneously able to address several conflicting objectives.

- **Responsive to both, events and customer timelines**: When events occurred, the research process needed to assimilate the occurrence and its implications and make it available to research in progress in case it was relevant. Simultaneously the research process needed to deliver specific pieces of research that spanned across event according to a customer defined timeline. The cycles of event assimilation and that of customer research delivery were completely independent of each other and could not be synchronised.

- **Isolation of activity but integration of output**: Research was produced by different associates in different roles addressing different subjects at different times. Therefore while there was communication, the activity of research had to be isolated in order to be manageable. However the output of all such activity had to be integrated, not only to satisfy customer needs but also to permit reuse in future research. While the former kind of integration did happen through the assembly and editing processes, the latter did not and was arguably more crucial.

- **In-process contribution out-of-process consumption**: Associates related towards research in two different roles, as contributors and consumers. In carrying out research, they would uncover not only content required by the work package, but also other related content that was not immediately relevant to the work package at hand but could be relevant to other concurrent or future work-package. However such content was usually lost and had to be recreated unless the associate was aware of all the other work packages and had sufficient insight to be able to anticipate the need, and the time to be able to contribute. The problem was that contribution could take place only in-process while consumption occurred out-of-process to the contributor. In order to be reliably useful, contribution and its context needed to be available across both, time and space.

- **Standardised by vocabulary but referenced by perspective**: In order for research to be easily reusable, it needed to use a common vocabulary shared by all the associates. However each associate had a different perspective depending upon their specialisation and used a vocabulary commonly used in that perspective. For example, while there are overlaps the vocabulary familiar to mobile operators is quite different from that used by banks. This is not a problem as long as the former provides communications services and the latter provides financial services. But digital money overlaps both and results in the same information viewed from different perspectives. Thus conflict is inevitable. So reuse demands a strict ontology while access requires a permissive ontology.

- **Explicit information, tacit knowledge**: Most of the research focussed on finding out information *about* certain entities as they related to particular topics. However, very often, associates needed to discover information *relating* certain entities in order to contextualise information about them. Information about entities could be captured and stored as part of the research, but information relating entities remained tacit and frequently had to be recreated. For example, it is possible to report the number of users of a service provided by a subsidiary organisation in a country, but to be able to determine its rank in the country, one needs to know about other equivalent organisations in that country and their user base for that service. Often in discovering of an organisation, it is just as easy to find information for all its services as it is for one. However once the rank is reported, the knowledge of relationships was abandoned, and had to get recreated for another service. Other kinds of tacit knowledge included observations and judgements, and references to news regarding specific entities that associates made from their knowledge and experience. The "remarks" section in the work products was meant to be the place to capture such tacit knowledge, but in the absence of an accessible structure did not fulfil its intent.

I.6.2 Planning Action

The way to address these conflicting objectives was to design a "buffer", containing all the information uncovered, to which information could be contributed as it became available, and from which information could be consumed as it was needed. If such a buffer could be created then the operational definition of the research component of a client engagement would translate to the "gap" in the "buffer" that needed to be filled in order to complete the engagement. Such a "buffer" had to support the following capabilities:

- **Multiple evolving entity classes**: An entity class represents the set of all entities that have the same information attributes. "University" is an entity class while a specific university e.g. UWE is an entity belonging to class "University" and one of its information attributes could be "number of students". The kind of information attributes relevant to a university would be very different from those relevant to say a railway station. So "Railway Station" would be a different entity class. The point, however, is that it is not possible to determine in advance all the possible entity classes of interest in an ecosystem particularly a rapidly evolving one. Also it is not possible to predetermine all possible information attributes until events dictate or clients demand information for that attribute. Therefore the "buffer" would have to support multiple evolving entity classes.

- **Multiple evolving relationship classes**: Entities in the ecosystem are related to other entities in several different ways. For example if "Company" and "Individual" are two entity classes, then a particular individual could be related to a particular company in two different ways, as an "Employee" or as a "Shareholder". The information attributes for these relationship classes would be quite different from each other. Again the point is it is not possible to predetermine all classes of relationships between entities, the information attributes of such classes and the actual relationships themselves. Again they are determined as a consequence of assimilating events or responding client's information needs. Therefore the buffer would have to support multiple evolving relationship classes.

- **Multiple evolving perspectives**: Research is dictated by the client and the entity classes and relationship classes and information attributes of interest depend upon the perspective of the client. For example a bank asking for transaction volumes in a particular geography would tend to look at financial institutions and their associates, and money transactions as opposed to mobile operators who might be interested in air-time as well or retailers with their loyalty points which are all some form of digital money. Again it is not possible to predetermine all possible perspectives, so the buffer would have to support multiple evolving perspectives and not favour any one of them.

- **Multiple Knowledge contexts**: If the operational definition of the research component of a client engagement translated to the "gap" in the "buffer" that needed to be filled, the knowledge context would mean those entities "adjacent" to that "gap" and a means of determining what "adjacent" meant. This usually implied a list of entity and relationship classes of interest, the kind of information expected and some guidance to determine the depth of search for that particular research. Since there would always be concurrent work packages, there would also be multiple active knowledge contexts which had to be supported.

- **Common Vocabulary (ontology), multiple synonyms**: As discussed earlier, for the research to be shared and reused, a shared ontology was crucial. At the same time, associates were familiar with the vocabulary preferred by their specialisation and would prefer to interact with the buffer using that vocabulary. Also the information would need to be translated to the vocabulary preferred by the client. Therefore the buffer would have to support the creation of a single consistent ontology and its translation to different vocabularies.

- **Extensibility of entity and relationship classes**: Extensibility is related to the concept of specialisation. For example, banks and mobile operators are both players in the digital money ecosystem, and have information attributes common to all players. But then they also have attributes that exist only for their class. This is what distinguishes them from other classes. The "Bank" and "Mobile operator" classes can therefore be considered to specialise or extend the "Player" class. They may themselves be further specialised or extended. Again it is not possible to determine this extension structure in advance, the need for creating distinctions arises as a result of client demand or the impact of events.

- **Distributed, Federated and Versioned**: Associates are geographically distributed, they may concurrently be working on overlapping knowledge contexts and their work is related to a specific piece of research. Therefore the buffer must support distributed concurrent access, but must ensure that control of entities is federated, so that different associates do not overwrite each other's research. Because information collected over time can change, it is also necessary to version the information used in a particular piece of research in case it is necessary to recreate or justify that research. Therefore the buffer must support distribution, federation and versioning.

- **Support for capturing related tacit knowledge**: While the use of classes and extensibility would result in the ability to make more and more knowledge explicit, there would always remain observations, opinions and thoughts that needed to be captured in context. Therefore the buffer must support the capture of such tacit knowledge in-process.

Since the "buffer" would become the base for an organised accumulation of information through experience, observation, communication or inference, which the associates could believe and value this buffer came to be called the Knowledge Base. This distinguished it from an information warehouse which was seen as a structured collection of facts.

The existence of such an "inventory" of knowledge, would allow the process of research to be more effectively disentangled from the other business processes by reducing synchronisation and resource dependencies. While this would reduce management complexity as discussed in I.5.1.3, it would result in moving the attributes of complexity as shown in Figure 41: Iteration 3 - Process Attributes of Complexity from the process to the knowledge base. Therefore the focus of managing complexity must shift from process and resource to the complexity of knowledge base itself

The strategy devised for the intervention consisted of the following steps:

1. Design a knowledge framework to accommodate evolving ontologies

2. Design a knowledge base infrastructure to support the digital money ontology and research

3. Design an appropriate research process to contribute to the knowledge base

4. Design the operating model to consume from the knowledge base

5. Align associates, their roles and responsibilities, to the new operating model

6. Construct an initial knowledge base to get the process started

I.6.3 Taking Action

I.6.3.1 Step 1: Designing a knowledge framework

Conventional approaches to designing information structures depend upon defining a priori, the entities and relationships pertinent to the problem space. As discussed earlier, however, because of the evolving nature of the ecosystem, no assumptions could be made about the kind of entities and relationships that the information structures would be required to support.

Therefore the solution was to define a "meta" structure using which structures could be defined in a standard way. If the assumptions that the supporting infrastructure made were restricted to the meta structure, then it should be able to support any new entities and relationships defined on the basis of that structure.

A key constraint was that it should be possible to implement such a meta structure with technologies familiar to ST for purposes of processing, storage and communication of information. That meant that concepts defined in the meta structure had to be capable of being mapped into the appropriate technologies. The most common processing and storage technology was relational databases.

The solution was designed on the basis of the following key observations;

- Any fragment of information[10] could be abstracted into the concept of an information resource (iResource), a set of defined attributes with a unique identifier. Such a resource could then be implemented using the relational database concepts of tables, where the defined attributes were the table columns, the specific resource was the row, with a unique value in its identifier column which would be the primary key. Each resource would belong to a class, which defined the attributes for that resource.

- Information class descriptions (iClass) could themselves be thought of as information resources belonging to a special class that identified all the attributes applicable to a specific class.

- Information attribute descriptions (iAttribute) could also be thought of as information resources, belonging to a special class that identified characteristics of the attributes (e.g. text, numeric, currency and Boolean etc.) and facets (e.g. length of text, precision of numbers etc.). These would map to data types in the underlying database technology.

- Relationships (iRelationship) could be thought of as information resources that identified two other resources in a specific order which indicated the direction of the relationship

- If classes were allowed to inherit attributes from other classes, as well as add their own, it would then be possible to represent all the explicit information generated by the research using only these concepts. While simple information might require only a single resource, more complex information would be represented by a set of resources organised into a web of relationship, with the complexity of the web representing the complexity of the information it represented.

This scheme is shown in Figure 45: Iteration 4 - Information Framework .

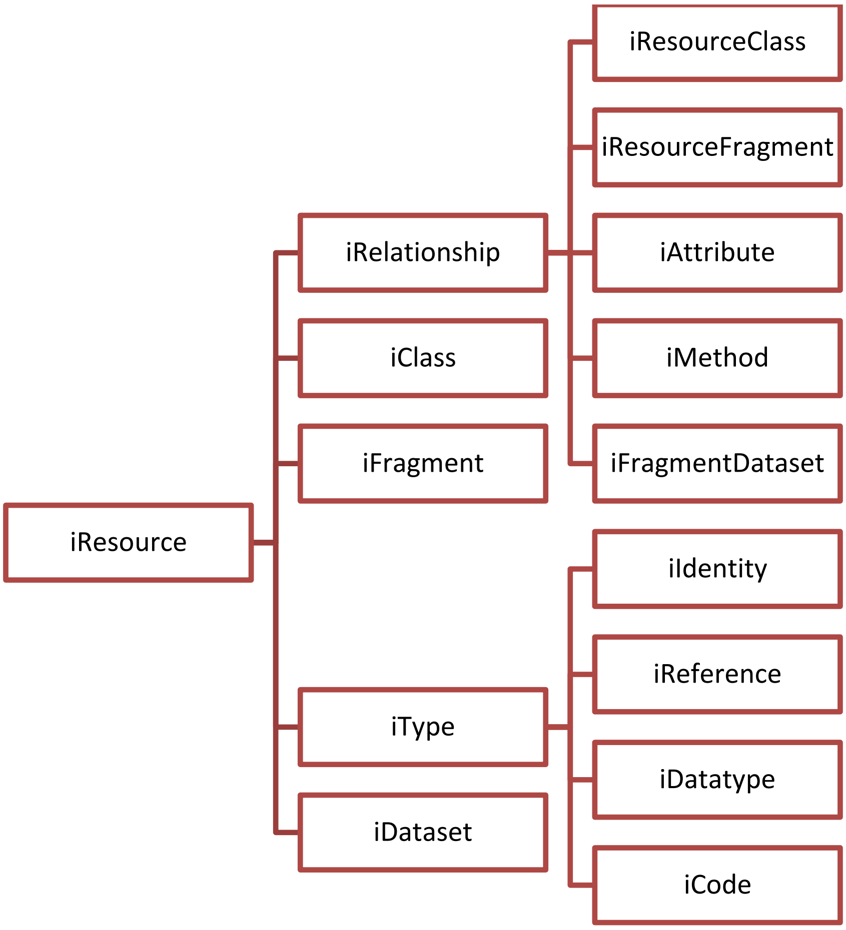

Figure 45: Iteration 4 - Information Framework

Multiple, evolving and extensible entity and relationship classes can then be directly be supported in this scheme by letting classes be derived for iResource or iRelationship classes.

