Towards a management tool for technology platforms based on technology management capabilities

by

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Declaration

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Abstract

Technology platforms have proven to provide companies the agility required to mitigate market disruption and give them an edge on their competitors but require unique management strategies and considerations that differ from traditional linear businesses. The need for such technologies has also escalated during the Covid-19 pandemic which caught many businesses off guard who did not have a digitally aligned strategy. For new and existing platform owners to traverse the life cycle of technology platforms and ensure the success of their businesses they need to understand the intricacies of technology management. By adopting a technology management capability perspective, they can approach this challenge with a holistic understanding of technology management that includes the technology application processes.

This study aimed to develop a practical management tool for technology platforms and their surrounding ecosystems based on the technology management capabilities (TMC) perspective. To achieve this goal, the researcher developed ten objectives which were subsequently translated into a research design based on the six Design Science Research Methodology (DSRM) activities developed by Peffers et al. [1].

The first problem identification and motivation activity included the background and research methodology as mentioned. The second activity, define solution objectives, comprised the objectives necessary to build a competent knowledge base for the researcher to accurately define the solution objectives for the management tool. This included the researcher conducting a systematized literature review to determine the state of the problem and which aimed to gain knowledge about the relationship between TMC literature and the management of technology platforms. The conclusions drawn from the systematized literature review formed the building blocks for further research conducted as part of a conceptual literature review. The culmination of knowledge gained during the two reviews were utilized to define the design requirements used to develop the preliminary management tool during the third DSRM activity.

Semi-structured interviews were conducted to validate the concepts used throughout the preliminary management tool and to gain insight from various experts in the fields of technology platforms and technology management capabilities. Further quantitative data regarding the preliminary management tool's efficacy was also gathered by conducting an impact-effort analysis of the proposed technology management routines. Following the analysis of the data gathered during the evaluation process both structural and conceptual changes to the preliminary management tool were proposed. These included additional routines required for platform management, the definitions of the existing routines being updated, and the level of effort to implement each routine being reflected.

The evaluation process resulted in the preliminary management tool being updated to form the final management tool which was communicated as part of the last DSRM activity. The final management tool comprised two canvases which were used to present and define the forty-two practical technology management routines proposed as part of this study. The routines formed the final level in the hierarchal structure of technology- and supporting management capabilities. The study was concluded with the researcher listing the limitations faced and giving recommendations for future work.

Opsomming

Dit is al gevind dat tegnologieplatforms vir maatskappye die nodige behendigheid verskaf om markontwrigting te versag en om ‘n voorsprong op hul kompetisie te gee, maar benodig unieke bestuurstrategieë en oorwegings wat verskil van tradisionele lineêre besighede. Die nood vir sulke technologieë is ook versterk deur die Covid-19 pandemie wat vir talle besigheded onkant gevang het omdat hulle nie ‘n digitale gerigte strategie gehad het nie. Om vir nuwe en bestaande platformeienaars die lewensiklus van tegnologieplatforms te kan verstaan en die sukses van hul besighede te verseker, moet hulle die ingewikkeldhede van tegnologiebestuur verstaan. Deur 'n tegnologiebestuursvermoë perspektief toe te pas, kan hulle hierdie uitdaging aanpak met 'n holistiese begrip van tegnologiebestuur wat ook die toepassing daarvan insluit.

Die doel van hierdie studie was om 'n praktiese bestuurshulpmiddel vir tegnologieplatforms en hul omliggende ekosisteme te ontwikkel wat gebaseer is op tegnologiebestuursvermoëns. Om hierdie doel te bereik, het die navorser tien doelwitte ontwikkel wat later in 'n navorsingsontwerp omskep is. Die navorsingsontwerp was gebaseer op die’ Design Science Research Methodology’ (DSRM) se ses aktiwiteite wat ontwikkel is deur Peffers et al. [15].

Die eerste probleemidentifisering en motiverings-aktiwiteit het die agtergrond en navorsingsmetodologie soos genoem, ingesluit. Die tweede aktiwiteit, definieer oplossingsdoelwitte, bestaan uit die doelwitte wat nodig is om 'n bekwame kennisbasis te bou vir die navorser om die ontwerpsvereistes vir die bestuurshulpmiddel akkuraat te kan definieer. Dit het ingesluit dat die navorser 'n gesistematiseerde literatuurstudie gedoen het om die status van die probleem te bepaal en wat daarop gemik was om kennis op te doen oor die verhouding tussen tegnologiebestuursvermoë -literatuur en die bestuur van tegnologieplatforms. Die gesistematiseerde literatuurstudie se gevolgtrekkings het die boustene gevorm vir verdere navorsing wat gerig was as ‘n konseptuele literatuurstudie. Die versameling van kennis wat tydens die twee literatuurstudies opgedoen is, is gebruik om die ontwerpvereistes te definieer wat gebruik was om die voorlopige bestuurshulpmiddel te ontwikkel.

Semi-gestruktureerde onderhoude was gevoer om die konsepte wat vir die voorlopige bestuurshulpmiddel gebruik was te bekragtig, en om insig van verskillende kundiges te kry oor die gebied van tegnologieplatforms en tegnologiebestuursvermoëns. Verdere kwantitatiewe data oor die doeltreffendheid van die voorlopige bestuurshulpmiddel was ook versamel deur 'n impak-inspanning-analise van die voorgestelde tegnologiebestuursroetines uit te voer. Die ontleding van die versamelde data het gelei tot voorgestelde strukturele en konseptuele veranderinge tot die voorlopige bestuurshulpmiddel. Die voorgestelde veranderinge het addisionele roetines wat nodig is vir platformbestuur ingesluit, die definisies van die oorspornklike roetines verander, en die inspanningsvlak om elke roetine te implementeer geweerspieël.

Die evalueringsproses het daartoe gelei dat die voorlopige bestuurshulpmiddel opgedateer word om die finale bestuurshulpmiddel te vorm. Die finale bestuurshulpmiddel bestaan uit twee ‘Canvas’-komponente wat gebruik was om die twee en veertig praktiese tegnologiebestuursroetines voor te stel en te definieer. Die roetines vorm die finale vlak in die hiërargiese struktuur van tegnologie- en ondersteunende bestuursvermoëns. Die studie was afgesluit deur die navorser wat 'n lys van die studiebeperkings te lys en aanbevelings te gee vir toekomstige werk.

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Glossary

Acronyms and Abbreviations

API	Application Programming Interface
CMM	Capability Maturity Model
DITC	Dynamic Information Technology Framework
DS	Design Science
DSR	Design Science Research
DSRM	Design Science Research Methodology
FMT	Frameworks, Models and Tools
GDPR	General Data Protection Regulation
HT	High-Technology
IP	Intellectual Property
IT	Information Technology
KM	Knowledge Management
KNIT	Knowledge, Innovation and Technology
KPI	Key performance Indicator
LMT	Low-Medium Technology
MoT	Management of Technology
MS	Microsoft
NPD	New Product Development
R&D	Research and Development
RBV	Resource Based View

SECO	Software Ecosystem
SECO-SAM	Software Ecosystem Strategy Assessment Model
SMC	Supporting Management Capabilities
SMEs	Small to Medium-sized Enterprises
SPO	Software-Producing Organisation
TC	Technological Capabilities
TM	Technology Management
TMC	Technology Management Capabilities

Chapter 1

Introduction

Chapter 1 key objectives:

- Present the background to the study,
- Define the research problem,
- State research questions and objectives,
- Outline research design and methodology,
- Present the research contributions,
- Provide the research document structure.

Chapter 1 focuses on the purpose of the research conducted for this report. A brief background to technological platforms, their management tools, and how technology management capabilities can be utilized for platform management, form the base to understanding the research problem. This insight provides the background against which the research questions are posed, and the objectives are set. It is then followed up with the research design, outlining the path to achieving these objectives. Figure 1.1 below illustrates the structure of the chapter.

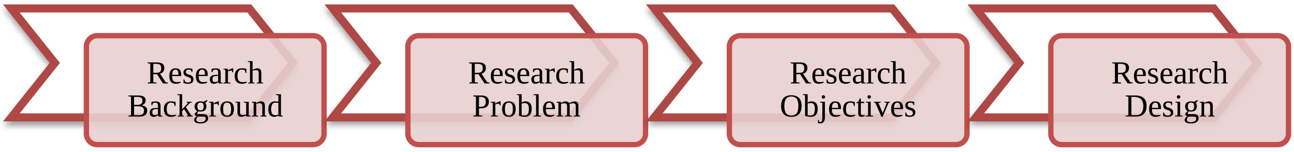


Figure 1.1: Chapter 1 Content Description

1.1. Background

With the rise of the Covid-19 pandemic that devasted a multitude of industries the need for companies to have a digitally aligned strategy became more apparent [2]. The pandemic confronted business leaders with the reality of being digitally agile as most had to fast-track their digital strategies [2].

Technology platforms have been identified to provide companies the agility required to mitigate market disruption and get an edge on their competitors [3] as they provide a space to digitally connect people and resources and create an interactive ecosystem though which value can be generated and distributed [3]. These platforms have the ability to scale rapidly and efficiently, and create new capabilities for companies to capture, analyze and exchange large quantities of data [4]. As examples of companies who have implemented technology platforms for years, Google, Amazon and Microsoft have benefited greatly by implementing these strategies into their business and organizational models and have become leaders in their respective industries [5].

This said, although technology platforms have been identified to give companies that competitive edge, sound management procedures and techniques are essential for effective and continuous growth of the company.

Platform owners require established strategies to utilize their positions in the local market to attract new stakeholders by offering them a cheaper and faster method to enter new ecosystems where they can establish and expand their businesses.

New platform owners can benefit greatly from having a well-considered platform strategy or having a management tool that can guide them to establish and expand their capabilities. This can allow them to attract and incorporate local and international knowledge that can cultivate innovation within their companies. Effective technology platforms give companies in many business areas the ability to provide efficient demand and-supply matchmaking to stakeholders [6].

1.2. Technology Platforms and Ecosystems

Platforms, in a business context, is defined as an infrastructure that is open and encourages participation between producers and consumers to facilitate value-creating interactions that are regulated by pre-determined governance conditions [5]. The main assets of a platform are information and interactions, which when combined, form a source of value and give competitive advantage [4]. The infrastructure takes form of a centralized platform with an interactive ecosystem that has formed around it [3].

Autio and Thomas defined a platform ecosystem as *"a network of interconnected organisations, organised around a focal firm or a platform and incorporating both production and use side participants"* [5].

After further research, they refined this definition by placing emphasis on value creation through innovation [7]. Companies that implement platforms have the ability the retain their competitiveness, but only if they extend their vision to include the entire ecosystem, ensuring future growth [3]. Figure 1.2 illustrates the typical participants in a platform ecosystem.

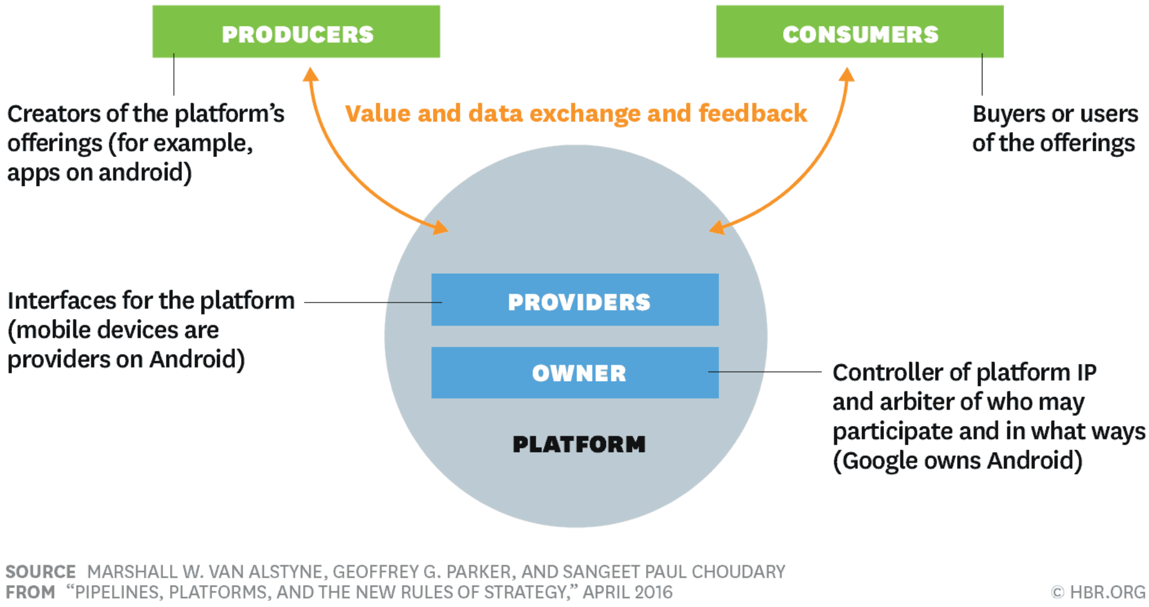


Figure 1.2: Technology Platform Ecosystem (Copied from [4]**)**

The platform owner acts as both the designer and manager of the technology platform, determining the governance conditions mentioned before that the developers and users must adhere to [5]. These conditions ensure the success and growth not only for the platform, but also for the ecosystem [5]. The provided central platform is typically not very variable but offers high reusability for developers (providers) who create a large variety of applications on the platform that result in new innovations [8].

1.3. Management of Technology Platforms

Platforms require unique management strategies due to their variation from traditional linear businesses strategies of upstream value creation and downstream value consumption [5]. There are three key differences between a linear business strategy and a platform business strategy, namely:

- Resource control vs. Resource orchestration,
- Internal optimization vs. External interaction, and
- Focus on customer value vs. Focus on ecosystem value [4].

For linear business strategies the company's competitive advantage comes from the control that they have over scarce and valuable resources, while for platforms the chief assets consist of the network created by the community and the resources its members own and contribute [4]. Instead of optimizing production chains to increase the company's competitive advantage, it is more important for platform owners to effectively govern their ecosystem by facilitating interactions between external producers and consumers [4]. Finally, the business owner must shift their focus from the end of the linear process and how to maximize the lifetime of individual customers of services and products, to expanding the ecosystem in a circular, iterative, feedback-driven process [4].

The platform owner must conduct a balancing act where they exert adequate control over the platform, but not in such a way that it hinders innovation amongst the developers [9]. This equilibrium can be achieved by adequately defining the platform openness in terms of the technology and interfaces [9], implementing proportional control mechanisms [9], providing overall support to the entire ecosystem, keeping awareness of the ecosystem entry and exit barriers and fairly creating and distributing value between the participants [8]. The varying management strategies between linear businesses and platform businesses and the additional management considerations all contribute to the challenges platform owners face. Further management considerations and challenges are discussed in-depth in Section 4.4 of this study.