In this scheme, a perspective is simply a set of nodes that constitute a starting point from which the exploration of the knowledge base can commence. In addition, a perspective can map names of certain resources in the knowledge base through the use of aliasing. A perspective is therefore simply a specialisation of the iRelationship class, whose instances relate a user or a role resource to a set of other resources. This allows the scheme to support multiple evolving perspectives.

Analogous to perspectives, in this scheme, a knowledge context is simply a set of nodes that constitute a starting point from which the exploration of the knowledge base can commence. A knowledge context is therefore simply a specialisation of the iRelationship class, whose instances relate a work-package resource to a set of other resources. This allows the scheme to support multiple evolving knowledge contexts.

In the scheme each class and its attributes have unique base names. At any point in time therefore, the base names of current class structure and attributes defines the ontology of the knowledge base. In addition it is possible to define a list of aliases with each resource. A class, by virtue of being a resource may also have aliases which represent synonyms of concepts represented by the ontology. While this can give rise to antonyms, typically it is possible to disambiguate based upon the context of use.

The use of appropriate relational database infrastructure capabilities enables distributed concurrent access to a shared knowledge base. In this scheme, federation is handled through each resource having an identified owner, by default the creator, who can specify rights to this resource. The relational database infrastructure can then control access to the resource depending upon these rights.

Finally every change to a resource results in the earlier version of that resource being time-stamped and logged. Thus the right version of the knowledge base can always be recreated by specifying the time at which it was valid.

In this scheme, tacit knowledge is supported by capturing observations, comments, action request, notes, warnings, guidance etc. as instances of classes derived from iRelationship that relate a user resource to a resource to which that knowledge applies. This is also the route through which controlled change to the structure of the knowledge base and the content of federated resource can be managed.

I.6.3.2 Step 2: Designing the knowledge base infrastructure

The knowledge base infrastructure was constructed out of a set of core components to support:

- **Key Actions**: This included the ability to create new classes based on defined classes, attributes, instances of resources based upon defined classes, Instances of relationships based on defined relationship classes; the ability to modify the content of attributes for an information resource, attributes themselves, classes and their hierarchy; and delete content of attributes for an information resource, attributes in a class, classes themselves and their hierarchy;

- **Scanning topics:** (information resources of class Topic) from sources such as periodicals, web searches, library searches and correspondence and tagging related information resources in knowledge base with and its source discovered in the scanning.

- **Exploring the knowledge base** starting with any information resource and following its relationships, keyword and standard searches, standard templates for referencing information etc.

I.6.3.3 Step 3: Designing an appropriate research process

The main difference in designing the research business process was a shift in the goal of the process from predictable fulfilment of specific requests within finite resource constraints to continuous enrichment of the knowledge base while providing access to that knowledge for different needs and at different times.

The objective was to decouple the creation of knowledge from its consumption thus disentangling the research process from the other processes in the operating model. The target was to capture up to 90% of information needed for most engagements through this process, so that only the remaining information would require additional resources to fulfil.

The business process was designed as a cycle consisting of five processes which was repeated at periodic intervals and on demand within those intervals. The business process is depicted in Figure 46: Iteration 4 - Research Business Process

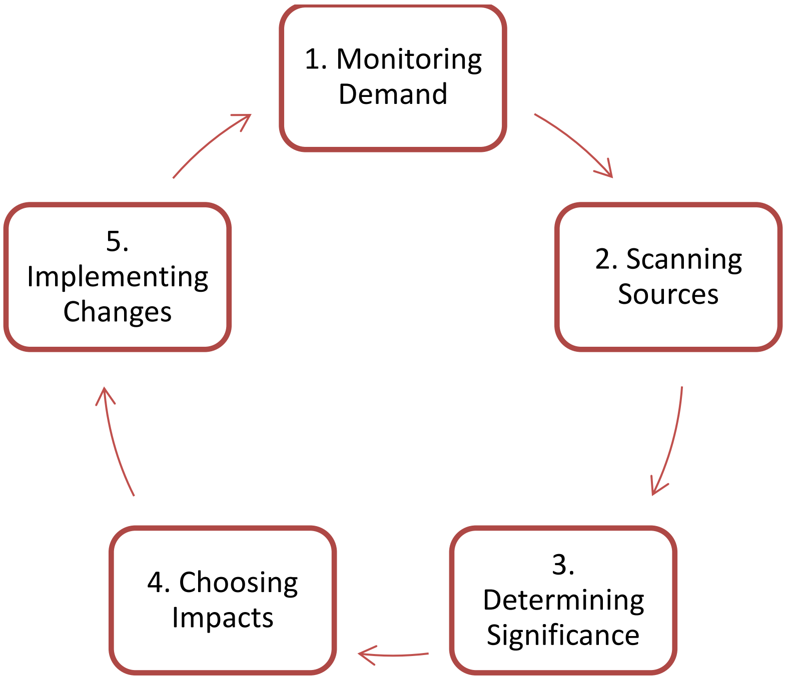

Figure 46: Iteration 4 - Research Business Process

These processes are described in more detail below.

Monitoring Demand - In the process, topics are the main unit of demand. A topic is an information resource of class topics. Associated with each topic is a list of keywords relevant to that topic. The knowledge base contains a list of topics that drive the research process. This list is used in the scanning process to identify material from the information sources that might be related to the topic. This step in the process is invoked in different ways. The first way is by defining an interval between invocations, say weekly or monthly. The second is by means of a schedule. This is needed if it is anticipated that information may become available within an interval, perhaps because a key report is expected to be published on the internet on a specific day. The third is by adding a new topic to the knowledge base or by modifying an existing one, thus triggering the need to refresh the knowledge base. The fourth is by explicitly requesting a refresh. The output of an invocation is a list of topics for scanning.

Another activity in this process is monitoring how knowledge is being consumed or is expected to be consumed with the objective of detecting repeatable patterns. If such patterns are detected, then these become another input to the implementation step that occurs further in the cycle.

Scanning Sources - Using the list of topics, a list of sources is scanned. These sources include reports published periodically, web searches using search engines, searches of the existing document library and searches of the existing correspondence. This step is almost completely automated, as the keywords associated with the topic serve as the keywords for a generalised search algorithm that invokes various other search engines to search the list of sources. The output is a list of relationships for each topic to various sources, each link containing a hyperlink to the source, the context of the relationship (usually an abstract of the content within which a keyword was found, a list of information resources already in the knowledge base that the source could be relevant for, and further status information). If that relationship had already been identified, it is not repeated. This is important so as to limit the list to only new information to be addressed by the following steps.

Determining Significance - Using this list of relationships, associates determine the significance of each relationship. This is necessary to limit the noise in the knowledge base. For example, certain events are reported by several sources in different forms in roughly the same time frame, but they all carry much the same information, so it is not necessary to address all of these individually, so long as the appropriate number is selected to cover the information deemed relevant. There are also situations where the search engine picks up sources which are deemed relevant on the basis of syntax, but are semantically not of relevance. This may be because the keywords matched a completely different context. Finally it may be necessary to ignore trivial relationships or those deemed not reliable. The output is a pared down list of relationships that need to be addressed further.

Choosing Impacts - Each item in this pared down list contains a list of existing information resources that may be relevant to that item. Since this relevance is syntactically established using the synonyms associated with the information resource, it is necessary for associates to confirm that relevance. Should a resource be deemed relevant, it is still necessary to identify what of that source is relevant to that resource and how that impacts the resource. Impacts could be as simple as merely retaining a link to the source, to modifying the value of some attributes of that resource, to adding more attributes, to creating a completely new specialised class to creating new relationships between resources based upon the new information.

Implementing Changes - The changes identified in the previous process are then implemented in the knowledge base. When this step is completed for all the items in the pared down list the knowledge base is deemed to be completely refreshed.

The other input to this step is a set of patterns of consumption detected during the monitoring demand step earlier. Often these take the form of specific representation of certain kinds of information. These can be fulfilled through the provision of standard searches, parameterised code fragments, standard templates or reference lists of documents, which could directly be embedded into the final deliverable.

I.6.3.4 Step 4: Designing the operating model

The new design of the operating model is where the actual disentanglement of research from the other processes is achieved. The operating model is depicted in Figure 47: Iteration 4 - Operating Model.

Disentanglement is achieved by means of the following

- Separating process information from ecosystem information and ensuring that all ecosystem information is maintained in the knowledge base, while process information continues to be transferred between processes through control documents or other means as before. Process information is all information that is relevant to a single process instance and includes status information, control information, work products etc. This is largely used by the practice lead to define a process instance and control its execution. Ecosystem information reflects all the information gathered about the entities in the ecosystem and continues to be actively used over the lifetime of several process instances.

- Providing capabilities within processes to contribute to or consume from the knowledge wherever appropriate and for whatever appropriate to the process. This interaction can be understood as a set of interfaces between each of the business processes in the operating model and the knowledge base.

- Making research a fully-fledged and independent business process and making each business process asynchronous from the others in terms of their operating cycle with synchronisation of work for a specific engagement managed through work packages communicated between interacting processes through prioritised queues.

Figure 47: Iteration 4 - Operating Model

The interfaces between the Knowledge Base Infrastructure and the business processes are described in Figure 48: Iteration 4 - Interfaces.

Interface with	Description
Marketing	Consumes current conferences, current topics
Sales	Consumes knowledge base as sales collateral, for determining requirements and defining deliverables
Production	Consumes information for defining “gap” in work packages, assembling, editing and compiling deliverables
Delivery	Consumes for defending the presentation of deliverable
Research	Contributes information and structure to knowledge base

Figure 48: Iteration 4 - Interfaces

I.6.3.5 Step 5: Realigning associates

As a consequence of this operating model, the roles and responsibilities of the associates needed to be realigned. Research associates were no longer responsible for construction of any of the deliverables; they were responsible only for executing steps 3 to 5 of the research process. All other activities were carried out by the practice lead supported by additional resources depending upon the load at that time.

I.6.3.6 Step 6: Seeding the knowledge base

The success of the approach depended upon having a viable knowledge base with enough information to be able to support the first few cycles of the research process. Recalling that there was considerable information produced, but lying unused in the context documents of earlier engagements, and beginning with a clean version of the knowledge base, the process depicted in Figure 49: Iteration 4 - Seeding the knowledge base was applied.

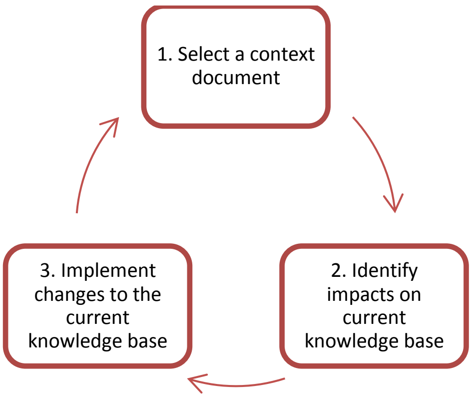

Figure 49: Iteration 4 - Seeding the knowledge base

This led to the identification of a set of classes and a number of entities and relationships that could be seeded into the knowledge base. This proved sufficient to bootstrap the research process.

I.6.3.7 Challenges in implementation

There were a number of challenges encountered in implementing the plan and these are discussed below:

Resistance to magnitude of change – The implementation demanded major changes in the processes which had to be absorbed, along with considerable effort solely for the purpose of implementation which had to be undertaken while the practice lead and associates were already busy delivering existing work. Such radical change, required to be carried out "in-flight", provoked resistance and calls for an evolutionary approach. This was unfortunately not possible.