One of the main shortcomings that lead to the downfall of prospective platform companies is the inability to grow critical mass [6]. It is important in the initial phases for a platform owner to focus on their platform's surrounding ecosystem to grow critical mass, while keeping value creation in mind [6]. This method ensures that the platform gains user momentum. To do so the platform owner needs to be aware of their platform's scaling capabilities and should also implement systems and regulations to keep users on their platform.

Alibaba's Taobao platform, for example, initially gave users the opportunity to enlist for free and concentrated on keeping them enlisted by offering a personalized user experience, widening the platform's horizontal services and keeping users protected by addressing security and counterfeit issues [6]. The platform firm thus requires capital at the initiation phase to be able to provide these free services.

1.4. Research Problem

As stated earlier, the use of technology platforms to cultivate an ecosystem where technology, information and resources are distributed between multiple stakeholders working together has proven to give companies the agility required to mitigate market disruption caused by everyday business and extreme scenarios such as the Covid-19 pandemic. Additionally, by adopting technology platforms new entrepreneurs can get a foothold into the global market where established platform ecosystems can help cultivate an open innovation culture between companies. The implementation of technology platforms thus creates a snowball effect where the knowledge and technology shared within current platforms and ecosystems can pave the way for future technology platforms.

But, to support new platform owners in their endeavors they need to understand the unique management strategies and considerations required to create and evolve a technology platform and surrounding ecosystem. This can be aided by the use of a management tool. The management of technology should be addressed in such a way that it captures the dynamic nature of technological advancement and the managerial aspects needed to guide this advancement.

Technology Management (TM) as a research field has been around since the 1970s, but has mostly gained popularity in last three decades [10]. It has become common to be approached from a capabilities perspective, and has been defined as the process of managing the development and implementation of technological capabilities to achieve the strategic objectives of a company [11]. Here technological capabilities refer a company's knowledgebase that is embedded within its employees, equipment and organization [12]. This holistic understanding of TM brings into account both the 'hard' aspects of technology, such as science and technology, and 'soft' dimensions that include the technology application processes [13].

More recently, Cetindamar et al. [13] have explored the idea of addressing technology management through the lens of dynamic capabilities theory. They define dynamic capabilities theory as a form of resource management that is not primarily concerned with fixed assets [13]. By adopting this perspective, TM itself can be addressed as a capability that explains how a firm allocates its resources for innovation over time to expand its technological platform, how it generates and implements existing resources throughout the surrounding ecosystem, and where it obtains new resources.

Thus, a platform management tool based on technology management capabilities can help guide new platform owners through the stages of a platform life cycle, troubleshoot novel problems that arise within the platform ecosystem and cultivate an open innovation culture

1.5. Research Questions and Objectives

1.5.1. Research Questions

The research question that this study will aim to answer is: *What constitutes a management tool that utilizes technology management capabilities to aid platform owners to help administer their platforms?*

To address the research problem, further sub-questions were formulated:

- What existing technology platform management tools are there?
- What are the key characteristics that these management tools share?

- How can TM research and dynamic capabilities theory be implemented to create a new platform management tool?

Research questions for the **literature review** include:

- What is the relationship between technology platforms, their surrounding ecosystems and the actors that populate these ecosystems?
- What existing technology management tools and frameworks are there that are based on dynamic capabilities theory?
- What are the benefits of addressing technology management as dynamic capabilities?
- Which dynamic capabilities are critical for technology management?
- To what extent has TM research been implemented in the management of technology platforms?

Research questions for the **management tool development** include:

- How can the tool reflect the dynamic nature of managing technology platforms and platform ecosystems?

Finally, the research questions regarding the **evaluation of the management tool** include:

- How can the usefulness of the management tool be measured in practice?
- Which methods of evaluation (interviews, case study, theoretical case studies, etc.) would best guide the researcher to improve the tool?
- Which type of professionals will have meaningful inputs to the development and evaluation process of the management tool?
- Which capabilities might have a higher impact on platform management and business performance than others?
- Which capabilities might be more difficult to implement than others?

1.5.2. Research Objectives

For this study, a two-phase strategy was adopted into which the objectives were divided. Phase one focused on the theoretical components and phase two focused on the practical components.

Phase 1: The first phase was divided into three components. Firstly, a systematized literature review was conducted to identify if there are gaps in the exiting literature between technology management capabilities and management of technology platforms, and to gain an understanding of technology management capabilities and their key concepts. Secondly, a conceptual literature review was conducted to gain a more in-depth understanding of the different characteristics of technology platforms, how they are managed, existing management tools for technology platforms and their surrounding ecosystems, and the key concepts identified throughout the systematized literature review. Finally, the existing literature gathered during the two literature reviews was translated into design requirements for the management tool. The main outcomes of phase one were a systematized literature review, conceptual literature review and the design requirements for the preliminary management tool.

Phase 2: The second phase was divided into two main actions. The first action concerned the development of the management tool. The second action encapsulated the entire evaluation process used to determine the validity, usefulness, and practicality of the management tool. The first method of evaluation included validating the preliminary management tool based on the design requirements formed from the literature reviews. Following the validation, semi-structured interviews with professionals in the fields of technology management and management of technology platforms were conducted to determine the validity of the design requirements and the concepts used within the management tool and its usefulness.

Specific research objectives (ROs) addressed by phase one and two:

Phase 1 – Identify key concepts of technology management and the research gaps between technology management and the management of technology platforms, and translate existing literature into design requirements for a management tool based on dynamic capabilities theory:

- RO1: Identify the key concepts of technology management capabilities and dynamic management capabilities by conducting a systemized literature review.
- RO2: Establish the literature gap between technology management capabilities and management of technology platforms and platform ecosystems.
- RO3: Elaborate further on the key concepts identified during the systematized literature review through conducting a conceptual literature review.
- RO4: Establish the contexts and requirements of management tools for technology platforms through conducting a conceptual literature review.
- RO5: Translate the existing literature gathered during the systematized and conceptual literature reviews into design requirements for a management tool.

Phase 2 – Develop a management tool for technology platforms based on technology management capabilities theory and evaluate the validity, usefulness, and practicality of the management tool through semi-structures interviews:

- RO6: Develop a preliminary management tool for technology platforms based on the existing literature gathered during the systematized and conceptual reviews.
- RO7: Validate the preliminary management tool with the design requirements defined during Phase 1.
- RO8: Evaluate the validity of the design requirements and concepts used within the management tool through semi-structured interviews.
- RO9: Update the preliminary management tool based on the feedback from the semi-structured interviews.
- RO10: Present final management tool for technology platforms based on technology management capabilities.

1.6. Research Design Overview

Peffers et al.'s [1] design science research methodology (DSRM) was followed to develop the management tool in this study. The DSRM comprises of six activities: (1) problem identification and motivation, (2) define solution objectives, (3) design and development, (4) demonstration, (5) evaluation, and (6) communication. Objectives were determined for each activity based on their definitions to guide the researcher in satisfying this study's research objectives. Figure 1.3 below shows the six activities with their objectives and the corresponding research objectives.

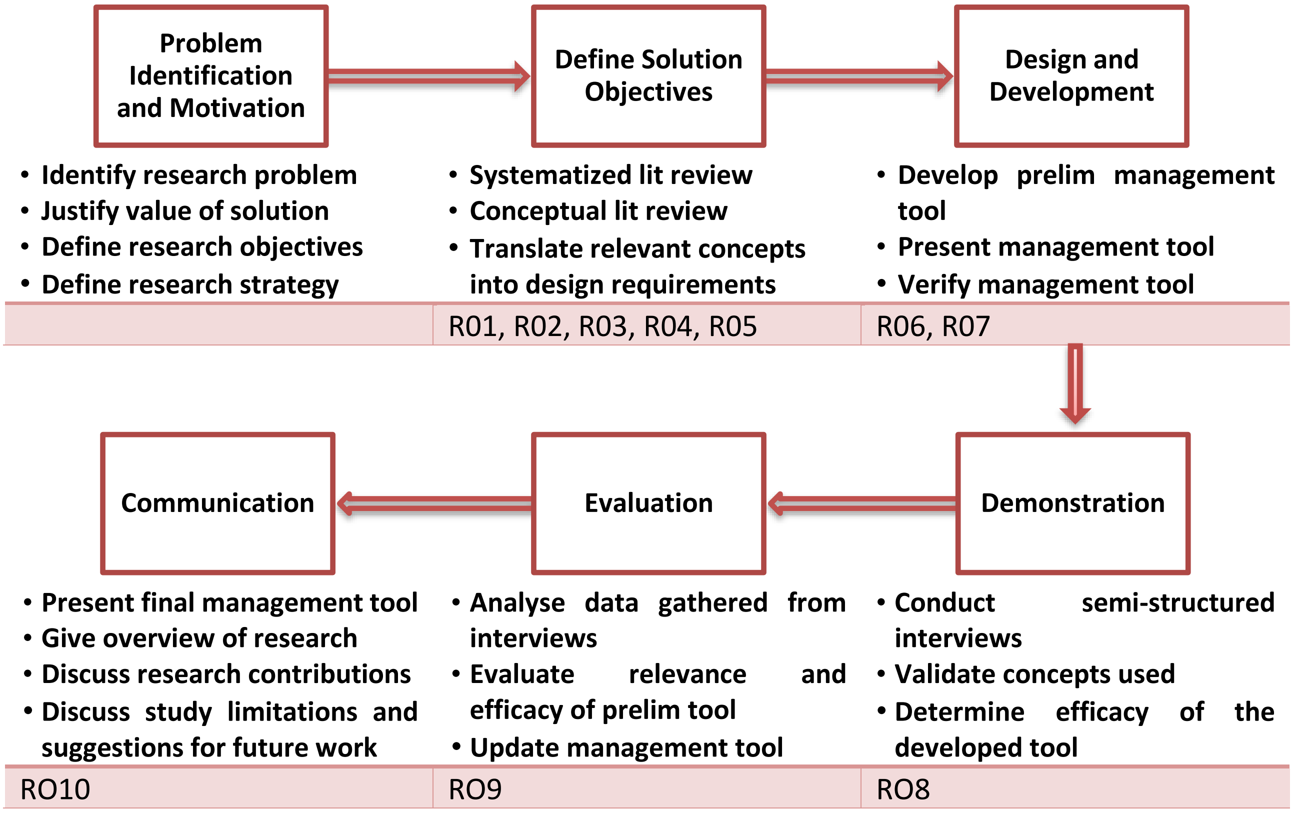


Figure 1.3: Research Design Overview

1.7. Research Contributions

The new management tool is not industry specific so can offer business owners that implement technology platforms in any venture a guide to develop and manage their company. The research conducted during this study will also contribute towards technology platform-, technology management- and dynamic capabilities literature and help address the lack of TMC literature in developing countries. The total contributions are discussed in Section 9.3 of this study.

1.8. Ethical Considerations

During the evaluation process of the management tool ethical clearance from the Departmental Ethics Screening Committee (DESC) of the University of Stellenbosch was required. The semi-structured interviews conducted during the evaluation process involved gathering expert opinions. The researcher was aware of all physical or psychological risks or discomforts that could have been experienced by the participants during the interviews and implemented safeguards to completely mitigate these risks while creating an atmosphere that is safe and conducive to learning. The ethical clearance for this study was granted by the DESC under SU project number 21857 and the researcher took note of the following during the semi-structured interviews and case study:

1. The participation in the interviews were completely voluntary and any participant was free to withdraw at any time.
2. The researcher was responsible for obtaining electronic consent from participants before data collection.
3. The participants were not forced to answer any questions if they did not feel comfortable with the question.
4. All information gathered during the interviews remained confidential and stored securely.
5. No personal information of any participant was disclosed throughout the study.

1.9. Research Document Outline

Throughout this study research context diagrams (shown in Figure 1.4 below) will be presented at the beginning of each chapter. The purpose of these diagrams is to give context of that specific chapter with relation to the design science research methodology and the activity objectives the chapter addresses. The DSRM is discussed in detail in Chapter 2.

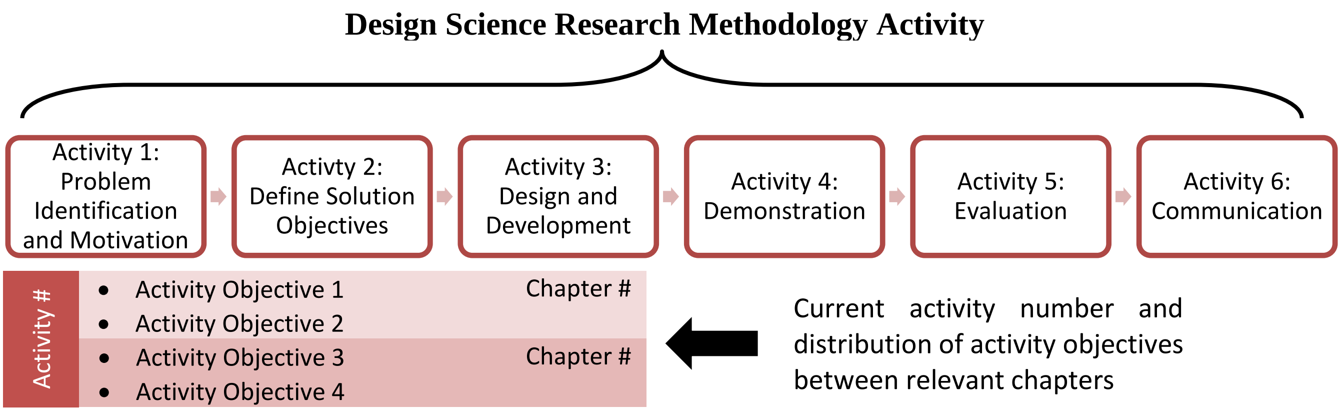


Figure 1.4: Research Context Diagram Example

At the end of each relevant chapter items from a design science research progression checklist proposed by Hevner and Chatterjee [14] are listed that were addressed during the chapter. The full progression checklist is given in Section 2.4.1.

This document consists out of nine chapters. A summary of each follow:

Chapter 1: Introduction

The introductory chapter presents the context of the study. Background information for the problem motivation is given that includes an overview of the main concepts of technology platforms, their management, and how technology management capabilities can be utilized for platform management, which forms the base of the research problem. This leads to defining the research questions and objectives. The research contributions and ethical considerations of this study are also discussed and the chapter concludes by giving an overview of the research document.

Chapter 2: Research Design and Methodology

Chapter 2 focuses on the research design of this study. The researcher delves into the background of research and discusses the three main research approaches: qualitative, quantitative, and mixed research. From there, design science research is broken down into its core concepts and discussed in depth. This leads to the introduction of design science research methodology which is implemented throughout this study. Finally, interviews as an evaluation method are explored and the chapter concludes with the research design followed for the remainder of the study.

Chapter 3: Systematized Literature Review

Chapter 3 presents the systematized literature review conducted with the aim of establishing the literature gap between technology management capabilities and management of technology platforms and platform ecosystems and identifying the key concepts surrounding TM capabilities.

Chapter 4: Conceptual Literature Review

The fourth chapter includes the conceptual literature review. The review starts with giving in-depth background information regarding technology platforms and platform ecosystems and how they will be represented throughout this study. Subsequently, different ecosystem actors' governance methods, how platform businesses deviate from linear business models, and various existing management tools are examined. This is followed by an analysis of each of the technology management capabilities key concepts identified during the systematized literature review.

Chapter 5: Design Requirements for a Framework for Technology Platforms that Implements TMC

Chapter 5 concludes the process of defining the solution objectives. During this chapter, the key features of conceptual frameworks are identified, and the knowledge base built over the third and fourth chapters is utilized to translate the critical concepts required for TM capabilities and management of technology platforms into design requirements for a management tool.

Chapter 6: Towards a Management Tool for Technology Platforms based on TMC

Chapter 6 methodically presents the rational used by the researcher during the management tool's development process, followed by the preliminary management tool being introduced. The chapter concludes with the researcher finalising the initial development process cycle by verifying that all the original design requirements were adhered to.

Chapter 7: Demonstration and Evaluation: Semi-Structured Interviews

For the demonstration DSRM activity semi-structured interviews with platform owners, developers and industry experts were conducted. During these interviews, the concepts implemented throughout the management tool were validated and the tool's efficacy analyzed. The evaluation DSRM activity included the researcher transcribing the interviews to code and analyze the collected data. The analysis process followed is then discussed, and the insights gained from the interviews scrutinized. Following the evaluation process, the management tool was adapted. The update process also included implementing the recommendations received from the platform owners, developers, and industry experts.

Chapter 8: Presentation of Final Management Tool

Chapter 8 commences with an overview of the objectives and purpose of the tool. The final management tool for technology platforms based on technology management capabilities is then presented.

Chapter 9: Conclusions and Future Work

The final chapter starts with a concise summary of the research design followed in this study. The research objectives are then discussed and how they were achieved. The research contributions by this study are then listed and the limitations specified. The study concludes with the researcher giving recommendations for future work.

1.10. Chapter 1 Summary

During the first chapter background information is given regarding technology platforms, platform ecosystems and the management thereof. This background information is translated into a research problem that justifies the need for a management tool based on technology management capabilities. Subsequently, research questions and objectives are developed to solve the research problem. An overview of the research design is given, and the research contributions and ethical considerations created by this study are discussed. Finally, summaries of each the document's chapters are presented.

The design science research progression checklist items defined by Hevner and Chatterjee [14] as set out in Section 2.5, Table 2.4 that were addressed during Chapter 1 are listed below.

Table 1.1: Design Science Research Progression Checklist [14] **– Item 1**

NUM	QUESTION	RESPONSE
1	- What is the research question (design requirements)?	- The main research question is: What constitutes a management tool that utilizes technology management capabilities to aid platform owners to administer their platforms? This question is broken down into sub-questions regarding platform management tools, and the literature reviews and evaluation methods required.

Chapter 2

Research Design and Methodology

Chapter 2 key objectives:

- Give brief background on research,
- Detail quantitative, qualitative and mix methods,
- Introduce Design Science Research,
- Describe the Design Science Research Methodology process,
- Detail the evaluation process,
- Present final research design.

Chapter 2 reviews the different research approaches considered for this project's research design. These research methodologies and processes are translated into a formal research design in Section 2.7 to achieve the project objectives. The research for this project is qualitative in nature and follows the Design Science Research Methodology (DSRM) to develop the management tool. As part of the DSRM process a progressive evaluation process is used to develop the final management tool. The context of Chapter 2 relating to the DSRM process, and within this document, is shown in Figure 2.1 below.

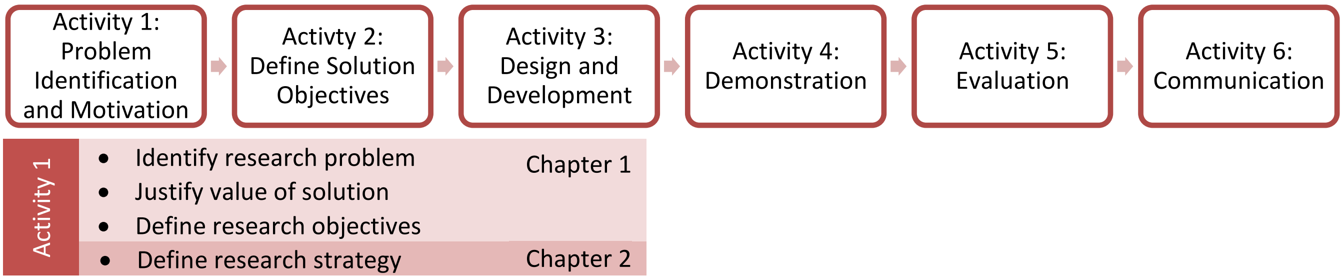


Figure 2.1: Research Context Diagram - Chapter 2

2.1. Background to Research

Throughout a research project the researcher is faced with deciding which methods, methodologies and perspectives they will implement. To understand the research paradigm it is important to understand the difference between these concepts and their interrelationships [15]. One method, as described by James [15], is to adopt the metaphor of an iceberg to conceptualise the nature of research.

Figure 2.2 on the following page illustrates how this metaphor relates to the research paradigm.

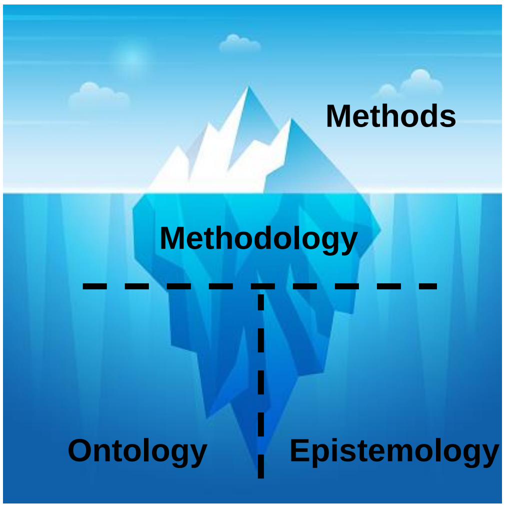


Figure 2.2: Iceberg Metaphor for Research (Adapted from [15]**)**

The metaphor distinguishes between the "well-known" research aspects and the interlocked facets that are below the surface. In research the most well defined characteristics are the methods used [15] and is denoted by the section above the water. Research methods include both the data collection methods such as questionnaires, interviews and participant observation, experimental arrangements and photo elicitation; and analytical techniques to interpret the data such as discourse analysis and coding [15].

The first section beneath the surface of the water is represented by research methodologies. The methodology of a research a project is the approach that the researcher has chosen to implement [15]. The research approaches or designs that can be implemented are quantitative, qualitative and mixed methods [15]. Further methodological resolutions include case studies, ethnography and experimentation [15]. The deepest, and biggest, part of the iceberg is divided between ontology and epistemology. Epistemology refers to the chosen view of what is acceptable regarding the origin, nature and limits of knowledge [15],[16], [17]. Ontology refers to the study of existence in general, or what is seen as reality and of what applies naturally to it [15],[16],[18]. The combination of the ontological and epistemological orientations can be seen as the researcher's perspective of knowledge [19]. Derived from this perspective is the research approach (methodology) adopted by the researcher [19]. The research paradigm can be seen as a sequence of choices made by the researcher, as illustrated in Figure 2.3 below.

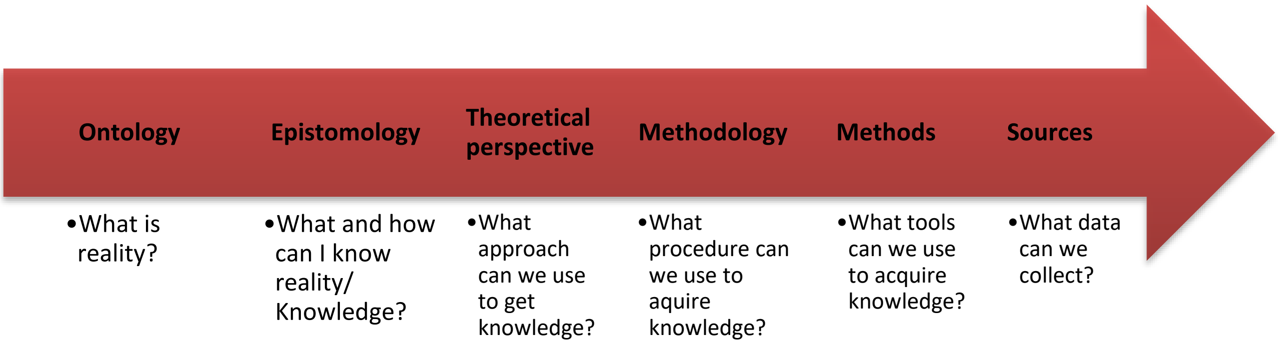


Figure 2.3: The Relationship between Research Concepts (Adapted from [19]**)**

2.2. Quantitative, Qualitative and Mixed Methods

The three main research approaches are qualitative, quantitative and a mixed methods where each have a different relationship between theory and research [16]. Qualitative research follows an inductive approach, which rejects the natural scientific models and follows methods for individuals to interpret their social surroundings resulting in theories being developed as the outcomes [16]. Theories are based on data gathered through interviews and focus groups [16]. Quantitative research follows a deductive approach, placing emphasis on testing and revising theories that guide the research by implementing the practices of natural science and positivism [16]. Table 2.1 below lists the fundamental differences between quantitative and qualitative research approaches.

Table 2.1: Differences between Quantitative and Qualitative Research Approaches

AREAS	QUANTITATIVE	QUALITATIVE
Principal orientation to the role of theory in relation to research	Deductive, empirical testing of theory	Inductive, generation of theory from data
Epistemological orientation	Natural science model, in particular positivism	Interpretivist
Ontological orientation	Objectivism	Constructionist

Qualitative research is an ongoing process where concepts are continuously developed and refined [16],[20]. This process involves writing and transcribing through text, and collecting and analysing non-numerical data [20]. The non-numerical data is collected by analysing individuals or groups, how they interact, and communicate, with the goal of providing explanations for their behaviour [16],[20],[21].

The epistemological orientation of quantitative researchers orientates them to focus on causality, measurement, generalisation and replication [16],[21]. Each of these concepts shape the researcher's view on knowledge. Causality refers to taking into consideration both the cause and effect of a result, measurement refers to the ability to reliably measure concepts, generalisation refers to the ability to generalise the findings beyond the research context, and replication refers to implementing well defined methods that can be replicated by other researchers resulting in the same conclusions [16].

These two researcher approaches vary in purpose, approach, data collection and independence of the researcher [16],[20],[21]. Herman [22] tabulated these differences as illustrated in Table 2.2.

Table 2.2: Qualitative and Quantitative Research Approach Differences [14],[16],[20],[21]

COMPONENT	QUALITATIVE	QUANTITATIVE
Purpose	Discover ideas, In-depth understanding of phenomenon	Test hypothesis or specific research questions
Approach	Observe and Interpret	Measure and Test
Data Collection	Unstructured – Rich, thick and deep data	Structured – Hard, reliable data
Researcher Independence	Researcher intimately involved	Researcher uninvolved, objective results

COMPONENT	QUALITATIVE	QUANTITATIVE
Most often used in	Exploratory research designs	Descriptive and casual research designs
General Approach	Words and Description	Numbers and Measurement

A mixed methods approach utilizes both quantitative and qualitative data and distinct design methods that can involve theoretical frameworks and philosophical assumptions [16],[20]. The main justification for using a mixed methods approach is that the researcher can create a more complete understanding of the research problem by integrating the two different approaches [20].

Cetindamar and Unsal [23] recommend using a qualitative approach for technology management research. They reason that finding comparable and reliable financial data for small and mid-size companies is difficult and that technology management activities contribute qualitatively to a company [23].

For the research project to this report a qualitative approach was adopted as per recommendation. There are four important considerations needed to be taken when following a qualitative research approach. They include choosing an appropriate research design and data collection method, deciding how to analyse and interpret the collected data, and defining the evaluation criteria for the qualitative research [16].

Table 2.3: Qualitative Research Considerations [16], [20], [22]

Research Design Options	Data Collection Methods	Data analysis and interpretation	Evaluation Criteria
Ethnography	Direct observation	Coding	Validity
Phenomenology	Participant observation	Statistics	Trustworthiness
Grounded Theory	Qualitative interviews	Narrative Analysis	Credibility
Case study	Surveys	Content Analysis	Reliability
Narrative research	Focus Groups		
	Case Studies		

2.3. Design Science Research

Design Science Research (DSR) is driven by the desire to better the environment by introducing new and innovative artifacts and the processes of building them [24]. Due to this drive, DSR is an adequate methodology to implement to achieve the final objective of this study which is practical management tool. To understand DSR it is critical to first look at Design and Design as a science.

Hevner and Chatterjee [14] define design as "*the instructions based on knowledge that turns things into value that people use*". When using this definition it is important to distinguish that design is not the '*thing'*, but rather design embodies the instructions for making the '*thing'* [14]. The resultant '*thing'* is commonly referred to as an artifact. An artifact is seen as something that is artificial, or constructed by humans, rather than something that occurs naturally [24].

To define what comprises science is a daunting task, but to determine if design is a science can be achieved by examining the elements of how science is structured. Science can be seen as having two end points on a scale, namely basic fundamental research and applied research [14],[25]. While science falls within this spectrum, it is not stagnant, it develops through various stages over time [14]. Figure 2.4 illustrates the Stokes Matrix that is commonly used to analyse the development of science.

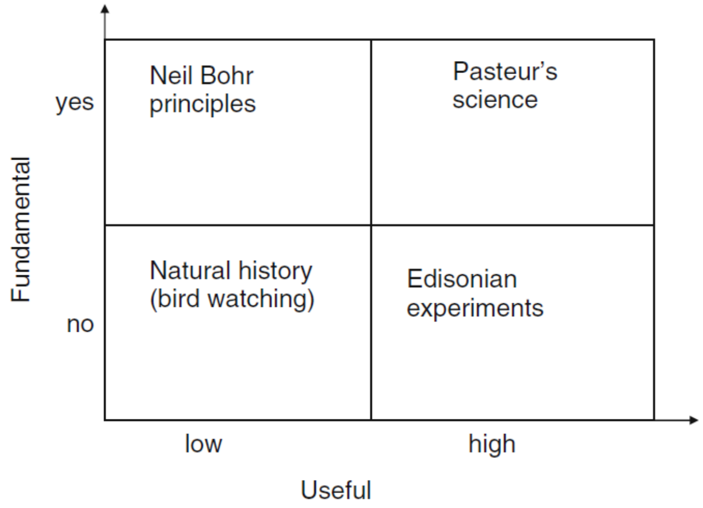


Figure 2.4: The Stokes Matrix (Copied from [24]**)**

The two axes represent how fundamental the knowledge is (vertical axis) and how useful the knowledge is to solve problems (horizontal axis). Most sciences start in the "natural history" quadrant where scientists observe a phenomenon and capture their observation (much like bird watching) [14]. Sciences enter the "Edisonian experiments" quadrant as knowledge is gathered through useful experiments [14]. Currently the understanding of design can be placed in the "Neil Bohr" quadrant, as a lot of tacit and codified knowledge of design, design processes and product outputs has been captured [14]. Although there is a lot of fundamental knowledge that designers can put to use, it cannot yet be seen as being useful to solve everyday problems [14]. Finally, within the "Pasteur's science" quadrant is where the science of design will emerge.