Resistance to unfamiliar roles/activities – Associates, used to greater latitude in terms of defining their outputs and the way they carried out their work, resisted the process which now constrained what was researched and how they could contribute.

Resistance to unfamiliar tools and structures – The concept of knowledge as a network of information resources was itself hard for the practice lead and associates to accept and the resulting scepticism led to resistance in implementation.

Construction and stability of infrastructure – As all of the infrastructure had to be created and implemented "in-flight" the development was iterative and stability took some time to establish. The lack of stability in the early versions also contributed to misgivings and resistance.

As a consequence of the resistance, the approach to change, which was based upon logic and motivation, now needed to depend upon faith in leadership and formal power, a style which was distinctly uncomfortable for ST management.

I.6.4 Evaluating Action

As a consequence of implementing the process strategy the Digital Money practice in ST has witnessed significant positive impacts on processes, margins and cycle times, resources and scalability, management complexity and growth of the knowledge base. These are discussed below.

I.6.4.1 Impact on Processes

Process	Impact
Select Topics	Topics are represented as instances of a class derived from iResource. Topics are now selected based upon the frequency of activity and recency of information associated with the topic resources in the knowledge base. The collection of information about the topic occurs automatically as part of the scanning activity in the research process. If the topic is chosen then the remaining activities in the research process can be prioritised for that topic. New topics may also be added as resources to the knowledge base and are automatically part of the research process. This reduces the need for the practice manager to exercise judgement very significantly.
Select Conferences	Conferences are also represented as instances of a class derived from iResource. The collection of information about the conference occurs automatically as part of the scanning activity in the research process. If the conference is chosen then the remaining activities in the research process can be prioritised for that conference. New conference may also be added as resources to the knowledge base and are automatically part of the research process. This reduces the need for the practice manager to individually research each conference.
Develop Presentation	Contents, information fragments and even complete templates can be inserted into presentations such that content is always recent and can be assured to have gone through the research process. This reduces both, the need for presentation specific research and the effort of constructing or updating the presentation frequently. Such currency of information appears to have had a very positive impact on clients in terms of credibility.
Write Blogs	As part of the scanning process item discovered is related to the relevant resources through tagging. This allows the practice lead to choose significant news items and apply a standard analytic structure detailing the impact of the item on all the relevant resources using of information fragments and templates. This has a very positive impact upon the rigour and credibility of the blog with little effort.
Write Brochure	As with blogs and presentations, contents, information fragments and even complete templates can be inserted into brochures such that content is always recent and can be assured to have gone through the research process. This reduces both, the need for brochure specific research and the effort of constructing or updating the brochure frequently. Again such currency of information appears to have had a very positive impact on clients in terms of credibility.
Make Presentation	Presentations can be thought of as another representation of a knowledge context and can link back to the knowledge base. This makes for compelling interactive presentations, further enhancing credibility.
Present Credentials	Demonstrating the content, power and flexibility of the knowledge base helps justify claims about the validity, and currency of the content, the reliability of the research process, the flexibility of the deliverables and the speed of the delivery. Ultimately it reinforces faith in the ability to address client needs.
Determine Requirements	Requirements can now be simply described as consisting of two components, a “gap” in the knowledge base, and the representation of that “gap” in terms of a deliverable. Since the knowledge base can be

Process	Impact
	interactively explored, there is little need for multiple iterations to determine requirements. Also expectations can be precisely set in defining requirements. It is not unusual for the “gap” not to exist, and the engagement then becomes merely a refactoring of the representation.
Define Deliverables	Given the new way of determining requirements, deliverables can often be represented by a template whose structure and sources of content can be defined and agreed up front, and the content filled in through the engagement. This leads to precise definition, expectation setting and negligible risk of rework or rejection.
Distribute work to associates	Work packages essentially translate specific “gaps” identified in the knowledge base into a knowledge context and guidance towards filling the gap. There is no need to transfer complex documents in the course of distributing work and it is easier to track how far the “gap” has been bridged.
Execute work	Executing work translates the “gaps” identified in the knowledge context into the necessary changes to the knowledge base. Typically this means creating new resources, attributes or classes and rescanning or updating existing resources on the basis of information already scanned. In either the need for judgement is restricted to accurate interpretation of scanned information, thus eliminating anomalies of terminology or representation.
Assemble work	Typically the deliverable is already defined in terms of a template, which identifies gaps to be filled. Most such information can now be captured directly from the knowledge base through information fragments and templates or from the completed knowledge contexts of the work packages. This has significantly reduced the effort and time required to assemble work into a compiled deliverable and this can now be done frequently thus spotting problems early and avoiding rework.
Edit work	Since the research effort and output is standardised and validated in a distributed manner, there is little or no need to verify individual information elements. Editorial work can therefore concentrate solely on sense making, readability and coherence. The use of templates further accelerates this as well edited documents get reused.
Compile Deliverable	This process is eliminated as the Assemble Work process results in a compiled deliverable
Present Deliverable	As in making presentations, the availability and linkage with the knowledge base makes for compelling interactive presentation and justification of the deliverable, further enhancing clarity.
Manage Changes	Changes are relatively rare but are easily managed if it is a matter of capturing additional information already in the knowledge base. If more research is necessary then it is treated as an additional work package, and the cost is usually then borne by the client.

Figure 50: Iteration 4 - Impact on processes

I.6.4.2 Impact on Margins, Cycle Time

Margins improved dramatically due to a cycle of effects. Standardisation of knowledge structures, reuse and automation meant a significant reduction in effort accompanied by an equally significant improvement in quality. This led to less need for constant communication and rework, fewer priority changes and greater productivity. This in turn led to significantly shorter cycle times. This reduced the risk that clients would introduce changes midway through the engagements and freed up the practice lead to concentrate on better requirement and deliverable definition. This further accelerated leading to further standardisation, reuse and automation. In concrete terms cycle times for standard deliverables have reduced by up to 90% while margins, which were never above 10% are now rarely below 40%.

I.6.4.3 Impact on Resourcing and Scaling

Once the knowledge base reached a critical mass, it became apparent that most clients tended to request very similar information depending upon the current topics and challenges, but to be delivered in very different forms. In the past, since the form of the deliverable was entangled with the process of research, this meant that research had to be conducted essentially from scratch for every deliverable. Now that such information was automatically available, research only had to be commissioned for the gaps. This meant that the need for associate effort diminished, to the point where the practice lead could fulfil demand without any need for associates. ST has therefore dispensed with the need for permanent associates altogether. It is particularly easy to scale back up because the knowledge base dramatically shortens the learning curve for associates. The constraint has now shifted from production to demand and the practice lead is therefore now focussed on marketing and sales.

I.6.4.4 Impact on Management Complexity

Because of the reduction in entanglements, dependencies, interfaces and hand-offs, there has been a dramatic reduction in management complexity. In objective terms this is reflected in a steep drop in process management effort, the number of control documents, the need for status review meetings and communications, priority changes and exception management.

I.6.4.5 Impact on Productivity

The knowledge base has become the core asset for the Digital Money practice A way of measuring the value of the asset is the number of iResources it contains. A way of measuring the productivity of the organisation is comparing the rate of adding value against the effort in doing so. For the latter, the number of associates is a good proxy. As Figure 51: Iteration 4 - iResources compared to Associates indicates there has been a dramatic rise in the number of resources accompanied by a significant fall in the number of associates.

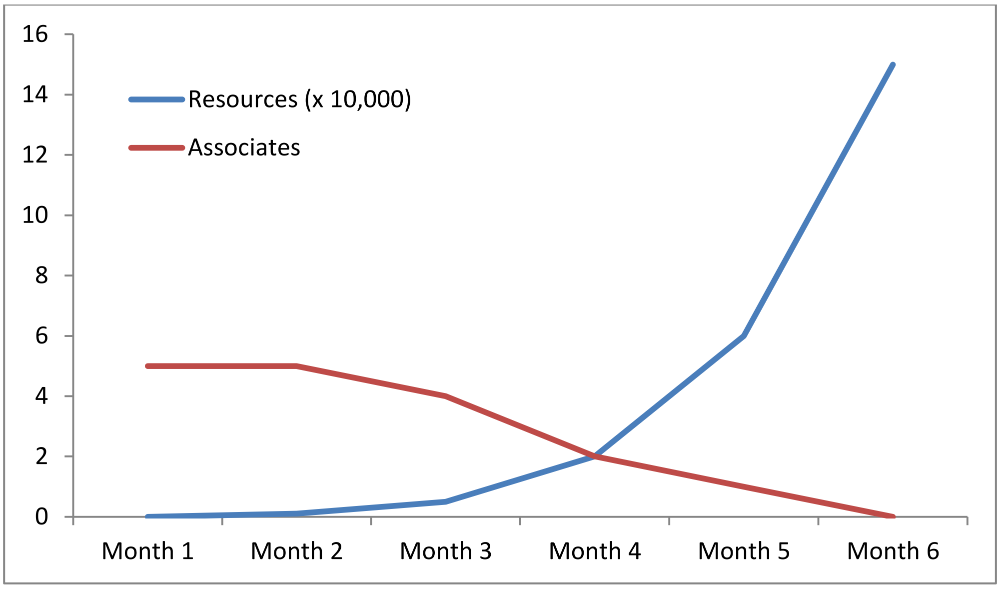

Figure 51: Iteration 4 - iResources compared to Associates

I.6.4.6 Impact on Knowledge

Arguably the greatest impact has been on the way knowledge is perceived and managed.

The earlier perspective on knowledge was akin to raw material that was harvested, processed and delivered to be sold in the market place. Consequently the role of the Digital Money practice was akin to that of manufacturing and it was managed accordingly.

The perspective on knowledge is now that of a tangible asset, one that is easily understood but constantly under construction and refinement. The role of the practice is now understood to be that of enrichment and stewardship of that asset, which has changed the way it is managed, and is a source of pride and motivation.

The existence of a shared ontology has led to a convergence in understanding of perspectives while still encouraging divergence in their expression and vocabulary. It could be said that the knowledge base is considered the "mind" of the practice, the knowledge being expressed through the voices of associates.

It had always been assumed that it was the tacit knowledge of the associates that contributed the greatest value. However, the process of capturing observations and comments has shown that much of that knowledge was not so much *tacit* as *unstructured*. It has become apparent that the problem earlier was more the lack of information availability in the right context, rather than its lack of structure.

Also most observations and comments eventually end up decomposed into content stored in resource attributes, or relationships between resources. Those that don't usually represent original thought and become the basis for blogs and articles.

I.6.4.7 Impact on Organisation Challenges

Challenge	Impact
Agility	Agility has improved in several ways. ST can now access several internal, federated and internet data sources and extend that list of sources very easily. It can also scan for an extensible vocabulary of terms attaching related information fragments to appropriate resources in the knowledge base pending validation. It can now deliver an extensible set of reports in template formats on an extensible set of topics, essentially on demand. It can also extend its working vocabulary of terms to address emerging topics seamlessly.
Scalability	The original scale sensitive processes of data gathering, indexing and sorting, report assembly and distribution are largely automated and can be scaled up as desired simply by increasingly the technology provided, an approach to which there is no practical limit. The process elements that involve judgement are largely dis-entangled and can therefore be scaled up, scaled out or time shifted depending upon the load. This permits delegation of judgement across time and geography, which dramatically increases access to resources and thus scalability.
Throughput	Since the bulk of the long duration process activities are largely automated, these now require little time to execute. Therefore the key bottlenecks in the process are generally only those that involve judgement and typically such judgements once made are reusable across other requirements. A combination of these factors has led to a greater than 10 fold increase in throughput.
Scope	The key difference in the new approach is that the vocabulary is determined by the knowledge context. This means that the knowledge harvesting activities in the research process can adapt to extended vocabulary in the knowledge context. Scope is easily and often dynamically extended without greater load on the process.
Productivity	With critical knowledge resources being released from the maintenance of the knowledge base in terms of periodic harvesting, indexing and referencing, and the production of reports from predefined report templates, they can now concentrate upon the judgement activities or refining vocabularies, approving or modifying references suggested by the research algorithms, building new report templates and debating new topics with customers and adding them to the knowledge context. This has led to a quantum jump in productivity, with a significant jump in turnover without additional cost.