By taking the above notions into consideration Hevner and Chatterjee [14] define design science research as follows:

"*Design science research is a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence. The designed artifacts are both useful and fundamental in understanding that problem.*"

They continue by adding the fundamental principle of DSR is that during the building and application of an artifact, knowledge and understanding of the design problem and its solution are acquired [14]. The end goal of this problem-solving paradigm is to produce an artifact that must be evaluated to show that it both solves the problem and provides utility to the user in an efficient manner [14].

2.3.1. Design Science Research vs. Routine Design Practice

A common misunderstanding is where design science research (DSR) is confused with routine design practice [14]. The key difference between the two processes is if knowledge is created as a result of the design [14]. Routine design practice is merely the application of best (existing) practices, while with DSR new knowledge is created through the combination of existing components to create a new artifact [14].

2.3.2. Design Science Research Cycles

Hevner [26] identifies three design science research cycles that is applicable to every design research project. For a project to be defined as following design science research these three cycles must be present and clearly identifiable.

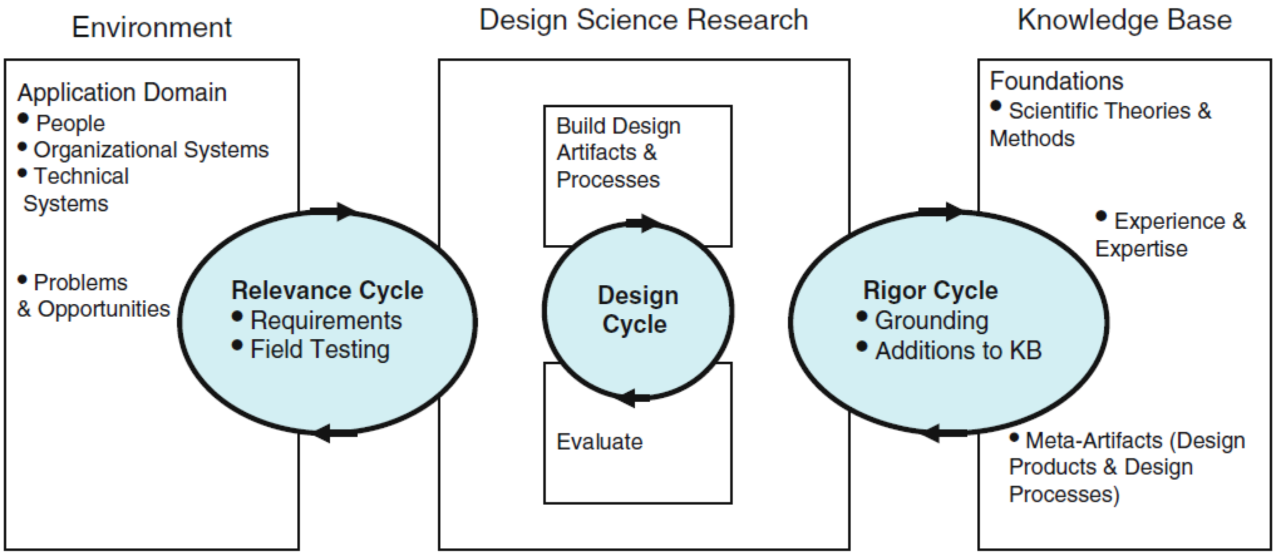


Figure 2.5: Design Science Research Cycles (Copied from [26]**)**

2.3.2.1. Relevance Cycle

The "Relevance Cycle" forms the bridge between the design science activities and the contextual environment of the research project [14], [26]. Usually, the first step in DSR is to identify and present opportunities and problems that occur in the application environment [14], [26]. The application domain consists of organizational systems, technical systems, and the people operating them in order to satisfy a certain goal [14], [26]. This first step provides the requirements for the research (e.g., the opportunity/ problem to be addressed) and defines the evaluation criteria for the research results [14], [26]. These requirements are then fed into the DSR domain. The other half of the cycle returns the outputs from the DSR domain back into the application domain through field testing for evaluation [14], [26]. As the cycle indicates, this process is iterative and will recommence with feedback from the environment as better aligned research requirements discovered from actual experience [14].

2.3.2.2. Rigor Cycle

The "Rigor Cycle" acts as the connection between the knowledge base (scientific foundations, experience, and expertise) that informs the research project and the design science activities [14]. DSR is grounded on existing ideas and the rigor cycle ensures that the constructed article is innovative by providing access for the research project to past knowledge [14].

Livari [27] lists different sources from which inspiration for creative design activity can be drawn, including existing artifacts, problems/opportunities from the application environment, theories and analogies/metaphors.

Successful DSR feeds knowledge created as a result of the research activities back into the knowledge base, which forms the other half of the rigor cycle [14]. Additions to the knowledge base include the newly created artifact and its design process, extensions/additions to the existing theories and methods, the experience gained from performing the iterative design activities, and the experience gained from field testing the resulting artifact in the application environment [14].

2.3.2.3. Design Cycle

The final "Design Cycle" is located at the centre of the DSR and iterates between the building- and evaluation activities of the design artifact and processes [14]. Balance must be maintained during the design process between constructing and evaluating the evolving design artifact, where both activities must be compellingly based on relevance and rigor [14].

2.4. Design Science Research Methodology

The design science research methodology (DSRM), developed by Peffers et al. [1], is a commonly accepted framework and methodology used to carry out the production and presentation of design science (DS) research [14],[1]. It provides researchers a mental model of how to conduct design science research successfully [14],[1]. The mental model helps the researcher to recognize and validate the DS research objectives, processes, outputs and finally present their work with reference to a commonly understood framework [14]. The design science research model proposed by Peffers et al. [1] consists of six activities: Problem identification and motivation, define the objectives for a solution, design and development, demonstration, evaluation and communication [1], [14]. An explanation of each activity follows.

Activity 1: Problem Identification and Motivation

The first activity includes two objectives, namely defining the research problem and justifying the value of a solution [14],[1]. In order to define the research problem, it can be atomized conceptually to capture the complexity of the problem [14],[1]. The goal of a well-defined research problem is to form the base on which the artifact will be developed [1], [14]. The second goal, justifying the value of the solution, forms the motivation for the research to pursue the solution [1], [14]. It also helps the audience to understand the researcher's reasoning and understanding of the problem [1], [14]. In order to accomplish these two goals the researcher needs to possess knowledge of both the state of the problem and the importance of the solution [1], [14].

Activity 2: Define the Objectives for a Solution

The second activity includes forming objectives for a solution [1], [14]. These objectives should be derived rationally form the problem specification and must be possible and practical [1], [14]. An objective can either be quantitative or qualitative [1], [14]. The inputs for this activity include knowledge of the state of the problem, existing solutions and their efficacy [1], [14].

Activity 3: Design and Development

The main objective of the third activity is to create the artifact [1], [14]. The artifact can either be a standalone model, construct, instantiation or method; or in the form of new properties of "technical, social, and/or informational resources" [1], [14], [28]. The main criteria to which the artifact has to adhere to is that the design of the object must include contributions to the research field [1], [14]. The main objective is split into three sub-objectives, namely determining the artifact's functionality, architecture and then creating the artifact [1], [14]. The culminative knowledge of research theory is required to move from objectives to design and development [1], [14].

Activity 4: Demonstration

During the fourth activity the artifact's efficacy is tested by demonstrating its ability to solve "one or more instances of the problem" [1], [14]. The possible demonstration methods implemented during this activity include simulation, proof, case study, interviews, experimentation, or other appropriate activities [1], [14]. In order to demonstrate the efficacy of the artifact, effective knowledge of how to use it to solve the problem is required [1], [14].

Activity 5: Evaluation

Following the artifact demonstration, the evaluation process/activity commences. The role of this activity is to observe and measure the artifact's ability to solve the problem [1], [14]. This is accomplished by comparing the results observed during the artifact's demonstration with the solution objectives as set out in Activity 2 [1], [14]. There are various evaluation methods that can be implemented with the type of evaluation process required dependent on the nature of the problem venue and the artifact [1], [14]. The comparison measures implemented can include quantitative performance measures, such as budgets, client feedback, or simulations; quantifiable system performance measures, such as availability and response time; and comparing the artifact's functionality with the solution objectives [1], [14].

The evaluation can include any appropriate empirical evidence or logical proof [1], [14]. At the end of the evaluation process the researcher can either iterate back to Activity 3 in order to improve the effectiveness of the artifact, or continue to Activity 6 [1], [14].

Activity 6: Communication

During the final activity the researcher must communicate the problem and its importance, the novelty, utility and effectiveness of the artifact, the thoroughness of its design [1], [14]. The inputs of this activity include knowledge of the disciplinary culture [1], [14].

2.5. Progression Checklist for DSR

Hevner and Chatterjee [14] provide a widely used checklist of questions to assess the progress on design research projects. By successfully answering these questions, researchers can ensure that their project address the key aspects of design science research.

The questions that form this checklist is given in Table 2.4.

Table 2.4: Design Science Research Progression Checklist

NUM	QUESTION(S)
1	What is the research question (design requirements)?
2	What is the artifact? How is the artifact represented?
3	What design processes (search heuristics) will be used to build the artifact?
4	How are the artifact and the design processes grounded by the knowledge base? What, if any, theories support the artifact design and the design process?
5	What evaluations are performed during the internal design cycles? What design improvements are identified during each design cycle?
6	How is the artifact introduced into the application environment and how is it field tested? What metrics are used to demonstrate artifact utility and improvement over previous artifacts?
7	What new knowledge is added to the knowledge base and in what form (e.g., peer-reviewed literature, meta-artifacts, new theory, new method)?
8	Has the research question been satisfactorily addressed?

Hevner and Chatterjee [14] map these eight questions to the various research cycles in order to demonstrate their relationship, as illustrated in Figure 2.6 . They advise that the researcher must continually refer to this checklist through the design research process to ensure that the activities are being followed correctly.

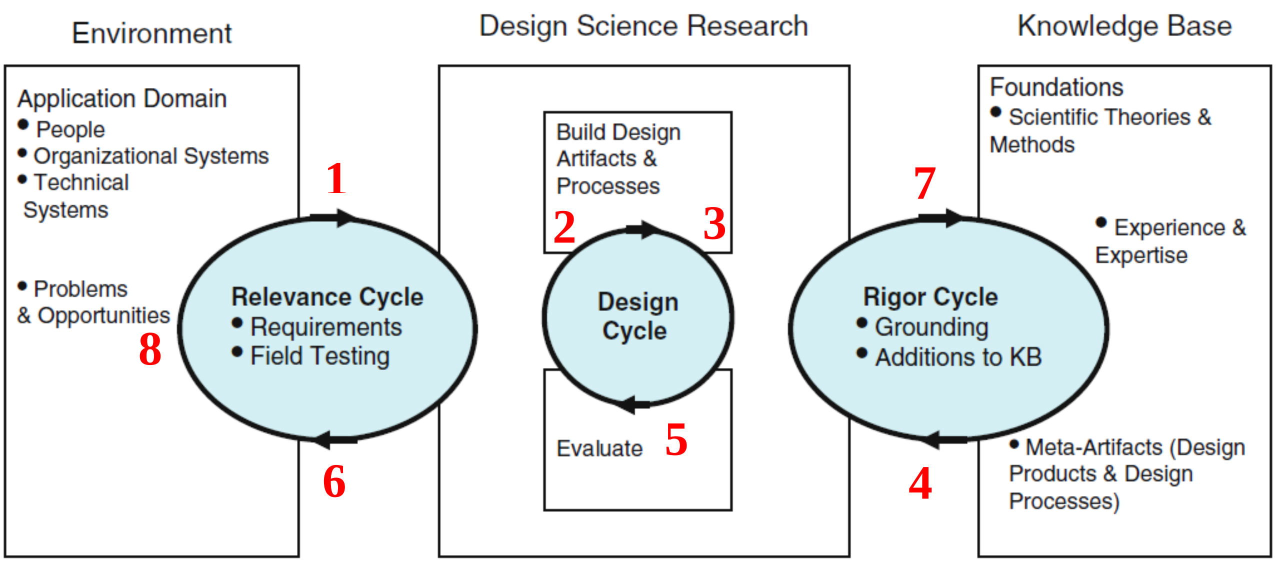


Figure 2.6: Relationship between DSR Checklist and Design Research Cycles (Adapted from [14]**)**

2.6. Evaluation Processes

As part of the design science research methodology the designed artefact needs to be demonstrated and evaluated to determine its efficacy in the field and validity of the theory implemented. Thus, to evaluate the management tool developed in this study the researcher had to gather data from the field.

There are multiple methods of data collection in qualitative research [29] and as O'Leary [30] remarks, "*Collecting credible data is a tough task, and it is worth remembering that one method of data collection is not inherently better than another*."

Interviewing has been described as a common and powerful method for data collection to build understanding [31], [32]. Gray [33] argues that using interviews as a research instrument has various advantages, such as enabling the researcher to gather highly personalized data, gain opportunities for further probing and providing a good return rate.

Finally, interviews have been identified as a suitable method for validating an artefact designed through the DSR process [34], [35]. Thus, for the purpose of this study, interviews were conducted as part of the DSR demonstration and evaluation process.

Rabionet [36] developed a six-stage process to conduct an interview. This process was followed to develop the interview protocol and guide the researcher during the interview process. Table 2.5 below shows the different stages as set out by Rabionet [36].

Table 2.5: Six-Step Interview Process [36]

STAGE	STAGE DESCRIPTION
Select type of interview	Decide which type of interview structure to follow
Establish ethical guidelines	Consider the possible consent, confidentiality, and protection issues that may arise during the interview.
Craft interview protocol	Provide interview context and develop questions and follow-up probes.
Conduct interviews	Conduct interviews and determine how they will be recorded.
Analyse interviews	Summarizing gathered data and data analysis
Report findings	Present the results from the interview data analysis

There are many types of interviews [29]. For this study three types of interviews, namely structured, unstructured, and semi-structured interviews, were considered. Each interview type is discussed below, including their advantages and disadvantages.

Structured Interviews

Structured interviews, or standardized interviews [29], entails the interviewer asking the same questions to all the interviewees [37].

The advantages of structured interviews include the researcher having a detailed interview guide, which can be especially helpful if the interviewer is inexperienced [29]. Furthermore, it gives the researcher control over the topics and the format of the interview, making it easier to aggregate the interviewees replies and to analyse, code and compare the data gathered [29].

The disadvantages of using structured interviews are due to the research guide's rigidity [37]. Due to the detailed nature of the research guide the interviewer does not have a lot of opportunity to probe the interviewees for further questions, additionally the respondents may interpret or understand the questions differently, resulting in inadequate replies [29].