Figure 52: Iteration 4 - Impact on Organisation Challenges

I.7 Development Review

Although as a result of the last intervention there were clearly significant benefits for the Digital Money practice, the experience had raised several questions, which were debated with the practice lead and associates and are discussed below.

Was the problem unique to ST? The point here was that the practice lead and the associates had all had considerable experience working for research providing and research consuming organisations. Was the research process not an issue in the other organisations? If it was, how had it been addressed in those organisations? Why had the experience not been utilised by ST? Was ST guilty of reinventing the wheel?

It turned out that in the opinion of the participants, in consuming organisations research is generally a cost centre, the cost of specific research is approved if the business value is justified and scale is achieved through outsourcing. Crucially the general approach is to decompose the problem and then address each component as a piece of independent research.

On the other hand, in providing organisations, research is sold on the basis of brand not cost, the cost is passed on to the customer, and standard research content is often repackaged in bespoke engagements. Crucially, the research process itself is a provider to multiple business lines and does not have to justify its existence in isolation.

In contrast, within ST the Digital Money practice was an independent business line whose sole source of funding was the difference between the business value of the research perceived by the customer, and its own costs. Pure outsourcing was not an option, since the customer would perceive no added value, in the absence of an established brand, the value proposition was cost driven and customised. Also a key element of the proposition was the ability to integrate perspectives, so conventional problem decomposition was not a viable solution.

Consequently it became an existential challenge for the practice to find a solution that was cost-effective, fast, scalable and manageable. The positioning and proposition drove the cost structure and consequently the operating model in a different direction to other organisations.

In summary, the conclusion was that the problem did exist in all research, but as long as it did not become an existential crisis, it was essentially disguised as a resource and efficiency issue and addressed accordingly. When the issue became significant enough the research team was simply disbanded and the capability outsourced. The practice had in fact applied their experience in adopting conventional approaches for the first three iterations. It was only when these did not work were they persuaded to adopt a novel approach.

Why did conventional approaches not work? The point was that process maturity, lean, six sigma and theory of constraints are mature, well established approaches, adopted and validated by many organisations and in fact practiced and advocated by ST itself. Why then did these not work in Digital Money practice?

It was noted that the final operating model retained most of the improvements pertaining to the process control suggested by these more conventional methods. In fact it was perfectly possible to continue to benefit from these approaches in improving the final operating model. The problem seems to have been twofold.

Firstly applying these approaches did not lead to an identification and resolution of the complexity problem. That needed a completely different perspective and approach to develop a novel solution.

Secondly, once the complexity was addressed the conventional approaches are seen to be effective again. It would appear that one indicator of complexity is the lack of efficacy of such conventional approaches.

Consequently, the approaches remained valid, except that they were applied by ST in the wrong order.

Why was the solution resisted so strongly? The challenges in implementation have already been discussed earlier. The point here was that the resistance was often illogical, even when clearly both the practice lead and the associates seemed to understand the solution and stood to benefit considerably from the implementation. The consensus was that there were several simultaneous drivers to that resistance and these are discussed below

- **Paradigm shift**: The solution required that the team embrace a completely new way of thinking with the focus on complexity rather than process, a different way of thinking about dependency, and disentanglement. These were novel concepts and the team had no frame of reference to relate to or validate them.

- **Change in centricity**: The solution basically changed the process from being activity centric to being knowledge centric. Again this was a novel approach for the team whose experience was largely with the activity centric conventional approaches. This again made it difficult for the team to relate to and validate the solution. Had the solution been restricted to the complexity of knowledge contexts transferred between activities then this would have been accepted as merely an extension of a conventional approach. It was the definition of the knowledge context as a subset of the knowledge base that was difficult to appreciate.

- **Discontinuous innovation**: The solution also required fundamental changes the research activities and dependencies, and consequently the roles, expectations and behaviours of the team members. Such change was naturally resisted particularly when the team was already under pressure.

- **Discontinuous progress**: While the solution proved ultimately successful, there was a period when the infrastructure was being constructed and the knowledge base being seeded when no progress was visible. This impacted upon the credibility of the solution and morale of the team. Consequently the consensus was that while the solution was necessary to address complexity, it was not sufficient to implement it. Additional factors like the size of the team and its ability to absorb change, the leadership, the size of the problem, and the speed of implementation were also extremely important to reduce the risk to implementation.

- **Shift in focus of Information Systems**: Whereas the focus in the earlier iterations was the implementation of complex, highly integrated transaction and process control systems that hid the interfaces, the solution required a shift to loosely coupled tools and technologies that shared architecture, a platform and a knowledge management infrastructure that exposed the interfaces. This made the infrastructure appear even more complex and risky to the team.

How does this impact ST? This approach to managing complexity creates several new opportunities for ST. These are discussed below.

- **Products and Services:** The original business model was based upon leveraging the knowledge and experience of key knowledge workers in ST through consulting engagements and bespoke deliverables. With the advantages provided by the agility, scalability and throughput of the new process, focus is shifting towards the production of standardised off-the-shelf reports on topical issues that can be customised for a price. Interactive models can also be created that are driven by data and algorithms within the knowledge context but customised by parameters provided by the users and charged on a pay per use basis.

- **Business Lines:** The design of the knowledge base and its infrastructure makes it completely agnostic to the vocabulary outside the core knowledge context. Consequently, there is no reason to restrict the use of the process and platform only to the digital money ecosystem. ST is exploring similar initiatives in the renewable energy ecosystem and the mobile health ecosystem which would lead to the creation of completely new business lines.

- **Application Areas:** There are also opportunities for applying the approach to other application areas that have similar information complexity characteristics. These include complex account management, complex programme management, regulatory oversight, complex fund and trust administration, agent network models amongst others.

- **Limitations:** There are still several limitations in the implementation that relate to technology, process, information and functional coverage. In terms of technology, key network search algorithms need to be implemented and enhanced. In terms of process key knowledge context activities need to automated, such as the management of classes and attributes, enforcing of defined constraints and reporting on exceptions. In terms of information, the visualisation and interactive management of the knowledge context needs to be improved. In terms of coverage, multiple vocabularies need to be supported, control of resources needs to be federated, and access needs to distributed, secured and sustained.

- **Business Model:** A key observation was that the knowledge base is no longer merely one component of the process infrastructure but the most valuable asset that the practice can create. Consequently, the asset can itself be hired out for a fee for use in much the same way as used in Digital Money practice, i.e. to explore the ecosystem and harvest knowledge. The use of the asset can be subsidised through advertising revenue. There is also the opportunity to add more knowledge workers since they can take advantage of the shared knowledge base, thus increasing the scale of operation. The new opportunities in the business model are shown boldfaced and italicised in Figure 53: The New Business Model

<table>
<tr>
<td rowspan="2"><u>Key Partners</u>
Optimisation / Economy of scale</td>
<td><u>Key Activities</u>
Problem Solving
Platform / Network</td>
<td rowspan="2"><u>Value Propositions</u>
Customisation
Price
Cost Reduction
Acceleration
Newness
Performance
Getting the job done
Design
Brand/Status
Risk Reduction
Accessibility
Convenience/Usability</td>
<td><u>Customer Relationships</u>
Personal assistance
Dedicated Personal assistance
Self-service
Automated services
Communities
Co-creation</td>
<td rowspan="2"><u>Customer Segments</u>
Niche Market
Segmented
Diversified
Multi-sided</td>
</tr>
<tr>
<td><u>Key Resources</u>
Human
Tangible
Intellectual</td>
<td><u>Channels</u>
Sales Force
Web Sales
Partner Stores</td>
</tr>
<tr>
<td colspan="2"><u>Cost Structure</u>
Cost-Driven
Value-Driven
Economies of Scale
Economies of Scope</td>
<td colspan="3"><u>Revenue Streams</u>
Asset Sale
Lending / Renting / Leasing
Brokerage Fees
Usage Fee
Subscription Fees
Licencing
Advertising</td>
</tr>
</table>

Figure 53: The New Business Model

ST is already exploiting the opportunities created by the new approach and moving into other domains. It is also raising its profile and positioning in terms of both the clientele and the value of services that it is able to provide.

Appendix II. Change Assessment Instrument Data

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 1 - Pilot - AB	P1	Divisional Director	Strategic Perspective	Visibility	-1	1	2
Phase 1 - Pilot - AB	P1	Divisional Director	Strategic Perspective	Predictability	-2	2	4
Phase 1 - Pilot - AB	P1	Divisional Director	Strategic Perspective	Scalability	-4	3	7
Phase 1 - Pilot - AB	P1	Divisional Director	Strategic Perspective	Variability	-4	2	6
Phase 1 - Pilot - AB	P1	Divisional Director	Strategic Perspective	Quality	-3	2	5
Phase 1 - Pilot - AB	P1	Divisional Director	Strategic Perspective	Control	-2	2	4
Phase 1 - Pilot - AB	P2	Operating Officer	Operational Complexity Perspective	Visibility	-3	2	5
Phase 1 - Pilot - AB	P2	Operating Officer	Operational Complexity Perspective	Predictability	-3	2	5
Phase 1 - Pilot - AB	P2	Operating Officer	Operational Complexity Perspective	Scalability	-4	3	7
Phase 1 - Pilot - AB	P2	Operating Officer	Operational Complexity Perspective	Variability	-4	2	6
Phase 1 - Pilot - AB	P2	Operating Officer	Operational Complexity Perspective	Quality	-2	2	4
Phase 1 - Pilot - AB	P2	Operating Officer	Operational Complexity Perspective	Control	-3	2	5
Phase 1 - Pilot - AB	P3	Programme Director	Change Delivery Perspective	Visibility	-3	2	5
Phase 1 - Pilot - AB	P3	Programme Director	Change Delivery Perspective	Predictability	-3	1	4
Phase 1 - Pilot - AB	P3	Programme Director	Change Delivery Perspective	Scalability	-2	2	4
Phase 1 - Pilot - AB	P3	Programme Director	Change Delivery Perspective	Variability	-2	1	3
Phase 1 - Pilot - AB	P3	Programme Director	Change Delivery Perspective	Quality	-3	2	5
Phase 1 - Pilot - AB	P3	Programme Director	Change Delivery Perspective	Control	-4	2	6

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 1 - Pilot - AB	P4	Process Owner	Process Resourcing, Goals, Outcomes	Visibility	-2	1	3
Phase 1 - Pilot - AB	P4	Process Owner	Process Resourcing, Goals, Outcomes	Predictability	-2	2	4
Phase 1 - Pilot - AB	P4	Process Owner	Process Resourcing, Goals, Outcomes	Scalability	-4	3	7
Phase 1 - Pilot - AB	P4	Process Owner	Process Resourcing, Goals, Outcomes	Variability	-3	2	5
Phase 1 - Pilot - AB	P4	Process Owner	Process Resourcing, Goals, Outcomes	Quality	-3	2	5
Phase 1 - Pilot - AB	P4	Process Owner	Process Resourcing, Goals, Outcomes	Control	-3	2	5
Phase 1 - Pilot - AB	P5	Process Administrator	Process Complexity Perspective	Visibility	-4	3	7
Phase 1 - Pilot - AB	P5	Process Administrator	Process Complexity Perspective	Predictability	-3	2	5
Phase 1 - Pilot - AB	P5	Process Administrator	Process Complexity Perspective	Scalability	-4	3	7
Phase 1 - Pilot - AB	P5	Process Administrator	Process Complexity Perspective	Variability	-2	1	3
Phase 1 - Pilot - AB	P5	Process Administrator	Process Complexity Perspective	Quality	-2	2	4
Phase 1 - Pilot - AB	P5	Process Administrator	Process Complexity Perspective	Control	-2	3	5
Phase 1 - Pilot - AB	P6	Client Relationship Manager	Process (Internal) Client Perspective	Visibility	-2	1	3
Phase 1 - Pilot - AB	P6	Client Relationship Manager	Process (Internal) Client Perspective	Predictability	-3	2	5
Phase 1 - Pilot - AB	P6	Client Relationship Manager	Process (Internal) Client Perspective	Scalability	-2	2	4
Phase 1 - Pilot - AB	P6	Client Relationship Manager	Process (Internal) Client Perspective	Variability	-1	1	2
Phase 1 - Pilot - AB	P6	Client Relationship Manager	Process (Internal) Client Perspective	Quality	-3	2	5
Phase 1 - Pilot - AB	P6	Client Relationship Manager	Process (Internal) Client Perspective	Control	-1	1	2
Phase 1 - Pilot - MN	P1	Country Managing Director	Strategic Perspective	Visibility	1	1	0
Phase 1 - Pilot - MN	P1	Country Managing Director	Strategic Perspective	Predictability	-1	2	3
Phase 1 - Pilot - MN	P1	Country Managing Director	Strategic Perspective	Scalability	-3	3	6

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 1 - Pilot - MN	P1	Country Managing Director	Strategic Perspective	Variability	-3	2	5
Phase 1 - Pilot - MN	P1	Country Managing Director	Strategic Perspective	Quality	-4	1	5
Phase 1 - Pilot - MN	P1	Country Managing Director	Strategic Perspective	Control	-3	1	4
Phase 1 - Pilot - MN	P2	Operating Officer	Operational Complexity Perspective	Visibility	-2	2	4
Phase 1 - Pilot - MN	P2	Operating Officer	Operational Complexity Perspective	Predictability	-3	2	5
Phase 1 - Pilot - MN	P2	Operating Officer	Operational Complexity Perspective	Scalability	-2	3	5
Phase 1 - Pilot - MN	P2	Operating Officer	Operational Complexity Perspective	Variability	-1	3	4
Phase 1 - Pilot - MN	P2	Operating Officer	Operational Complexity Perspective	Quality	-3	1	4
Phase 1 - Pilot - MN	P2	Operating Officer	Operational Complexity Perspective	Control	-2	2	4
Phase 1 - Pilot - MN	P3	Programme Manager	Change Delivery Perspective	Visibility	-2	3	5
Phase 1 - Pilot - MN	P3	Programme Manager	Change Delivery Perspective	Predictability	-3	1	4
Phase 1 - Pilot - MN	P3	Programme Manager	Change Delivery Perspective	Scalability	-3	2	5
Phase 1 - Pilot - MN	P3	Programme Manager	Change Delivery Perspective	Variability	-3	2	5
Phase 1 - Pilot - MN	P3	Programme Manager	Change Delivery Perspective	Quality	-2	2	4
Phase 1 - Pilot - MN	P3	Programme Manager	Change Delivery Perspective	Control	-3	2	5
Phase 1 - Pilot - MN	P4	Client Services Director	Process Resourcing, Goals, Outcomes	Visibility	-3	2	5
Phase 1 - Pilot - MN	P4	Client Services Director	Process Resourcing, Goals, Outcomes	Predictability	-3	3	6
Phase 1 - Pilot - MN	P4	Client Services Director	Process Resourcing, Goals, Outcomes	Scalability	-4	3	7
Phase 1 - Pilot - MN	P4	Client Services Director	Process Resourcing, Goals, Outcomes	Variability	-2	3	5
Phase 1 - Pilot - MN	P4	Client Services Director	Process Resourcing, Goals, Outcomes	Quality	-3	1	4
Phase 1 - Pilot - MN	P4	Client Services Director	Process Resourcing, Goals, Outcomes	Control	-3	3	6

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 1 - Pilot - MN	P5	Project Office Head	Process Complexity Perspective	Visibility	-2	2	4
Phase 1 - Pilot - MN	P5	Project Office Head	Process Complexity Perspective	Predictability	-2	3	5
Phase 1 - Pilot - MN	P5	Project Office Head	Process Complexity Perspective	Scalability	-3	2	5
Phase 1 - Pilot - MN	P5	Project Office Head	Process Complexity Perspective	Variability	-4	2	6
Phase 1 - Pilot - MN	P5	Project Office Head	Process Complexity Perspective	Quality	-3	3	6
Phase 1 - Pilot - MN	P5	Project Office Head	Process Complexity Perspective	Control	-1	3	4
Phase 1 - Pilot - MN	P6	Account Director	Process Client Perspective	Visibility	-1	1	2
Phase 1 - Pilot - MN	P6	Account Director	Process Client Perspective	Predictability	-3	1	4
Phase 1 - Pilot - MN	P6	Account Director	Process Client Perspective	Scalability	-1	3	4
Phase 1 - Pilot - MN	P6	Account Director	Process Client Perspective	Variability	-3	2	5
Phase 1 - Pilot - MN	P6	Account Director	Process Client Perspective	Quality	-2	1	3
Phase 1 - Pilot - MN	P6	Account Director	Process Client Perspective	Control	-1	2	3
Phase 2 - Development - ST - 1	P4	Account Associate	Account Perspective	Control	-1	0	1
Phase 2 - Development - ST - 1	P4	Account Associate	Account Perspective	Predictability	-3	-2	1
Phase 2 - Development - ST - 1	P4	Account Associate	Account Perspective	Quality	-2	0	2
Phase 2 - Development - ST - 1	P4	Account Associate	Account Perspective	Scalability	-4	-4	0
Phase 2 - Development - ST - 1	P4	Account Associate	Account Perspective	Variability	-3	-1	2
Phase 2 - Development - ST - 1	P4	Account Associate	Account Perspective	Visibility	-1	1	2
Phase 2 - Development - ST - 1	P1	Managing Director	Strategic Perspective	Control	-2	-1	1
Phase 2 - Development - ST - 1	P1	Managing Director	Strategic Perspective	Predictability	-4	-2	2
Phase 2 - Development - ST - 1	P1	Managing Director	Strategic Perspective	Quality	-2	-1	1

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 2 - Development - ST - 1	P1	Managing Director	Strategic Perspective	Scalability	-4	-4	0
Phase 2 - Development - ST - 1	P1	Managing Director	Strategic Perspective	Variability	-3	-3	0
Phase 2 - Development - ST - 1	P1	Managing Director	Strategic Perspective	Visibility	-1	2	3
Phase 2 - Development - ST - 1	P3	Marketing Associate	Marketing Perspective	Control	-1	0	1
Phase 2 - Development - ST - 1	P3	Marketing Associate	Marketing Perspective	Predictability	-1	0	1
Phase 2 - Development - ST - 1	P3	Marketing Associate	Marketing Perspective	Quality	-2	0	2
Phase 2 - Development - ST - 1	P3	Marketing Associate	Marketing Perspective	Scalability	-2	-1	1
Phase 2 - Development - ST - 1	P3	Marketing Associate	Marketing Perspective	Variability	-3	-1	2
Phase 2 - Development - ST - 1	P3	Marketing Associate	Marketing Perspective	Visibility	0	2	2
Phase 2 - Development - ST - 1	P2	Practice Lead	Operational Complexity Perspective	Control	-3	-1	2
Phase 2 - Development - ST - 1	P2	Practice Lead	Operational Complexity Perspective	Predictability	-3	-1	2
Phase 2 - Development - ST - 1	P2	Practice Lead	Operational Complexity Perspective	Quality	-2	1	3
Phase 2 - Development - ST - 1	P2	Practice Lead	Operational Complexity Perspective	Scalability	-3	-3	0
Phase 2 - Development - ST - 1	P2	Practice Lead	Operational Complexity Perspective	Variability	-2	-2	0
Phase 2 - Development - ST - 1	P2	Practice Lead	Operational Complexity Perspective	Visibility	0	3	3
Phase 2 - Development - ST - 1	P5	Product Associate	Product Perspective	Control	-2	-2	0
Phase 2 - Development - ST - 1	P5	Product Associate	Product Perspective	Predictability	-2	-2	0
Phase 2 - Development - ST - 1	P5	Product Associate	Product Perspective	Quality	-2	-1	1
Phase 2 - Development - ST - 1	P5	Product Associate	Product Perspective	Scalability	-2	-2	0
Phase 2 - Development - ST - 1	P5	Product Associate	Product Perspective	Variability	-2	0	2
Phase 2 - Development - ST - 1	P5	Product Associate	Product Perspective	Visibility	-1	0	1

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 2 - Development - ST - 1	P6	Research Associate	Research Perspective	Control	-3	-2	1
Phase 2 - Development - ST - 1	P6	Research Associate	Research Perspective	Predictability	-3	-2	1
Phase 2 - Development - ST - 1	P6	Research Associate	Research Perspective	Quality	-1	0	1
Phase 2 - Development - ST - 1	P6	Research Associate	Research Perspective	Scalability	-3	-3	0
Phase 2 - Development - ST - 1	P6	Research Associate	Research Perspective	Variability	-2	-1	1
Phase 2 - Development - ST - 1	P6	Research Associate	Research Perspective	Visibility	-2	0	2
Phase 3 - Validation - ST	P1	Managing Director	Strategic Perspective	Visibility	-3	2	5
Phase 3 - Validation - ST	P1	Managing Director	Strategic Perspective	Predictability	-3	3	6
Phase 3 - Validation - ST	P1	Managing Director	Strategic Perspective	Scalability	-4	3	7
Phase 3 - Validation - ST	P1	Managing Director	Strategic Perspective	Variability	-3	2	5
Phase 3 - Validation - ST	P1	Managing Director	Strategic Perspective	Quality	-1	2	3
Phase 3 - Validation - ST	P1	Managing Director	Strategic Perspective	Control	-4	3	7
Phase 3 - Validation - ST	P2	Practice Lead	Operational Complexity Perspective	Visibility	-4	2	6
Phase 3 - Validation - ST	P2	Practice Lead	Operational Complexity Perspective	Predictability	-3	1	4
Phase 3 - Validation - ST	P2	Practice Lead	Operational Complexity Perspective	Scalability	-4	2	6
Phase 3 - Validation - ST	P2	Practice Lead	Operational Complexity Perspective	Variability	-2	1	3
Phase 3 - Validation - ST	P2	Practice Lead	Operational Complexity Perspective	Quality	-2	2	4
Phase 3 - Validation - ST	P2	Practice Lead	Operational Complexity Perspective	Control	-3	2	5
Phase 3 - Validation - ST	P3	Marketing Associate	Research Perspective	Visibility	-2	0	2
Phase 3 - Validation - ST	P3	Marketing Associate	Research Perspective	Predictability	-3	2	5
Phase 3 - Validation - ST	P3	Marketing Associate	Research Perspective	Scalability	-4	3	7