Unstructured Interviews

Unstructured interviews follow a non-directed method and is the most flexible method of the three types [29]. No research guide is required and the interviewees are encouraged to speak openly in a casual setting [29].

The biggest advantages of unstructured interviews lie with the fact that there are no restrictions, giving the researcher the opportunity to gather background information about a topic and to investigate underlying motives of the interviewee [29].

Utilizing an unstructured interview method also has its disadvantages. Due to no research guide being available, inexperienced interviewers may not be able to direct the interview seeing that they do not know what to look for in the interviewee's answers [29]. This can lead to the interviewee going down tangents that are not relevant to the study and the interviewer not obtaining any relevant data [29]. Finally, even if relevant data is collected, it would be more difficult to code and analyse [29].

Semi-Structured Interviews

Semi-structured interviews are frequently used in qualitative analysis where a researcher discusses a list of key themes, issues and questions to be covered during the interview with experts in the respective field [29]. This method also incorporates an interview guide, but additional questions can be asked [29]. Semi-structured interviews are quite useful if no specific hypothesis needs to be tested [38].

Due to the explorative nature of a semi-structured interview the interviewer has the freedom to conduct the conversation as they seem fit [37], but still have a research protocol to guide them. Unlike the structured interviews, the interviewer can rephrase the questions if the interviewee is unclear on how to answer [29]. Furthermore, the interviewer can probe answers given by the interviewee to explore paths that were originally not considered [33]. Finally, as the interviewer has a research protocol to guide them through the interview, the data collected is much easier to code and analyse than unstructured interviews [29].

The only disadvantages with semi-structured interviews lie with the experience of the interviewer as they might miss ample opportunities to further prompt the interviewee, or the prompting questions might not be relevant [29].

Based on the advice given by O'Leary [30] the advantages and disadvantages of each interviewing method were weighed to determine which is the most applicable to this study. The researcher determined that semi-structured interviews were the best fit since the data gathered can be easily coded and analysed and that new insights can be gained surrounding technology management capabilities and technology platforms. Following the discussions on DSR methodology and evaluation methods, the full research design for this study is given in the subsequent section.

2.7. Research Design

A research design includes the detailed methods of data collection and analysis based on the chosen worldviews [20]. It gives the layout of the steps followed to meet the study objectives. The research conducted in this study is of qualitative nature and the methodology chosen is the design science research methodology proposed by Peffers et al. [1].

The six activities of the DSR methodology were adopted for this project. Each Activity was subdivided into key objectives derived from the activity explanations given in Section 2.4 required to satisfy this study's research objectives. The objectives for each activity within this study are given in Figure 2.7 below and discussed in the subsequent sections.

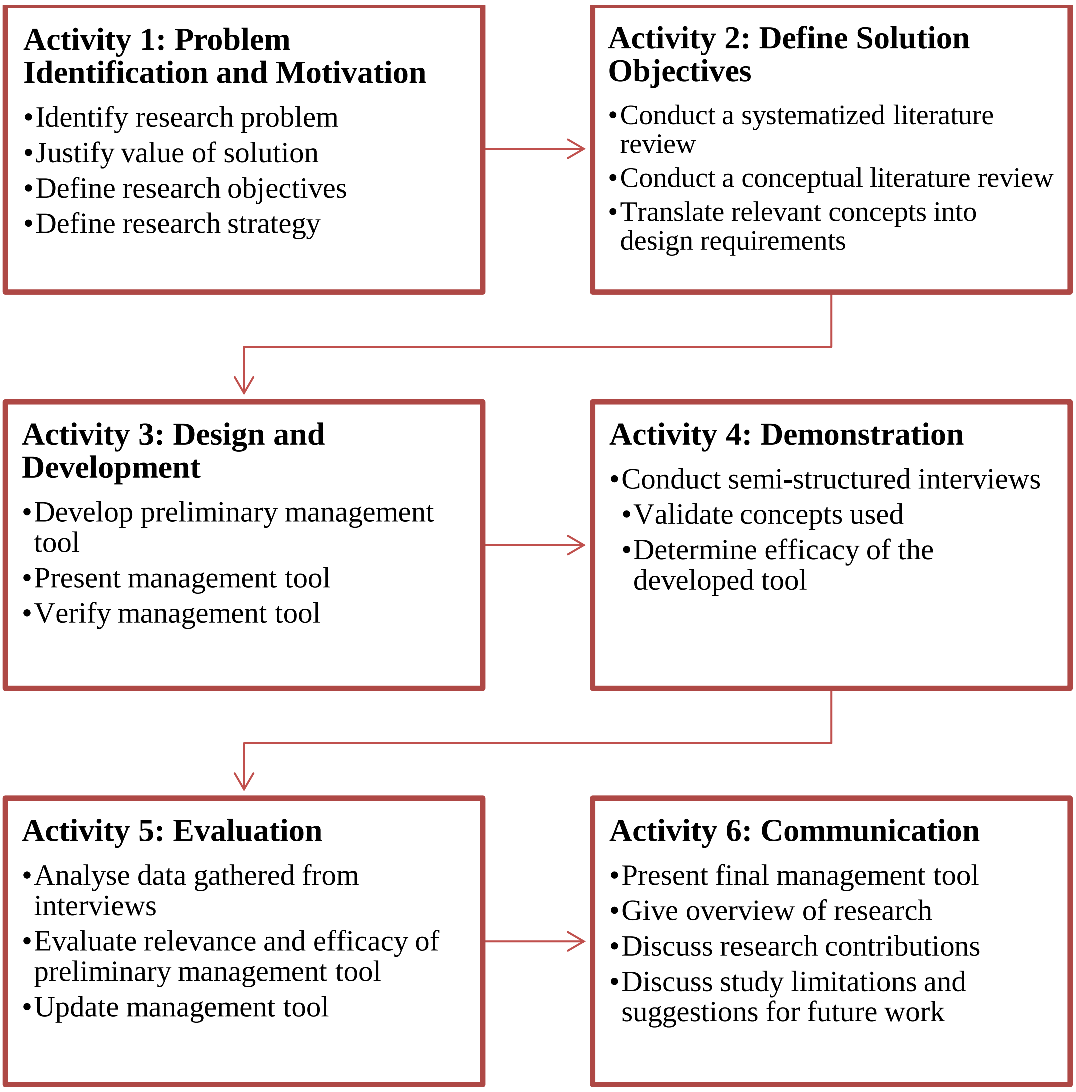


Figure 2.7: Research Design Overview

2.7.1. Activity 1: Problem Identification and Motivation

During the first activity background information was given into technology platforms and their surrounding ecosystems, management considerations of technology platforms, and how technology management capabilities can be utilized for platform management. This background information was used to define the research problem justify the need for a management tool. Subsequently, research questions and objectives were developed to solve the research problem. Further justification for the management tool was given by outlining the research contributions. The research method was then outlined to indicate the roadmap to be followed to answer the research questions and achieve the research objectives. Detailed research was conducted to determine the appropriate research and evaluation methods. The researcher concluded that the research is qualitative of nature and the design science research methodology developed by Peffers et al. [1] will be used in conjunction with semi-structured interviews for evaluation.

2.7.2. Activity 2: Define Solution Objectives

For the researcher to be able to accurately define the solution objectives they had to first build a competent knowledge base of the state of the problem, existing solutions, and their efficacy. This activity was divided into three steps. The first step included a systematized literature review where the researcher aimed to gain knowledge about the relationship between technology management capability literature and the management of technology platforms. The systematized literature review was also utilized to determine the key concepts required to effectively apply technology management capabilities. A conceptual literature review followed as part of the second step. During this review in depth knowledge was gathered about technology platforms, platform ecosystems, existing management tools, and the key TMC concepts identified during the systematized literature review. Finally, the knowledge gathered during the two literature reviews were supplemented with research regarding conceptual framework features to complete the knowledge base. The final step commenced by translating the gathered knowledge into design requirements for the preliminary management tool that acted as solution objectives.

2.7.3. Activity 3: Design and Development

The development process consisted out of three steps. The first included distributing the key concepts for technology platforms and platform ecosystems between identified technology management routines to determine the relevance of the existing routines in a platform business. During this process new routines were also defined to manage a platform business based on the existing literature and guided by the design requirements. An overarching framework was then developed to present the various routines required to manage a technology platform, platform ecosystem, and their relationships. The rational used by the researcher was supplemented by the knowledge base populated during the two literature reviews and methodically presented during the development process. Finally, the researcher concluded the development process by verifying that all the design requirements were adhered to.

2.7.4. Activity 4: Demonstration

The demonstration phase consisted of the researcher conducting semi-structured interviews with experts in the field of technology management and technology platforms. The interviews conducted had three main goals. The first was to validate the concepts used throughout the preliminary management tool. The second was to determine the efficacy of the preliminary management tool by conducting an effort-impact analysis. This was achieved by letting the experts rate the defined routines based on the effort required to implement the routine and level of positive impact the routine contributed to the platform company. Both these metrics were rated on a scale of 1 to 5 and mapped during the evaluation process. The third was to gain insight from the various experts to identify concepts that might have been overlooked by the researcher and determine where the management tool can be improved.

2.7.5. Activity 5: Evaluation

During the evaluation phase the researcher transcribed the data gathered from the interviews into Microsoft Excel in order for it to be coded and analysed. The analyses process included cross-examining the experts' answers to identify industry trends related to the technology management capabilities and their routines, and identifying new concepts and routines recommended. The effort-impact rating data was then mapped to evaluate the efficacy of the various routines. The evaluation process concluded with the researcher updating the preliminary management tool based on the analysed data.

2.7.6. Activity 6: Communication

The final activity commenced by presenting the final management tool for technology platforms and platform ecosystems. The study was then concluded by communicating the problem and its importance, giving an overview of the research process, discussing the contributions and limitations of the study, and giving suggestions for future research.

2.8. Chapter 2 Summary

Chapter 2 focuses on the research design of this study. The topics discussed includes a background of different research approaches, qualitative-, quantitative- and mixed research methods and design science research. The chosen design science research methodology and its application within this study is then elaborated on.

Table 2.6 below lists the six design science research methodology activities and how they relate to this study's research objectives and relevant chapters.

Table 2.6: DSRM Activities Relation to Research Objectives and Chapters

DSRM ACTIVITY	CORRESPONDING RO(S)	RELEVANT CHAPTER(S)
Activity 1		Chapter 1, 2
Activity 2	RO1, RO2, RO3, RO4, RO5	Chapter 3,4,5
Activity 3	RO6, RO7	Chapter 6
Activity 4	RO8	Chapter 7
Activity 5	RO9	Chapter 7
Activity 6	RO10	Chapter 8

The design science research progression checklist items defined by Hevner and Chatterjee [14] as set out in Section 2.5, Table 2.4 that were addressed during Chapter 2 are listed below.

Table 2.7: Design Science Research Progression Checklist [14] **– Item 3**

NUM	QUESTION	RESPONSE
3	- What design processes (search heuristics) will be used to build the artifact?	- The research methodology adopted for this study is the design science research methodology proposed by Peffers et al. [1]. Systematized and conceptual literature reviews were conducted to build the knowledge base. The gathered information was translated into the design requirements based on the recommendations made by Van Aken and Berends [39].

Chapter 3

Systematized Literature Review

Chapter 3 key objectives:

- Distinguish between systematized and systematic literature reviews,
- Outline common systematic literature review purpose and methodology,
- List advantages and disadvantages of systematized literature reviews,
- Detail planning and data collection procedures,
- Present descriptive and conceptual results of review,
- Discuss influence of results on further research.

Chapter 3 presents and discusses the systematized literature review conducted to establish the literature gap between technology management capabilities and management of technology platforms and platform ecosystems, and to identify the key concepts of technology management capabilities. Existing literature regarding systematic reviews is explored and used as a guideline to define the process followed during the systematized literature review. Firstly, a background to systematized and systematic literature reviews are given, outlining the steps and guidelines required of conducting a systematized review. These guidelines are then implemented to detail how, and which, data is to be collected for this study. This is followed by the descriptive and conceptual results gathered during the review and concludes by listing the limitations of the review. Chapter 3 forms the first half of the theoretical phase of this study.

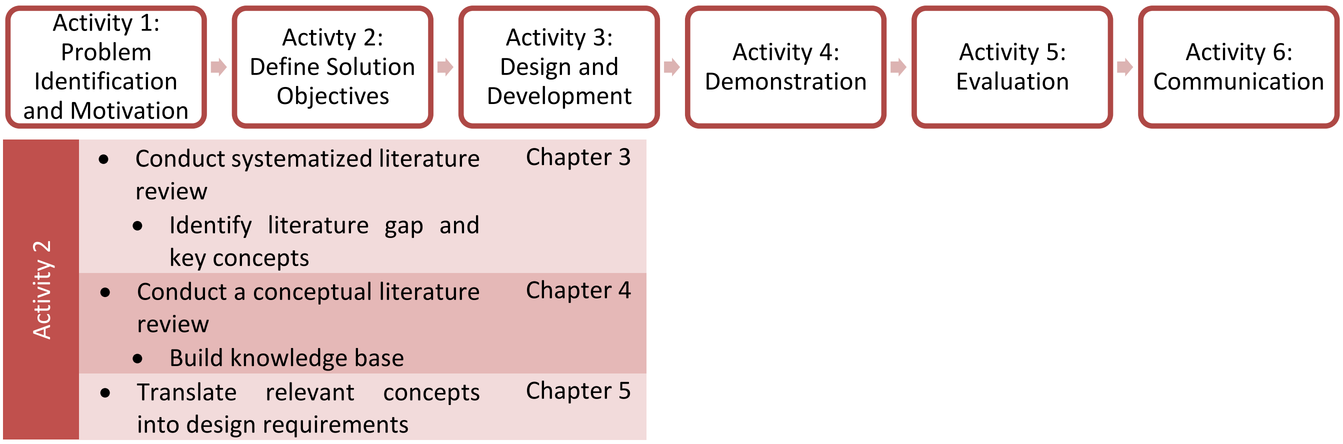


Figure 3.1: Research Context Diagram - Chapter 3

3.1. Background on Systematic and Systematized Literature Reviews

Systematic literature reviews were created to minimise the bias experienced when conducting traditional narrative reviews [40]. The bias is usually the result of the author choosing a specific area of study based on selection or availability [40].

For a systematic literature review, predetermined criteria are defined to answer specific research questions, with the author attempting to collect all empirical evidence with the aim of meeting these criteria [40]. A systematic literature review is based on a search strategy that identifies, appraises and synthesises data from several studies [40]–[42].

Kitchenham and Charters [41] stipulate that systematic literature reviews are conducted to understand the full extent of existing research and previous research methodologies implemented, identify gaps in the existing research and provide a framework to guide future research. They continue by emphasizing the importance of conducting a systematic literature review in a manner that is transparent and replicable by thoroughly documenting the research process [41].

Although the aim of a systematic literature review is to minimise bias, it too is subject it and due to thoroughness of these reviews and the attentiveness required during the research process, they take considerately more time and effort to complete in comparison to traditional literature reviews [41] [14].