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 3 - Validation - ST	P3	Marketing Associate	Research Perspective	Variability	-3	2	5
Phase 3 - Validation - ST	P3	Marketing Associate	Research Perspective	Quality	-2	3	5
Phase 3 - Validation - ST	P3	Marketing Associate	Research Perspective	Control	-3	3	6
Phase 3 - Validation - ST	P4	Account Associate	Research Perspective	Visibility	-4	0	4
Phase 3 - Validation - ST	P4	Account Associate	Research Perspective	Predictability	-4	2	6
Phase 3 - Validation - ST	P4	Account Associate	Research Perspective	Scalability	-4	3	7
Phase 3 - Validation - ST	P4	Account Associate	Research Perspective	Variability	-3	2	5
Phase 3 - Validation - ST	P4	Account Associate	Research Perspective	Quality	-2	3	5
Phase 3 - Validation - ST	P4	Account Associate	Research Perspective	Control	-3	3	6
Phase 3 - Validation - ST	P5	Product Associate	Research Perspective	Visibility	-4	0	4
Phase 3 - Validation - ST	P5	Product Associate	Research Perspective	Predictability	-4	2	6
Phase 3 - Validation - ST	P5	Product Associate	Research Perspective	Scalability	-4	3	7
Phase 3 - Validation - ST	P5	Product Associate	Research Perspective	Variability	-3	2	5
Phase 3 - Validation - ST	P5	Product Associate	Research Perspective	Quality	-2	3	5
Phase 3 - Validation - ST	P5	Product Associate	Research Perspective	Control	-3	3	6
Phase 3 - Validation - ST	P6	Research Associate	Research Perspective	Visibility	-4	0	4
Phase 3 - Validation - ST	P6	Research Associate	Research Perspective	Predictability	-4	2	6
Phase 3 - Validation - ST	P6	Research Associate	Research Perspective	Scalability	-4	3	7
Phase 3 - Validation - ST	P6	Research Associate	Research Perspective	Variability	-3	2	5
Phase 3 - Validation - ST	P6	Research Associate	Research Perspective	Quality	-2	3	5
Phase 3 - Validation - ST	P6	Research Associate	Research Perspective	Control	-3	3	6

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 3 - Validation - AB	P1	Divisional Director	Strategic Perspective	Visibility	0	1	1
Phase 3 - Validation - AB	P1	Divisional Director	Strategic Perspective	Predictability	-3	2	5
Phase 3 - Validation - AB	P1	Divisional Director	Strategic Perspective	Scalability	-4	2	6
Phase 3 - Validation - AB	P1	Divisional Director	Strategic Perspective	Variability	-3	2	5
Phase 3 - Validation - AB	P1	Divisional Director	Strategic Perspective	Quality	-1	1	2
Phase 3 - Validation - AB	P1	Divisional Director	Strategic Perspective	Control	-4	2	6
Phase 3 - Validation - AB	P2	Operating Officer	Operational Complexity Perspective	Visibility	-4	3	7
Phase 3 - Validation - AB	P2	Operating Officer	Operational Complexity Perspective	Predictability	-3	1	4
Phase 3 - Validation - AB	P2	Operating Officer	Operational Complexity Perspective	Scalability	-4	3	7
Phase 3 - Validation - AB	P2	Operating Officer	Operational Complexity Perspective	Variability	-2	1	3
Phase 3 - Validation - AB	P2	Operating Officer	Operational Complexity Perspective	Quality	-2	2	4
Phase 3 - Validation - AB	P2	Operating Officer	Operational Complexity Perspective	Control	-3	2	5
Phase 3 - Validation - AB	P3	Programme Director	Change Delivery Perspective	Visibility	-3	3	6
Phase 3 - Validation - AB	P3	Programme Director	Change Delivery Perspective	Predictability	-2	1	3
Phase 3 - Validation - AB	P3	Programme Director	Change Delivery Perspective	Scalability	-4	1	5
Phase 3 - Validation - AB	P3	Programme Director	Change Delivery Perspective	Variability	-1	1	2
Phase 3 - Validation - AB	P3	Programme Director	Change Delivery Perspective	Quality	-2	1	3
Phase 3 - Validation - AB	P3	Programme Director	Change Delivery Perspective	Control	-4	2	6
Phase 3 - Validation - AB	P4	Process Owner	Process Resourcing, Goals, Outcomes	Visibility	-3	1	4
Phase 3 - Validation - AB	P4	Process Owner	Process Resourcing, Goals, Outcomes	Predictability	-3	2	5
Phase 3 - Validation - AB	P4	Process Owner	Process Resourcing, Goals, Outcomes	Scalability	-4	2	6

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 3 - Validation - AB	P4	Process Owner	Process Resourcing, Goals, Outcomes	Variability	-4	2	6
Phase 3 - Validation - AB	P4	Process Owner	Process Resourcing, Goals, Outcomes	Quality	-3	1	4
Phase 3 - Validation - AB	P4	Process Owner	Process Resourcing, Goals, Outcomes	Control	-3	1	4
Phase 3 - Validation - AB	P5	Process Administrator	Process Complexity Perspective	Visibility	-4	0	4
Phase 3 - Validation - AB	P5	Process Administrator	Process Complexity Perspective	Predictability	-4	2	6
Phase 3 - Validation - AB	P5	Process Administrator	Process Complexity Perspective	Scalability	-4	3	7
Phase 3 - Validation - AB	P5	Process Administrator	Process Complexity Perspective	Variability	-3	2	5
Phase 3 - Validation - AB	P5	Process Administrator	Process Complexity Perspective	Quality	-2	3	5
Phase 3 - Validation - AB	P5	Process Administrator	Process Complexity Perspective	Control	-3	3	6
Phase 3 - Validation - AB	P6	Client Relationship Manager	Process (Internal) Client Perspective	Visibility	-2	2	4
Phase 3 - Validation - AB	P6	Client Relationship Manager	Process (Internal) Client Perspective	Predictability	-3	2	5
Phase 3 - Validation - AB	P6	Client Relationship Manager	Process (Internal) Client Perspective	Scalability	-2	1	3
Phase 3 - Validation - AB	P6	Client Relationship Manager	Process (Internal) Client Perspective	Variability	-1	1	2
Phase 3 - Validation - AB	P6	Client Relationship Manager	Process (Internal) Client Perspective	Quality	-2	1	3
Phase 3 - Validation - AB	P6	Client Relationship Manager	Process (Internal) Client Perspective	Control	-1	0	1
Phase 2 - Development - ST - 2	P4	Account Associate	Account Perspective	Control	0	1	1
Phase 2 - Development - ST - 2	P4	Account Associate	Account Perspective	Predictability	-2	-2	0
Phase 2 - Development - ST - 2	P4	Account Associate	Account Perspective	Quality	0	1	1
Phase 2 - Development - ST - 2	P4	Account Associate	Account Perspective	Scalability	-4	-4	0
Phase 2 - Development - ST - 2	P4	Account Associate	Account Perspective	Variability	-1	0	1
Phase 2 - Development - ST - 2	P4	Account Associate	Account Perspective	Visibility	1	1	0

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 2 - Development - ST - 2	P1	Managing Director	Strategic Perspective	Control	-1	-1	0
Phase 2 - Development - ST - 2	P1	Managing Director	Strategic Perspective	Predictability	-2	-2	0
Phase 2 - Development - ST - 2	P1	Managing Director	Strategic Perspective	Quality	-1	0	1
Phase 2 - Development - ST - 2	P1	Managing Director	Strategic Perspective	Scalability	-4	-4	0
Phase 2 - Development - ST - 2	P1	Managing Director	Strategic Perspective	Variability	-3	-2	1
Phase 2 - Development - ST - 2	P1	Managing Director	Strategic Perspective	Visibility	2	2	0
Phase 2 - Development - ST - 2	P3	Marketing Associate	Marketing Perspective	Control	0	0	0
Phase 2 - Development - ST - 2	P3	Marketing Associate	Marketing Perspective	Predictability	0	1	1
Phase 2 - Development - ST - 2	P3	Marketing Associate	Marketing Perspective	Quality	0	2	2
Phase 2 - Development - ST - 2	P3	Marketing Associate	Marketing Perspective	Scalability	-1	-2	-1
Phase 2 - Development - ST - 2	P3	Marketing Associate	Marketing Perspective	Variability	-1	-1	0
Phase 2 - Development - ST - 2	P3	Marketing Associate	Marketing Perspective	Visibility	2	2	0
Phase 2 - Development - ST - 2	P2	Practice Lead	Operational Complexity Perspective	Control	-1	0	1
Phase 2 - Development - ST - 2	P2	Practice Lead	Operational Complexity Perspective	Predictability	-1	-1	0
Phase 2 - Development - ST - 2	P2	Practice Lead	Operational Complexity Perspective	Quality	1	1	0
Phase 2 - Development - ST - 2	P2	Practice Lead	Operational Complexity Perspective	Scalability	-3	-4	-1
Phase 2 - Development - ST - 2	P2	Practice Lead	Operational Complexity Perspective	Variability	-2	-1	1
Phase 2 - Development - ST - 2	P2	Practice Lead	Operational Complexity Perspective	Visibility	3	2	-1
Phase 2 - Development - ST - 2	P5	Product Associate	Product Perspective	Control	-2	0	2
Phase 2 - Development - ST - 2	P5	Product Associate	Product Perspective	Predictability	-2	-1	1
Phase 2 - Development - ST - 2	P5	Product Associate	Product Perspective	Quality	-1	0	1

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 2 - Development - ST - 2	P5	Product Associate	Product Perspective	Scalability	-2	-2	0
Phase 2 - Development - ST - 2	P5	Product Associate	Product Perspective	Variability	0	0	0
Phase 2 - Development - ST - 2	P5	Product Associate	Product Perspective	Visibility	0	1	1
Phase 2 - Development - ST - 2	P6	Research Associate	Research Perspective	Control	-2	-1	1
Phase 2 - Development - ST - 2	P6	Research Associate	Research Perspective	Predictability	-2	-1	1
Phase 2 - Development - ST - 2	P6	Research Associate	Research Perspective	Quality	0	0	0
Phase 2 - Development - ST - 2	P6	Research Associate	Research Perspective	Scalability	-3	-3	0
Phase 2 - Development - ST - 2	P6	Research Associate	Research Perspective	Variability	-1	0	1
Phase 2 - Development - ST - 2	P6	Research Associate	Research Perspective	Visibility	0	1	1
Phase 2 - Development - ST - 3	P4	Account Associate	Account Perspective	Control	1	1	0
Phase 2 - Development - ST - 3	P4	Account Associate	Account Perspective	Predictability	-2	0	2
Phase 2 - Development - ST - 3	P4	Account Associate	Account Perspective	Quality	1	1	0
Phase 2 - Development - ST - 3	P4	Account Associate	Account Perspective	Scalability	-4	-4	0
Phase 2 - Development - ST - 3	P4	Account Associate	Account Perspective	Variability	0	0	0
Phase 2 - Development - ST - 3	P4	Account Associate	Account Perspective	Visibility	1	1	0
Phase 2 - Development - ST - 3	P1	Managing Director	Strategic Perspective	Control	-1	-1	0
Phase 2 - Development - ST - 3	P1	Managing Director	Strategic Perspective	Predictability	-2	-1	1
Phase 2 - Development - ST - 3	P1	Managing Director	Strategic Perspective	Quality	0	0	0
Phase 2 - Development - ST - 3	P1	Managing Director	Strategic Perspective	Scalability	-4	-4	0
Phase 2 - Development - ST - 3	P1	Managing Director	Strategic Perspective	Variability	-2	-3	-1
Phase 2 - Development - ST - 3	P1	Managing Director	Strategic Perspective	Visibility	2	1	-1

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 2 - Development - ST - 3	P3	Marketing Associate	Marketing Perspective	Control	0	0	0
Phase 2 - Development - ST - 3	P3	Marketing Associate	Marketing Perspective	Predictability	1	1	0
Phase 2 - Development - ST - 3	P3	Marketing Associate	Marketing Perspective	Quality	2	2	0
Phase 2 - Development - ST - 3	P3	Marketing Associate	Marketing Perspective	Scalability	-2	-2	0
Phase 2 - Development - ST - 3	P3	Marketing Associate	Marketing Perspective	Variability	-1	0	1
Phase 2 - Development - ST - 3	P3	Marketing Associate	Marketing Perspective	Visibility	2	2	0
Phase 2 - Development - ST - 3	P2	Practice Lead	Operational Complexity Perspective	Control	0	-1	-1
Phase 2 - Development - ST - 3	P2	Practice Lead	Operational Complexity Perspective	Predictability	-1	0	1
Phase 2 - Development - ST - 3	P2	Practice Lead	Operational Complexity Perspective	Quality	1	1	0
Phase 2 - Development - ST - 3	P2	Practice Lead	Operational Complexity Perspective	Scalability	-4	-4	0
Phase 2 - Development - ST - 3	P2	Practice Lead	Operational Complexity Perspective	Variability	-1	-2	-1
Phase 2 - Development - ST - 3	P2	Practice Lead	Operational Complexity Perspective	Visibility	2	3	1
Phase 2 - Development - ST - 3	P5	Product Associate	Product Perspective	Control	0	-1	-1
Phase 2 - Development - ST - 3	P5	Product Associate	Product Perspective	Predictability	-1	0	1
Phase 2 - Development - ST - 3	P5	Product Associate	Product Perspective	Quality	0	0	0
Phase 2 - Development - ST - 3	P5	Product Associate	Product Perspective	Scalability	-2	-3	-1
Phase 2 - Development - ST - 3	P5	Product Associate	Product Perspective	Variability	0	2	2
Phase 2 - Development - ST - 3	P5	Product Associate	Product Perspective	Visibility	1	0	-1
Phase 2 - Development - ST - 3	P6	Research Associate	Research Perspective	Control	-1	1	2
Phase 2 - Development - ST - 3	P6	Research Associate	Research Perspective	Predictability	-1	1	2
Phase 2 - Development - ST - 3	P6	Research Associate	Research Perspective	Quality	0	1	1

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 2 - Development - ST - 3	P6	Research Associate	Research Perspective	Scalability	-3	0	3
Phase 2 - Development - ST - 3	P6	Research Associate	Research Perspective	Variability	0	1	1
Phase 2 - Development - ST - 3	P6	Research Associate	Research Perspective	Visibility	1	0	-1
Phase 2 - Development - ST - 4	P4	Account Associate	Account Perspective	Control	1	1	0
Phase 2 - Development - ST - 4	P4	Account Associate	Account Perspective	Predictability	0	1	1
Phase 2 - Development - ST - 4	P4	Account Associate	Account Perspective	Quality	1	1	0
Phase 2 - Development - ST - 4	P4	Account Associate	Account Perspective	Scalability	-4	0	4
Phase 2 - Development - ST - 4	P4	Account Associate	Account Perspective	Variability	0	1	1
Phase 2 - Development - ST - 4	P4	Account Associate	Account Perspective	Visibility	1	2	1
Phase 2 - Development - ST - 4	P1	Managing Director	Strategic Perspective	Control	-1	2	3
Phase 2 - Development - ST - 4	P1	Managing Director	Strategic Perspective	Predictability	-1	2	3
Phase 2 - Development - ST - 4	P1	Managing Director	Strategic Perspective	Quality	0	1	1
Phase 2 - Development - ST - 4	P1	Managing Director	Strategic Perspective	Scalability	-4	2	6
Phase 2 - Development - ST - 4	P1	Managing Director	Strategic Perspective	Variability	-3	1	4
Phase 2 - Development - ST - 4	P1	Managing Director	Strategic Perspective	Visibility	1	2	1
Phase 2 - Development - ST - 4	P3	Marketing Associate	Marketing Perspective	Control	0	1	1
Phase 2 - Development - ST - 4	P3	Marketing Associate	Marketing Perspective	Predictability	1	2	1
Phase 2 - Development - ST - 4	P3	Marketing Associate	Marketing Perspective	Quality	2	2	0
Phase 2 - Development - ST - 4	P3	Marketing Associate	Marketing Perspective	Scalability	-2	0	2
Phase 2 - Development - ST - 4	P3	Marketing Associate	Marketing Perspective	Variability	0	1	1
Phase 2 - Development - ST - 4	P3	Marketing Associate	Marketing Perspective	Visibility	2	3	1

QDS ID	Participant ID	Role	Selected to Provide	Factor	Before	After	Change
Phase 2 - Development - ST - 4	P2	Practice Lead	Operational Complexity Perspective	Control	-1	3	4
Phase 2 - Development - ST - 4	P2	Practice Lead	Operational Complexity Perspective	Predictability	0	2	2
Phase 2 - Development - ST - 4	P2	Practice Lead	Operational Complexity Perspective	Quality	1	3	2
Phase 2 - Development - ST - 4	P2	Practice Lead	Operational Complexity Perspective	Scalability	-4	3	7
Phase 2 - Development - ST - 4	P2	Practice Lead	Operational Complexity Perspective	Variability	-2	2	4
Phase 2 - Development - ST - 4	P2	Practice Lead	Operational Complexity Perspective	Visibility	3	3	0
Phase 2 - Development - ST - 4	P5	Product Associate	Product Perspective	Control	-1	0	1
Phase 2 - Development - ST - 4	P5	Product Associate	Product Perspective	Predictability	0	2	2
Phase 2 - Development - ST - 4	P5	Product Associate	Product Perspective	Quality	0	2	2
Phase 2 - Development - ST - 4	P5	Product Associate	Product Perspective	Scalability	-3	0	3
Phase 2 - Development - ST - 4	P5	Product Associate	Product Perspective	Variability	2	2	0
Phase 2 - Development - ST - 4	P5	Product Associate	Product Perspective	Visibility	0	2	2
Phase 2 - Development - ST - 4	P6	Research Associate	Research Perspective	Control	1	1	0
Phase 2 - Development - ST - 4	P6	Research Associate	Research Perspective	Predictability	1	3	2
Phase 2 - Development - ST - 4	P6	Research Associate	Research Perspective	Quality	1	2	1
Phase 2 - Development - ST - 4	P6	Research Associate	Research Perspective	Scalability	0	2	2
Phase 2 - Development - ST - 4	P6	Research Associate	Research Perspective	Variability	1	2	1
Phase 2 - Development - ST - 4	P6	Research Associate	Research Perspective	Visibility	0	2	2

Appendix III. Notes

[1] **Complexity constrains incremental innovation in firms**

Firms may be reluctant to pursue complex innovations because (1) information is more difficult to integrate across firm units, and because (2) proposed projects without integrated information will appear more risky to decision makers (Kahneman & Lovallo, 1993; Ethiraj, Ramababu, & Krishnan, 2012).

Changing a complex product creates a cascade of impacts across interdependent units of the firm (Ulrich K. T., 1995). This cascade reduces the likelihood a firm will invest in innovation, especially when changes are hard for engineers to anticipate and coordinate retrospectively. (Ethiraj, Ramababu, & Krishnan, 2012)

[2] **Complexity and project management**

The importance of complexity to the project management process is widely acknowledged, for example determine planning, coordination and control requirements (Bubshait & Selen), hindering the clear identification of goals and objectives of major projects (Morris & Hough, 1987), as a criterion in the selection of an appropriate project organizational form (Bennett J. , 1991; Morris & Hough, 1987), influencing the selection of project inputs, e.g. the expertise and experience requirements of management personnel (Gidado, 1993), as a criterion in the selection of a suitable project procurement arrangement (Stocks & Male, 1984), and affecting the project objectives of time, cost and quality. Broadly, the higher the project complexity the greater the time and cost (Rowlinson, 1988).

Baccarini (1996) proposes that project complexity be defined as 'consisting of many varied interrelated parts' and can be operationalized in terms of differentiation and interdependency. Vidal et al. (2011) define project complexity as the property of a project which makes it difficult to understand, foresee and keep under control its overall behaviour, even when given reasonably complete information about the project system." Baccarini (1996) emphasizes that complexity is a distinctly different concept to two other project characteristics, size and uncertainty (Morris & Hough, 1987; Mintzberg, 1991).

[3] **Knowledge contexts**

Raghu and Vinze (2007) define a knowledge context with an operational focus, where the knowledge unit and the KM efforts are intertwined and indistinguishable. Critical to this orientation is a definition of an operational context for knowledge and its application provided by the business process. They consider the management of knowledge as consisting of three phases or orientations: storage and retrieval; knowledge sharing; and knowledge synthesis. They argue that it is the interactive nature of these orientations that accounts for the continuous evolution of knowledge and KM in organisations.

[4] **Literature on research methodology surveyed**

The researcher reviewed qualitative methods of social inquiry, and quantitative methods, with the specific literature searches shown in below. For each method the researcher identified an early reference, which could be expected to have included citations to the development of the method.

Broad area	Technique	Originator / First reference	Major references
Qualitative inquiry	Focus groups	Merton	(Merton & Kendall, 1946; Merton, Fiske, & Kendall, 1956; Morrison D. E., 1998)
	Action research	Lewin	(Lewin K. , 1946)
	Grounded theory	Glaser & Strauss	(Glaser & Strauss, 1967)
	Use cases (in ICT)	Jacobson	(Jacobson, 1992)
	Appreciative Inquiry	Cooperrider	(Cooperrider, 1986)
Quantitative methods	Survey research	not recorded	(Hennessy, 1975)
	Latin square design	Fisher	(Box, 1978)

[5] **Classification of qualitative approaches**

Sequence	Approach	Key references
Ontological	Social constructionism	(Berger & Luckmann, 1967; Gergen, 1999)
Epistemological	Pragmatism	(Dewey, 1991/1910)
	Critical realism	(Pawson & Tilley, 1997; Bell, 2003)
	Critical theory	(Alvesson & Sköldberg, 2000; Churchman, 1971)
Methodological	Participatory inquiry	(Chambers, 1997; Heron & Reason, 1997)
	Action research	(Lewin K. , 1946; Reason & Bradbury, 2001)
	Case study	(Yin, 1994; Stake R. , 1995; Kvale, 1996)

[6] **Action Research and its major streams**

Action research (AR) has been described as a technique characterized by intervention experiments that operate on problems or questions perceived by practitioners within a particular context, and as a family of research methodologies which pursue action (or change) and research (or understanding) at the same time, in terms of (a) action to bring about change in some community or organisation or program, and (b) research to increase understanding on the part of the researcher or the client, or both (and often some wider community). In most of its forms it does this by: (a) using a cyclic or spiral process which alternates between action and critical reflection, and (b) in the later cycles, continuously refining methods, data and interpretation in the light of the understanding developed in the earlier cycles.

Variety	**Major references**
Participatory action research (PAR)	(Lewin K. , 1946; Lewin K. , 1947; Whyte, 1991; Fals-Borda & Rahman, 1991)
Soft systems methodology (SSM)	(Checkland P. B., 1981; Checkland P. , 1999)
Action learning	(Revans, 1982)
Critical system heuristics (CSH)	(Ulrich W. , 1994)
Action science	(Argyris, Putnam, & Smith, 1985; Friedman, 2000)
Appreciative inquiry	(Cooperrider & Srivastva, 1987; Elliott, 1999)
Critical action research (stemming from Habermas and critical theory)	(Kemmis & McTaggart, 1988)
Total systems intervention	(Flood & Jackson, 1991)
Co-operative inquiry	(Heron, 1996)
Action inquiry	(Torbert, 1991)
Grounded action research	(Baskerville & Pries-Heje, 1999)
Anticipatory action learning	(Stevenson, 2002)
Community operational research	(Midgley & Ochoa-Arias, 2004)

[7] **Drivers and risks of the methodology**

The choice of Action Research is influenced by the need to align the characteristics of the chosen methodology with the context of the research as described below:

Firstly, the research was expected to be carried out in firms undergoing significant and rapid change in terms of structure, culture and direction. This argues for a methodology which was responsive and flexible in the face of continuous learning and change. Secondly, the research is designed to meet the needs of a certain context – Complex Knowledge Intensive business processes. The scope of research is therefore restricted to the information industry which represents a small population of which a very small proportion will actually undergo such a change during the period of research. This argues for a focus on logical rather than statistical validity. Thirdly, the research is focused on business process problems and initiatives to resolve these, and involves reflexive analysis of the process of change through the process of its implementation. This argues for an emphasis on reflexivity in the chosen methodology. Fourthly, research needs to be carried out within the organisation with the researcher being the agent of change, closely involved in various roles, including consultant, participant and analyst and not from an external standpoint. This argues for a participative form of enquiry. Fifthly, the initiatives being addressed involve cyclic creation of models, review of their appropriateness and reformulation. This argues for a retroductive strategy with the data gathered in each cycle influencing the strategy for the next cycle. Sixthly, participants responsible for business process operations and change, who typically take a constructionist perspective, are key partners to the research. The role of the researcher is that of a reflective partner, a dialogic facilitator and a mediator of languages rather than that of a detached observer. This argues for a constructivist interpretation of the researcher role with the researcher being close to the data. Seventhly, the duration of the research particularly relates to the development of the **Approach** was expected to be several months which argues for a longitudinal study. Finally, the outcomes of the initiatives are likely to be heavily contextualised and so would differ from organisation to organisation. This argues for the development of a particular rather than general theory with an assessment of its generalizability.