A systematized review is defined as an attempt to include one or more elements of a systematic review, where the process followed is derived from, or related to that of a systematic review [43]. This approach is followed if the researcher is unable to draw upon the resources required for a full systematic review, for example not having two reviewers [43]. The perceived strengths of implementing systematized review process is dependent on how stringently systematic review concepts and guidelines are adopted [43].

The downside of using a systematized review is that the quality assessment or synthesis may be more difficult to identify, due to the processes not being defined, or only a small set of eligible articles being modelled [43]. Once again, the full extent of the perceived weaknesses is dependent on how stringently systematic review concepts and guidelines are adopted, as these steps are critical to minimize bias.

The guidelines followed for this systematized literature review was based on the process suggested by Petticrew and Roberts [42] and Kitchenham and Charters [41]. The approach developed by Petticrew and Roberts [42] explains the steps required for a comprehensive systematic literature review process. They introduce a map comprised of twelve steps to ensure that the core objectives of a systematic review being transparent and replicable are achieved. These twelve steps are illustrated below in Figure 3.2.

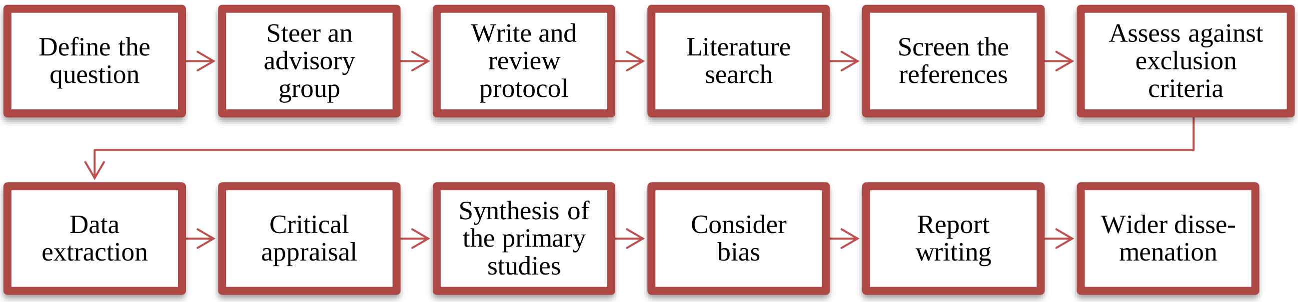


Figure 3.2: Proposed Steps in a Systematic Literature Review [42]

3.2. Planning the Review

As with a systematic review, before a systematized literature review can be initiated, it needs to be thoroughly planned. The first steps in the planning process include identifying the need for further research, defining the research questions to be answered, and writing a review protocol. This review deviates from a full systematic review as an advisory group was not approached as part of the study. During the initial stages of this study the requirement for a platform management tool was stressed and the novelty of technology management capabilities as a solution was identified in Chapter 1.

Petticrew and Roberts [42] propose that following the identification of a need a research protocol should be set up. A research protocol states the review questions, and includes the criteria and procedures required to select relevant studies, how the data is to be extracted from these core studies, and the data synthesis- and dissemination strategies of the review [42]. Although Higgins and Green [44] suggest the PICO (Participants, Interventions, Comparisons and Outcomes) criteria for the formation of the research questions for systematic reviews, further research [45] suggests that for qualitative studies the PICo (Problem or Population, Interest and Context) criteria is more suitable.

3.2.1. Research Questions

This systematized review aimed to answer the following questions:

- What is the relation between TMC literature and technology platform literature?
- Have technology management capabilities been utilized to manage technology platforms and platform ecosystems?
- Are there existing management tools for technology platforms based on technology management capabilities?
- What are the key concepts of technology management capabilities?
- How can TMC literature be adopted to develop a practical management tool?

3.2.2. Search Criteria

Search terms were generated from these research questions and used in the research database, Scopus, to obtain the primary studies for this review. Scopus was chosen due to the researcher being comfortable using the database.

The search results were exported into MicroSoft Excel for synthesis according to the predetermined criteria defined in the research protocol. These inclusion and exclusion criteria were based on the review questions as suggested Kitchenham and Charters [41] and were divided into two categories. These categories, namely C1 and C2, distinguished at which stage of the primary study identification process the criteria were to be applied. The criteria used are listed in Table 3.1 below.

Table 3.1: Study Selection Criteria for Systematized Literature Review

CRITERIA CATEGORY	CRITERIA	DESCRIPTION
C1	Type of Paper	Excluding conference reviews, notes and lecture notes.
C1	Language	Only English studies were accepted

Table 3.1 (Continued): Study Selection Criteria for Systematized Literature Review

CRITERIA CATEGORY	CRITERIA	DESCRIPTION
C1	Irrelevant studies	Exclude studies that focused on aspects not related to research questions. This criterion was subdivided by first screening the article's title and then its abstract to determine its relevance. All articles that mainly focused on knowledge management, innovation management, not the capability aspects thereof, etc. were excluded.
C2	Empirical Soundness	Methodology used to conduct the study and its validity. The number of questionnaires, response rates, the interviewed company and interviewee at the company were considered.
C2	Academic rigour of paper	Articles that were not referenced properly, did not implement clear theoretical concepts, follow proper methodology and state thorough conclusions were excluded.
C2	Online Availability	Exclude articles that are not available online.

The data to be extracted from the studies were defined in the protocol and included the studies' key concepts, research methodology, research approaches, which framework or theory was used, the citation numbers, and the geographic application of the study.

3.3. Data Collection

During data collection process the initial search results were sifted through to culminate in the final primary studies. These studies focused on Technology Management capabilities, their routines, and their relation to technology platforms and platform ecosystems. The online research database, Scopus, was used to conduct the search. Kitchenham and Charters [41] suggested that for digital libraries the search process documentation should include: (1) The name of the database, (2) the search terms, (3) the date when the search was conducted, and (4) the publication years covered by the search. Table 3.2 below documents the search process conducted for this study.

Table 3.2: Systematized Literature Review Search Process Documentation

SEARCH PROCESS DOCUMENTATION		
Name of search database	Scopus	
Search strategy	Search terms:	Results (Nr):
	Technology AND Management	401088
	Technology AND Management AND Capabilities	24370
	Technology AND Management AND Capabilities AND for AND Technology AND Platforms	2462
Date of search	20 March 2020	
Publication years covered	No Limitation	

As stated earlier the search terms were generated in order of descending relation from the research questions until the number of search results were of an acceptable amount.

The first search term 'Technology Management' yielded 401,088 results. By adding the term 'Capabilities' the number of results were reduced to 24,370. Finally, this number was then reduced further by adding 'for Technology Platforms'. The final search resulted in 2,462 research papers. These papers were then subjected to the inclusion and exclusion criteria set out in the research protocol to determine the final primary studies. Figure 3.3 illustrates the inclusion/exclusion process and yielded results of each criterion.

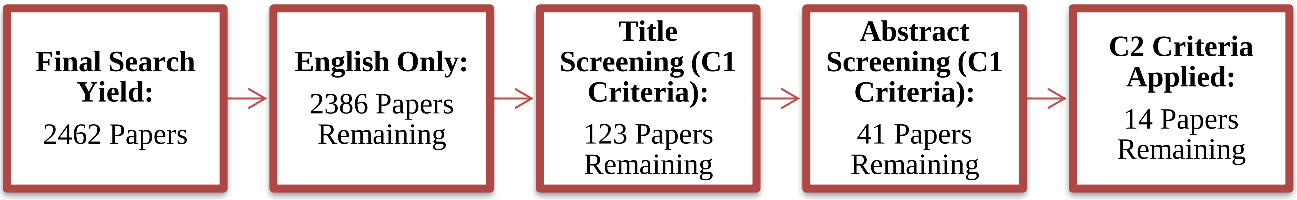


Figure 3.3: Systematized Literature Review Primary Study Identification Process

The first step was to exclude all papers that were not English, leaving 2386 search results. The titles of each paper were then screened using the C1 criteria to gather papers that seemed relevant to answering the research questions. After this process, 123 papers were remaining.

The resulting papers' abstracts were subjected to the C1 criteria again, which yielded 41 papers. Of these papers, only 14 were deemed relevant and useable after fully reading the papers and applying the C2 criteria. A list of the final papers is included in Appendix B.

The primary studies were re-read to identify the main concepts of each. These main or 'key' concepts were then extracted and categorised. This process was conducted systematically as proposed by Petticrew and Roberts [42]. The descriptive data extracted is presented in Section 3.4.1 and the conceptual data extracted is presented in Section 3.4.3.

3.4. Data Analysis

By following a systematized review process both descriptive and conceptual results were obtained. The descriptive data focuses on the field of study and gives deeper insights on the trends followed by the leading researchers in the field and the trajectory of their research. The conceptual data identifies and gives greater understanding of technology – and technology management capability concepts.

Although the primary goal of the systematized literature review is defined by the research questions, further interesting trends or limitations in technology management capabilities and their relation to technology platforms will be extracted to determine the scope of the research field.

By answering the following questions, the researcher can get a better idea of the scope of the research field:

- Has research been done linking TMC with technology platforms?
- How are technology platforms addressed in TMC research?
- What are the current focal points of technology management capabilities research?
- Has research regarding TMC within developing countries been conducted?

3.4.1. Descriptive Analysis Results

The descriptive data systematically gathered during the review included the author(s) names, year of publication, methodologies used in the papers, the geographical application, the key concepts discussed, and which papers linked technology management capabilities with technology platforms. The data was coded into MicroSoft Excel and analysed to gather insights that will assist further research.

The number of citations of the primary study authors were gathered from the research database Scopus on the 1st of May 2020 and are presented in Figure 3.4. These figures aided the researcher in identifying prominent researchers in the field of technology management capabilities. This data allowed the researcher to be more attentive to the identified researchers. While conducting further research for this project, it will help to confirm the legitimacy and empirical soundness for future papers collected.

The author citations were used for this purpose instead of the study citations as four out of the fourteen papers were published between 2019 and 2020. These papers had zero citations, but their authors rated in the top ten identified with the least having 265 citations, which indicates that these authors have published influential papers in the past, but that studies collected during this systematized literature review were still too new to have the same impact.

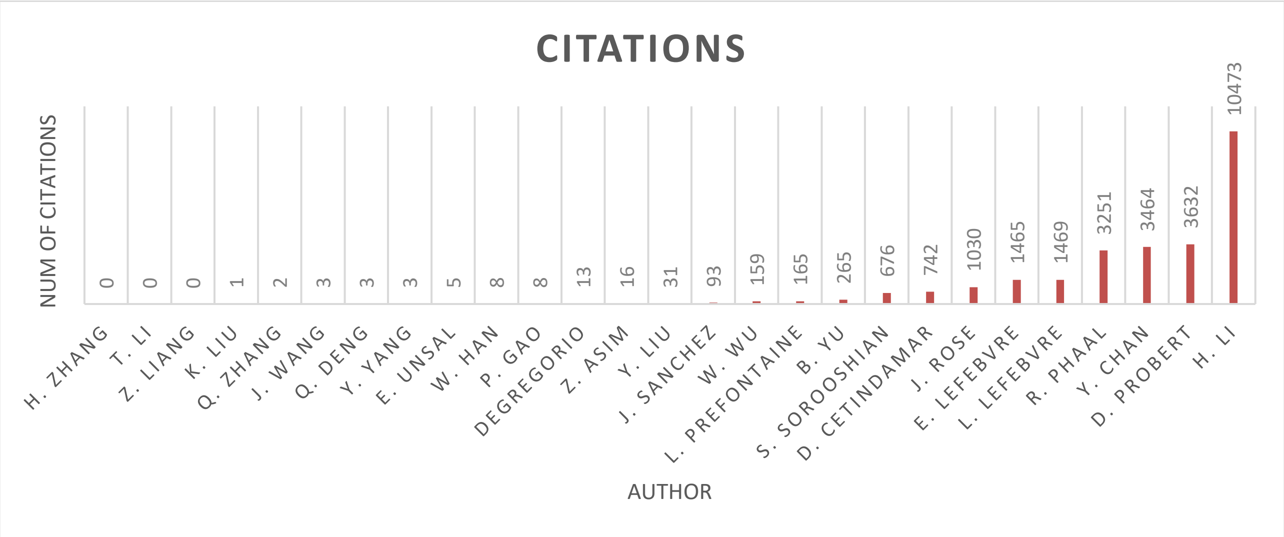


Figure 3.4: Primary Studies' Authors' Citations Rankings

In addition to the citation rankings of the papers' authors, a timeline of the primary study publication dates was determined and is shown in Figure 3.5. Although the timeline indicates that the first study was published in 1994, Y. Liu et al. [10] noted that technology management as a research field has been around since the 1970s.

The researcher should therefore not only focus on recently published papers but include older publications and at the same time be attentive to how and what kind of technology is addressed by the gathered studies, to ensure their relevance to this study.

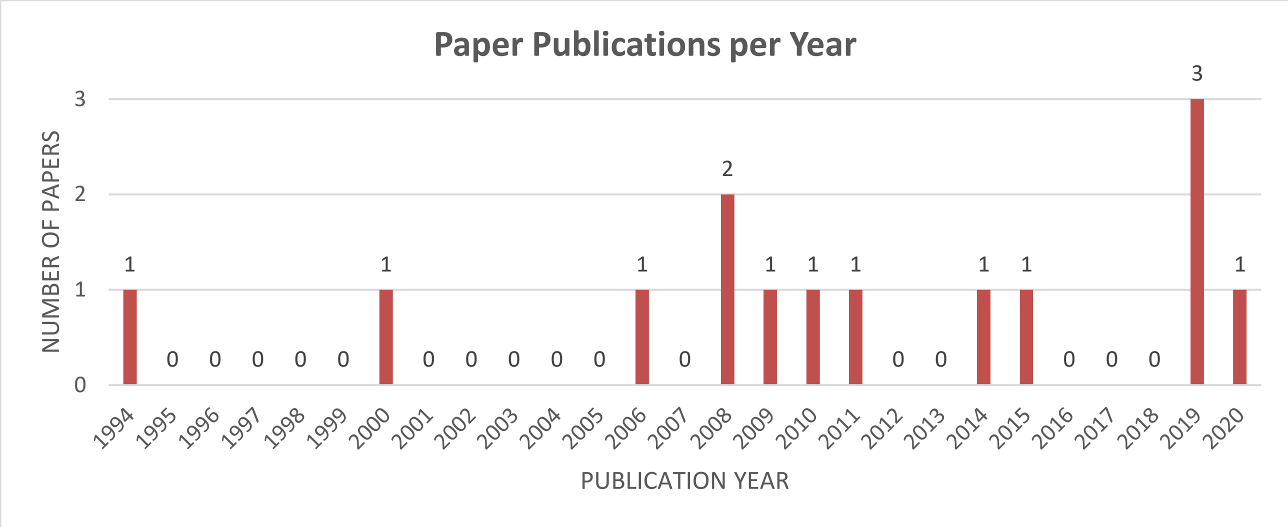


Figure 3.5: Primary Studies' Publication Years

Further, the evaluation methodologies used in the sample of papers gathered for this systematized review were noted. Of the fourteen primary studies, nine studies applied case studies and questionnaires to evaluate their findings, while the remaining five used widely accepted simulation modelling techniques or rigorous literature reviews to gather data and build their conclusions.

For the papers that made use of case studies or questionnaires, the geographical application area from which the data was collected was analysed. Figure 3.6 below illustrates that from the primary studies that implemented these empirical methods the majority were based in Asia, more specifically in China, followed by papers from Europe and the UK, and then from North America. Of the primary studies gathered, no studies were implemented in Africa or South America, further indicating the gap in literature addressed by this study.

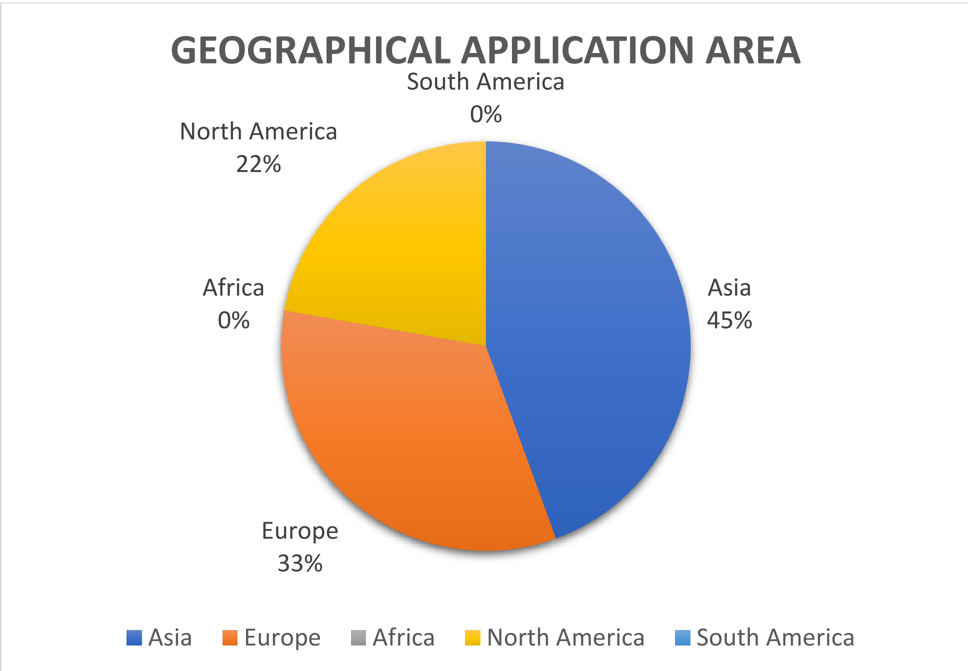


Figure 3.6: Geographical Application Areas of Primary Studies

The final two descriptive data categories that were analysed concerned the research goals of the primary studies and if the papers utilised technology management capabilities for technology platforms.

The research goals of each of the primary studies were analysed to determine the current trend in Technology Management Capabilities (TMC) research. A common theme identified among the primary studies is that there is no clear consensus on how to define technology management capabilities [13], [23], [46].

Figure 3.7 below shows the research goals of each primary study. Most of the studies identified had multiple research goals that overlapped with each other. From Figure 3.7 it can be seen that the majority of the studies discuss the impact of implementing the TMC businesses, while only two aim to identify TMC activities/routines but stop short of listing tools/techniques that can be implemented to practically implement each activity routine.

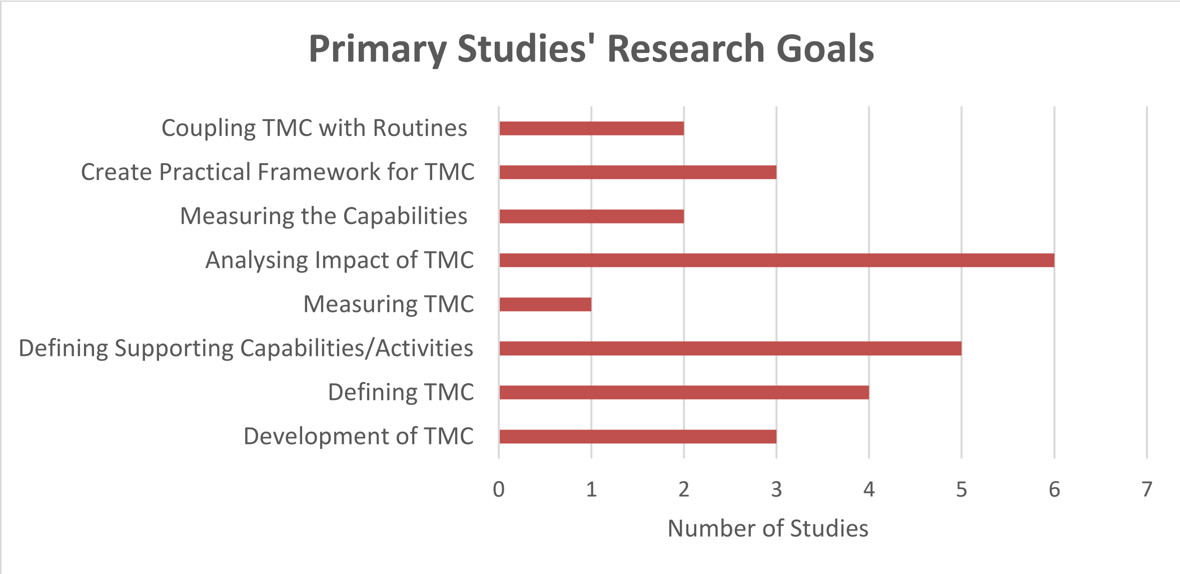


Figure 3.7: Primary Studies' Research Goals

Of the fourteen primary studies, only four papers address technology platforms through the lens of technology management capabilities. Three of the four papers acknowledge the critical role technology platforms play in a business as the infrastructure that enables knowledge sharing and business scaling [47]–[49]. Of these three, two refer to technology platforms as enablers for knowledge management capabilities [47], [49], while the third rather addresses a platform as a capability itself [48]. The fourth paper identified only defines a dynamically linked roadmaps strategy for technology management that can also be implemented for technology platform development [50]. A more in-depth look at how these papers address technology platforms through the lens of technology management literature is given during this review's conceptual analysis.

While analysing the papers in the final descriptive category the researcher found that Li and Chan [48] mention in their research studies on capabilities tend to exclude "*discussion of the IT-enabled nature of the business capabilities being examined*". In their research, technology (or as they state, digital) platforms are part of these information technology (IT) capabilities that require further attention [48].

3.4.2. Descriptive Analysis Conclusions

The descriptive analysis of the primary studies yielded interesting results regarding existing TMC research and shows that work has been done that links technology platforms with TMC literature. By analysing the literature that links technology platforms and technology management capabilities two conclusions were drawn.

The first includes the scarcity of literature that address technology platforms through the lens of technology management capabilities, the second is that of the gathered studies that do mention technology platforms, the platforms are rather addressed as enablers of technology- and knowledge management capabilities instead of playing an integral role in the business practices. Further, the fact that the three most occurring research goals of the existing studies are defining technology management capabilities, defining the supporting activities of technology management capabilities and analysing the impact of technology management capabilities indicates that the technology management capabilities research field is relatively new and untapped.

Finally, from the analysis the researcher concludes that there is a need for more practical research that explains the *"How"* of implementing TMC in a business that implements technology platforms and that there is a gap in the literature where none of the research gathered was conducted in Africa and South America.

It can be concluded from the descriptive analysis that this study addresses multiple gaps in the existing literature.

3.4.3. Conceptual Analysis Results

The conceptual data identifies and gives greater understanding of technology management capability concepts. The aim of the analysis is to identify and discuss the diversity of the research landscape and the key concepts that occur throughout the primary studies. By having a firm understanding of the key concepts of TMC literature the researcher can fully grasp how the primary studies address technology platforms through the lens of technology management capabilities.

Diversity of Research Area

Actively reading and re-reading the primary studies enabled the researcher to identify the different areas of research that were adopted in the primary studies, proving the multidisciplinary nature of the technology management capabilities approach to manage technology platforms. Further, it gave the researcher the opportunity to identify and document the key concepts of each study. Finally, the different angles from which technology management capability was analysed could also be recognised.

The research done for the systematized literature review verifies that a multifaceted approach needs to be adopted when addressing technology management capabilities and their relation to technology platforms. Table 3.3 show the identified research areas, their description, and the primary studies in which they were prevalent. The research areas were also divided into broader categories to gain a complete picture of the diverse applications of technology management capabilities.

Table 3.3: Primary Studies' Research Areas

CATEGORY	RESEARCH AREA	DESCRIPTION	REF(S)
FIRM PERFORMANCE	Research and Development	Discussing management capabilities that support research and development (R&D) and consequently improves a firm's competitive advantages and performance.	[23], [47]
	Firm Competitive-ness	Management techniques and capabilities that directly give firms a distinct advantage over competitors.	[23], [49], [51]
	Strategic Planning	Determining when to implement certain capabilities or reach a level of capability maturity to ensure maximum effect on firm performance.	[51], [52]
INNOVATION STUDIES	New Product Development	Discussing management capabilities that support New Product Development (NPD) practices and improve innovation at firm's level.	[10], [53], [54]
	Innovation Management	Management practices that promote science and technology that enhances R&D in order to create new innovative products [47].	[47]
SOFTWARE TECHNOLOGY STUDIES	Software Management	Management practices that promote the implementation and utilization of software within a company.	[55]
	Information Technology	Digital technologies that are used to transfer and store information at multiple levels within a company.	[48], [49], [51], [56]
MANAGEMENT STUDIES	Technology Management	Management practices that focus on the development and exploitation of various types of technologies within a company.	[13], [23], [47], [50], [52], [54], [57]
	Knowledge Management	Management practices that utilise IT to promote knowledge creation, organization, and transfer within a company.	[47], [49], [57]
FIRM CAPABILITIES	Dynamic Capabilities	An expansion of the resource-based theory where emphasis is placed on the dynamic processes/routines that improve resource development.	[13], [23], [48], [57]
	Technology Management Capabilities	The ability of a company to reconfigure, deploy and coordinate its technological capabilities with the goal of accomplishing its strategic and operational objectives [53].	[10], [13], [23], [51], [53], [54], [56], [57]
	Technological Capabilities	Tacit resources that encompass the knowledgebase of a company that is embodied within its personnel, equipment, information, and organisation.	[10], [53]

The research areas that were identified were grouped together into five broader categories. The first category included research areas focused specifically on well-defined institutions and activities that are known to positively influence firm performance. The research areas that focused on new methods to improve the process of creating new and innovative products were categorised together under innovation studies.

The software technology studies category includes research areas that focus mainly on the influence and management of digital technologies. Finally, as 'management' and 'capabilities' were part of the key search terms, they formed two individual categories. The management studies category included studies that focused on different management practices, while the firm capabilities category included research that focused more on a company's capabilities. Each identified research field will act as a starting point and guide further research for this study.

TMC Key Concepts

The concepts that occurred frequently while analysing the primary studies were identified and listed. The researcher adopted this process to identify the most frequently occurring terms which will form part of the key-concepts of technology management capabilities. Figure 3.8 below shows the concepts with the most occurrences.

The most-frequently occurring concept was the strategic nature of technology management, with the second and third most frequently occurring concepts being competition and innovation. This could indicate how effective strategic planning and implementation of management practices fosters innovation which in turn drives a company's competition. Other frequently occurring concepts that are important to note were the dynamic background of technology management capabilities, how TM practices go hand-in-hand with knowledge management, TM being a process itself, the adaptability of management capabilities, the capability maturity, different capability activities that support TM, how all these activities interlink on a multidimensional plane, the practical management routines and how specific capabilities at certain maturity levels should be coupled to maximise their effect on business processes.

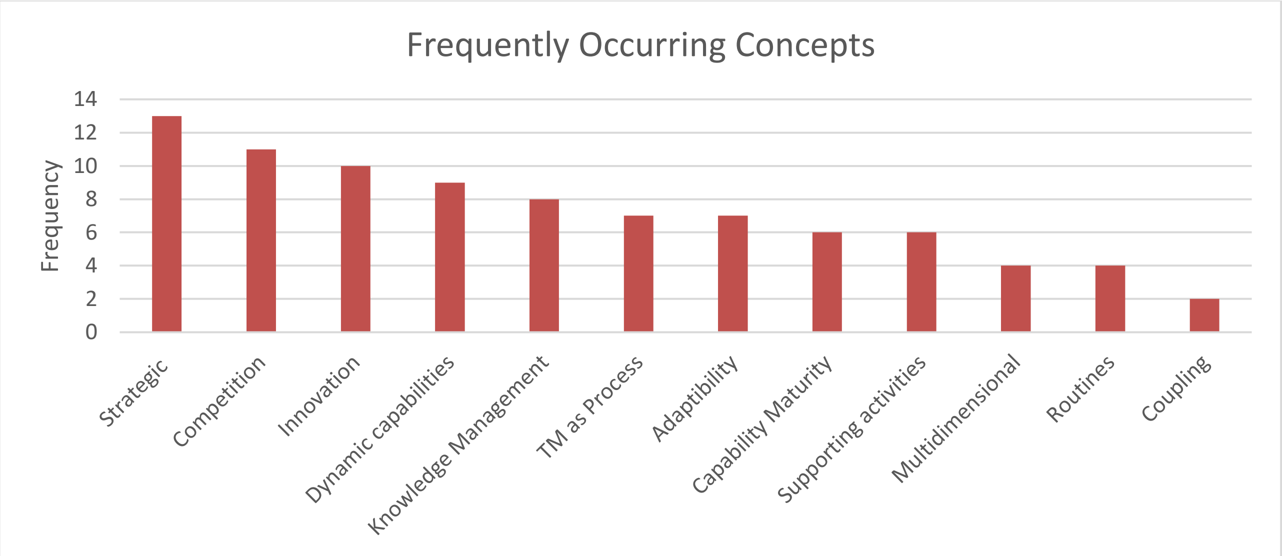


Figure 3.8: Frequently Occurring Concepts within Primary Studies

While keeping the above frequently occurring concepts in mind, the researcher identified further concepts throughout the primary studies, that formed integral parts of the knowledge base for understanding technology management capabilities and their relation to technology platforms. These concepts were extracted and categorised in MS Excel. The categorisation process aimed to link the concepts with the related search terms (Technology Management Capabilities AND Technology Platform).

Throughout the research process it became apparent that within the technology management research field technology platforms are mostly referred to as a technological capability themselves, and the management thereof form part of the TM process. Due to this, the categories that were linked to technology platforms were absorbed into the TMC search term categories. Table 3.4 lists the identified concepts, their sub-categories under the TMC search category and the primary studies in which they were referenced. The subcategories under which the concepts were categorised included business capability theory, technology management capabilities, technological capabilities, knowledge management capabilities and innovation management capabilities.