Addressing the risk of the methodology not being regarded as Action Research, however, required further review of the literature of Action Research. Exploring commonality between the methodologically and the epistemologically focused writers, Peters and Robinson (1984) distinguished three shared groups of characteristics: (1) Involvement-in-change characteristics – i.e. they are problem focused and directed toward the improvement of some existing social practice; (2) Organic process characteristics – i.e. research consists of a series of systematic cyclical or iterative stages of fact finding, reflection and planning, strategic action, and evaluation; and (3) the collaborative characteristic – i.e. research is carried on as a joint, cooperative endeavour among the participants. The implication, then, is that if any of the three is lacking, the method being used may not be action research.

To determine whether the method being considered could still be deemed to be action research, its elements were compared with Peters and Robinson's (1984) three characteristics shared by the methodological and epistemological emphases in action research, as shown below.

AR Characteristics	Method Characteristics
To what extent is it problem-focused and involved in change?	(a) participants come to understand the causes of process complexity and apply the Approach to the process under consideration (b) having learned the Approach through their immersion in it, participants can apply it to other processes that they are responsible for (c) In developing the Approach using the outcome of a cycle to improve the process in later cycles.
To what extent does it possess organic process characteristics?	The method is designed to make explicit use of the iterative cycle of action research, on two levels. At the case level, there is an iterative cycle of planning, implementation and review workshops, allowing time for reflection. At the level of development of the Approach, there is a larger cycle, in which the unit is the cycle within the case itself. After each cycle, there is an opportunity to change the Approach; this is the key "organic" characteristic.
To what extent does it use participatory, democratic processes?	Participants would be considering the characteristics of their own process, and could offer advice on the Approach, but because of their lack of expertise in methodological development, they would not be able to participate fully in the development of the Approach. In relation to the development of the Approach, the form of participatory action research used here would resemble the less-participatory Northern form derived from Lewin (as in (Greenwood & Levin, 1998)), rather than the more-participatory Southern form (as in (Fals-Borda & Rahman, 1991)). In relation to the use of the Approach after its development, the Southern form could more closely apply, provided that if experts or consultants were used, boundary critique (Ulrich W. , 1996; Midgley, Munlo, & Brown, 1998) was applied.

Differences of detail: In most published reports of action research projects, the researcher has long and repeated contact with the social entity being studied. While this was true of the Approach development phase of the research, in the pilot and validation phases less detail was collected.

Differences of involvement: In the more participative forms of action research, participants are highly involved with the process, because they are researching their own social entity. In this research, that was true at the inner (case) level, with participants considering the complexity of their own process. The researcher's own involvement at both levels was more that of an outsider, because the major purpose was to develop the Approach.

Differences of cycling: Cycling was only applied to the phase of the research that involved the development of the Approach, not to the pilot phase or to the validation phase. The purpose of the pilot phase was to "set the scene" in terms of testing and extending a theoretical framework for the actual development of the Approach and the purpose of the validation phase was to implement the approach and verify the results achieved. Since neither of these phases involved further development of the Approach, cycling was not necessary for these phases.

Therefore, given those instances of the defining criteria, the method used for the development of the Approach appears to qualify as action research. However, the method used differed from generic action research practice in three respects: collection of detail, degree of involvement, and more explicit use of cycles:

The other risk was that the method could be viewed as (business) consulting rather than Action Research. Baskerville (1999) contends that these differentiated in five key ways – motivation, commitment, approach, foundation for recommendations, and essence of organisation understanding. In summary, consultants are usually paid to dictate experienced, reliable solutions based on their independent review. Action researchers act out of scientific interest to help the organization itself to learn by formulating a series of experimental solutions based on an evolving, untested theory.

To determine whether the method being considered could still be deemed to be action research or merely business consulting, following Baskerville (1999) its elements were compared to these differentiators.

Differentiator	Action Research	Consulting	Method
Motivation	Scientific prospects, perhaps epitomized in scientific publications	Commercial benefits, including profits and additional stocks of proprietary knowledge about solutions to organizational problems	Scientific prospects epitomized by this thesis
Commitment	To the research community for the production of scientific knowledge, as well as to the client	To the client alone	To the research community and to client through the development of the Approach
Approach	Collaboration is essential because of its idiographic assumptions	Values its "outsider's," unbiased viewpoint, providing an objective perspective on the organizational problems	Highly collaborative and participative development of the Approach. The 'outsider' perspective is limited to the researcher's methodological contribution
Foundation for recommendations	Theoretical framework	Solutions that, in the consultant's experience, proved successful in similar situations	Theoretical framework
Essence of the organizational understanding	Founded on practical success from iterative experimental changes in the organization	Through consultant's independent critical analysis of the problem situation	Founded on success of iterative changes and validation in other contexts

From this analysis, and given those differentiators, the method used for the development of the Approach still appears to qualify as action research.

[8] **Resource Efficiency, Flexibility and Entanglement**

The strategies for reducing entanglements related to phase and resources are effective based upon the assumption that the process remains stable in terms of its structure over the period of assessment of the management challenge. Of course, if the goals of the process change as a result of changes in the organisation environment, then the structure must change as well. However even in the case that the goals remain stable, the stability assumption is rarely met. This is because agility and resource efficiency tend to be conflicting goals in designing the processes.

Such design usually revolves around issues of efficiency and flexibility. With the aim of increasing the workflow efficiency of a process, organizations typically focus on reducing handoffs, increasing concurrency or increasing automated tasks within the process (Hammer & Stanton, 1999). On the other hand, organizations seeking to increase workflow flexibility focus on increasing the number of cross-trained workers and improved resource allocation mechanisms (Campbell G. M., 1999; Kumar, Aalst, & Verbeek, 2001/2002).

If a process is designed with resource efficiency in mind that will reflect in its design, in that it will attempt to support the process goals with the minimum of resources. Usually this means that activities are organised and sequenced around resource availability and this results in a specific process cycle. But then, as a result of entanglement, another process requires this process to synchronise to its cycle, this can no longer be achieved without making the process less resource efficient than before.

One could of course set as a design requirement the need for two or more concurrent operating cycles and define resource efficiency in terms of meeting that new requirement. That would make the process as resource efficient as before under the new definition. However this assumes that all synchronisation and resource needs can be identified at design time and would remain stable throughout the lifecycle of the process. This is rarely if ever true in practice, and process changes become necessary not only because of goal changes in this or other entangled processes, but also because of the need to respond to exceptions in all the entangled processes. This can result in both resource and phase changes and calls for agility, the ability to adapt to change. Processes cannot therefore be designed to be maximally efficient and agile at the same time, or dynamically synchronise phases and resources while remaining maximally efficient.

[9] **Managing phase and resource entanglements**

If two processes are entangled then at least one of the processes depends upon the other in some way.

In the case where process A provides information to process B, entanglement can create problems if the information provided refers to a different time period than the information requested. This can happen because: (a) processes A and B operate over different durations (interval mismatch); or (b) processes A and B refer to information covering different degrees of detail (granularity mismatch)

Four strategies are available for managing problems arising from such an entanglement: (1) if process A is not sufficiently granular then the granularity can be increased. This would of course result in higher cost of operation for process A which would need to be balanced against the benefits. If process A has a higher granularity that is usually not a problem as detail can be aggregated to provide information for process B; (2) if process A is interval mismatched with process B then the interval for process A can be shifted to correspond to process B. However, this would create problems if process A was entangled with a third process as well. Again there would be cost implications that would have to be balanced against the benefits; (3) a "translation algorithm" can be developed to transform information from process A to a form suitable for process B. However such transformation will result in an approximation of the true information requested. This may have implications in terms of the risk this poses to process B which would have to be balanced against the benefits; and (4) create a process C that is equivalent to process A but is aligned to the interval and granularity of process B. This is potentially the most expensive of the alternative strategies and may also create further entanglements between process A and process B if they are to share information or depend upon other processes.

In the case where processes share resources, the strategies available are: (1) increase the resources available to the process to the point that balances costs and benefits; and (2) order activities in a manner that reduces or eliminates resource conflicts to the point where the benefits balance the decrease in process performance or increase in risk for the process.

As noted in the literature review complexity arises out of interdependencies between agents, and each of these strategies manages complexity by reducing the interdependencies while trading off against increased cost or risk.

[10] **Information fragments and the shared knowledge context**

A shared knowledge context can be conceptualised as a set of information fragments and the relationship between those fragments. An information fragment consists of an identifier for the fragment and a set of data attributes associated with the fragment. One of the attributes must be a reference to the description of the semantics of the information fragment. This is analogous to the concept of "entity" in relational data bases (Codd, 1982). The semantic information is utilised to make sense of the data contained in the information fragment. Typically information fragments of the same "class" will share common semantics so it is sufficient for each information fragment to reference a "class" information fragment that defines its semantics. An information fragments is related to other information fragments through the concept of a "relationship". The key point here is that the relationship itself is an information fragment where two of its attributes reference other information fragments.

An example of such a knowledge context is the notion of an "employee". An "employee" is a "relationship" of class "employees" between an "individual" of class "individuals" and an "employer" of class "employer". A specific "individual" information fragment will, in addition to its identifier, contain attributes such as name, date of birth, gender etc. A specific "employer" information fragment will contain name, date of incorporation etc. It is only the "employee" information fragment that will contain attributes related to the actual employment, such as start date, designation, contract terms etc. Being a relationship, it will in addition have references to the two information fragments it relates, the specific "individual" and the specific "employer".

This strategy of organising data has long been advocated as "normalisation" in relational database theory as a means of managing insert, update and delete anomalies for transactions against large databases. The key difference is that in knowledge contexts, relationships are information fragments in their own right, as opposed to being mere references to other entities in relational databases.

This strategy can be extended to arbitrarily complex knowledge contexts. Also it does not require that all the data for each of the information fragments be copied each time the knowledge context is communicated. The semantic information associated with the fragment can be used to locate its data source whenever the data is needed in the process. This keeps the knowledge contexts itself lean.

Such a knowledge context is intuitively a network of stand-alone information fragments – the "resources" and the connecting information fragments – the "relationships" which are in fact just a special kind of "resource". This has the effect that all that it needs is a reference to the initial resource in the network, provided the process has access to a database of all information fragments. It can then walk the network, deducing all the information it needs in order to execute. Crucially, it is not constrained by the information provided to it by the preceding activity or process and can make use of resources contributed by other processes and activities as well. This helps reduce entanglement because providing processes can now operate asynchronously and modify resources while consuming processes can discover necessary resources at the time of execution. This increases dynamism because processes are free to change the structure of the network in terms of the resources and relationships. Finally this increases agility because processes may also change the semantics in terms of extending, specialising and modifying classes.

Again it should be intuitively obvious that the union of shared knowledge contexts across an ensemble of processes would consist of all the resources and relationships that all the processes in the ensemble need to operate leading to a common shared knowledge context. When the processes are allowed to modify the semantics of the resources and relationships, not just the data and the references, this leads to a common agile knowledge context. In effect processes in the ensemble become agents in a shared discourse based upon a common vocabulary, semantics and access to data.