Table 3.4: TMC Key Concepts and Categories

SUB CATEGORY	KEY CONCEPTS	DESCRIPTION	REF(S)
BUSINESS CAPABILITY THEORY	Capability Hierarchy	The capabilities within a company are ranked in hierarchal format where higher order capabilities are needed to create and implement changes to lower order capabilities.	[23], [47], [48], [54]
	Dynamic Capabilities	First-order capabilities that enhance the understanding of TMC by shifting the focus away from specific technological innovations and static models and utilizes market changes as a guideline for strategic product reconstruction.	[13], [23], [47], [48], [50], [52]–[54], [57]
	Ordinary Capabilities/ Routines	Zero-order capabilities which represent activities that are inherent and repeatable within a company and address market complexities, support learning and knowledge management and enhance innovation [23].	[13], [23], [48], [54]
	Process Capability Set	Technology-, Innovation- and Knowledge management capabilities that include multiple processes within functional units of a firm [47].	[13], [47], [52], [54], [57]
	Strategic Capability Set	Technology-, Innovation- and Knowledge management capabilities that form major components of business planning [47].	[13], [23], [47], [48], [52], [57]
	Infrastructure Capability Set	Technology-, Innovation- and Knowledge management capabilities that focus on integrating existing-, and constructing new knowledge sharing platforms within a company [47].	[47], [49], [57]
	KNIT capabilities	The theory that Knowledge-, Innovation- and Technology (KNIT) management capabilities all overlap, are interconnected and act as supporting activities to each other.	[23], [47]
	Capability Maturity	Measurement of a company's capacity, effectiveness and perfection degree of implementing TM processes [52].	[23], [52], [55]
	Multidimensional	Multiple capability activities, at various stages of maturity, continuously interact with each other during a process' lifecycle.	[48], [50], [51], [54]

TECHNOLOGY MANAGEMENT CAPABILITIES	Identification	TMC routines that monitor various business environment levels to identify new technologies, or technology management techniques.	[13], [23], [47], [52], [54], [56], [57]
	Selection	TMC routines that determine when specific technologies need to be implemented in order to gain maximum efficiency.	[13], [23], [47], [52], [54], [56], [57]
	Acquisition	TMC routines that promote R&D processes.	[13], [23], [47], [54], [57]
	Exploitation	TMC routines that focus on the implementation, adaptation, and support of technologies application.	[13], [23], [47], [54], [56], [57]
	Protection	TMC routines that manage the safeguarding mechanisms of a company's intellectual property.	[13], [23], [47], [54], [57]
	Learning	TMC routines implemented during the post-project phase to gain insights on how to improve future projects.	[13], [23], [47], [54], [57]
TECHNOLOGICAL CAPABILITIES	Coupling relationships	Linking technology management- and technological capabilities at various stages during their dynamic co-evolution to gain maximum efficiency in business processes.	[10], [53]
	Technology Platform as Capability	Defining a technology platform itself as a first order dynamic capability with related lower order capabilities that focus on the functionality, integration and flexibility of digital infrastructure.	[48], [49]
KNOWLEDGE MANAGEMENT CAPABILITIES	Organisational Culture	A culture of effective knowledge management should be cultivated, focusing on the knowledge creation, organization, transfer, and application within in a company.	[47], [49], [51], [55]–[57]
	Knowledge Creation	The organisation's capability to assign value to new knowledge and exploit it in order to improve on existing knowledge.	[47]–[49], [54], [57]
	Knowledge Organization	The process of translating, storing and maintaining knowledge within the company's knowledge infrastructure so that new knowledge can retain its value and be efficiently utilized.	[47]–[49], [54], [57]
	Knowledge Transfer	The organisation's ability to transfer new knowledge throughout the company. A process where the members within a company can find, distribute, and absorb new knowledge.	[47]–[49], [57]
	Knowledge Application	The organisation's member's ability to effectively integrate and apply the newly attained and absorbed knowledge in order to address new and novel problems.	[47], [49], [54], [57]

INNOVATION MANAGEMENT CAPABILITIES	Innovation Management	Management practices that focus on R&D for new product development [47], where the processes are actively intertwined with technology management practices.	[13], [23], [47]

The first subcategory, business capability theory, included concepts that formed the background to understanding what a firm's capabilities are and how they work. In the primary studies it is continuously discussed how capabilities within a firm should be organised in a hierarchal manner [48] in which the higher-level capabilities manage the lower level ones. At the base, or zero-order, are the ordinary capabilities that form the routines [23], [48] within a company. These routines can be defined as regular and predictable practices which implement TM tools or techniques that are implemented by firms and lie at the roots of dynamic capabilities theory [23]. Dynamic capabilities form the higher order capabilities and are necessary to construct, reconfigure and incorporate the lower order capabilities to cope with the ever changing and complex environment [54]. If a novel situation arises, or the environment drastically shifts, first-order dynamic capabilities can become insufficient and second-order dynamic capabilities would be required to adapt the first-order capabilities [48].

As every TM process becomes more intrinsic to the organisation and they can be pre-emptively initiated to deal with an identified change in the environment, the maturity level of the capability rises. Asim and Sorooshian [47] argued that Technology management capabilities can be divided into three subsets, namely: process, infrastructure and strategic capabilities. Where the capabilities in each set collaborate with each other, as well as the capabilities in the other sets, to form the driving factors of technology management. Finally, multiple primary studies ([13], [23], [47], [57]) argue that TMC's are interconnected and continuously supported by knowledge management capabilities and innovation management capabilities, which further feeds into the multidimensional nature of an organisation's capability framework. As the Knowledge-, Innovation- and Technology (KNIT) capabilities are so intertwined, the need arises to understand all three concepts and their relation to each other – thus each form a conceptual category.

Although Technology Management Capabilities was part of the search phrases, it also forms the second subcategory. The first five technology management process capabilities as defined by Gregory [58] (Identification, Selection, Acquisition, exploitation, protection) are widely used throughout the primary studies ([13], [23], [47], [54], [57]), with the addition of learning by Cetindamar et al. [23], who also created a preliminary framework arranging technology management routines under these six first-order TMC's.

The third subcategory addresses technological capabilities and can be defined as the tacit resources within a company that encompass their knowledgebase which is embodied within its personnel, equipment, information and organisation [53]. Because technology has become intrinsic within every part of organisation, a firm's technological capabilities form the infrastructure capability sets within the higher order KNIT management capabilities. As part of the search terms for this study, technology platform-based companies formed the emphasis of the type of technology infrastructure discussed. Due to a technology platform's abilities of rapid scaling and adaptability, the ability to effectively manage a technology platform is earmarked as a crucial capability within a company [48], [49]. The analysis of the primary studies also revealed that it is important to actively focus on the coupling relationships between technology management capabilities and their relative technological capabilities [10], [53].

To address the coupling relationship, a manager needs determine when a process needs to be TMC led or TC led, the level of maturity to required for each capability within the process and if internal or external coupling relations should be strengthened. Effectively coupling TMC and TC improves the synergy between the various capabilities and thus the innovation process efficiency [53].

The knowledge management capabilities (KMC) of a company form the third subcategory. Cetindamar et al. [23] stressed the importance of knowledge management as a supporting activity for technology management and how it should form part of any TM framework. KMC processes should be cultivated throughout the entire company where it is not just the responsibility of the top tier employees, but also integrated into the company culture between the lower tier employees. Li et al. [49] identified four processes that promote knowledge management, namely: knowledge creation, knowledge organization, knowledge transfer and knowledge application. Each of these four concepts occur regularly throughout the primary studies and how technology platforms pay a pivotal role in each [49].

The final subcategory includes the final KNIT capability, innovation management capabilities. As with knowledge management, innovation management processes are intertwined with technology management processes. These processes rather include the larger scheme decisions that need to be made within a company that drive the company's ability to be competitive and should be seen as the initial steps that kickstart new product or business unit development processes.

3.4.4. Technology Management Routines

During their research, Cetindamar et al. [23] constructed a TM framework to arrange 27 technology management routines that were identified by Levin and Barnard [46] between the technology-, knowledge- and innovation management processes identified by Gregory [58]. They continued by adding strategy and knowledge management to the framework as they argued that these were crucial to the technology management process. The routines identified by Levin and Barnard [46] are listed below in Table 3.5. These routines and the framework developed by Cetindamar and Unsal [23] are defined and discussed further in Section 4.10 of this study.

Table 3.5: TM Routines Identified by Levin and Barnard [46] **and arranged by Cetindamar** [23]

CAPABILITIES AND ROUTINES	CAPABILITIES AND ROUTINES
IDENTIFICATION	**LEARNING**
Business Unit Environmental Monitoring	Post-Project Audit
R&D Environmental Monitoring	
Corporate Environmental Monitoring	
SELECTION	**STRATEGY MANAGEMENT**
Technology Roadmapping	Corporate Business Strategy
Technology Needs Assessment	Corporate Technology Strategy
Business Unit Technology Strategy	Technology Alliance Management

CAPABILITIES AND ROUTINES	CAPABILITIES AND ROUTINES
ACQUISITION	**INNOVATION MANAGEMENT**
R&D Technology Strategy	Ideation
R&D Portfolio Management	Feasibility
Technology Transfer	Initial Programme/Project Selection
R&D Funding	New Business Unit Development
EXPLOITATION	**PROJECT MANAGEMENT**
Product Portfolio Management	Project Execution
Technology Adaptation	Performance Management
Post-Project Support	Personnel Management
Business Unit Business Strategy	
Product Line Planning	
PROTECTION	**KNOWLEDGE MANAGEMENT**
Intellectual Property Management	Knowledge management

3.4.5. Technology Platforms Through the Lens of Existing TMC Literature

As stated earlier, the primary studies placed emphasis on correctly utilizing technology infrastructure and addressed technology platforms as a type of technology infrastructure capability. But rather as the driving force behind innovation, Asim and Sorooshian [47], for example, addressed infrastructure capabilities as an essential "*contributor*" to the knowledge-oriented economy. Where technology platforms are referred to as the tool required to accommodate existing knowledge and share new knowledge [47].

This view is echoed by the research conducted by Li and Han [49] who looked at the effect of utilizing technology platforms to promote knowledge management capability processes. Their research did indicate the positive effect technology platforms have on business performance, but contributed these findings to effective knowledge management processes as the technology platforms only "*supported*" knowledge management [49].

Li and Chan [48] delve deeper into the role which platforms play within a company and propose a Dynamic Information Technology Capabilities (DITC) framework based on the theoretical foundation for IT resources presented by Bharadwaj [59] which states that IT resources can be classified into three categories: IT infrastructure, human IT resources, and IT-enabled intangibles. Within their DITC framework they incorporate digital/technology platforms as a dynamic first-order capability, including two other capabilities: Dynamic IT management capability and Dynamic IT knowledge management Capability [48].

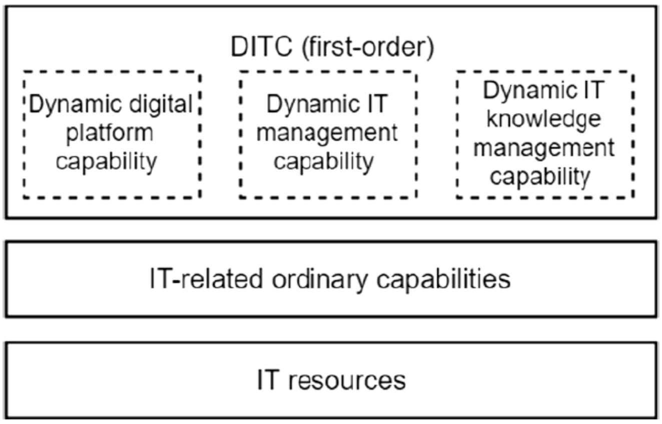


Figure 3.9: High-level DITC Framework [48]

Where Li and Chan [48] differ from Asim [47] and Li [49], is that they acknowledge a platform having more than just a supportive role to other capabilities and define the dynamic digital platform capability as "*the IT unit's capacity to appropriate value from the organization's IT infrastructural components*" [48]. This is done by supporting firm-level sensing, seizing, and reconfiguring activities [48]. The capability is based on the organization's supporting IT infrastructure and the IT unit's ability to change the infrastructure as required [48].

The second capability, dynamic IT management capability, is defined as "*the IT unit's ability to design and execute changes to business processes that control IT resources and practices in a manner aligned with the firm's goals and priorities*" [48]. The main purpose of this primary capability is to implement management activities that ensure effective adoption of IT by business personnel [48] and mainly addresses the results of effective adoption and exploitation and not how to link the role of IT infrastructure to business processes.

The final component, dynamic IT knowledge management capability, Li and Chan [48] define as "*the IT unit's capacity to facilitate firm-wide IT knowledge creation, transfer, and retention*". The focus of this capability is solely orientated on the influence of effective knowledge management practices, but not on how the IT infrastructure (technology platforms) should be utilised to realise these practices.

From the DITC framework the only capability that addresses how to utilise, and the effect of successful implementation of, digital/technology platforms is the dynamic digital platform capability. Based on this realisation the researcher decided to only focus on this primary capability. For the dynamic digital platform capability Li and Chan [48] propose three ordinary (or zero-order) capabilities, namely IT infrastructure functionality, IT integration capability and IT infrastructure flexibility [48].

Figure 3.10 shows an extract from their DITC framework showing the hierarchy structure between the different capabilities relating to digital/technology platforms.

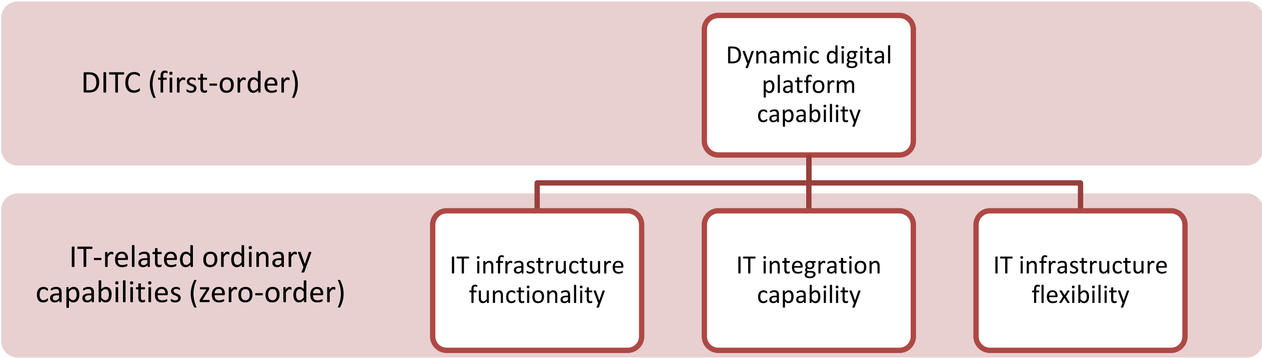


Figure 3.10: Dynamic Digital Platform Capability Hierarchal Structure [48]

For the DITC framework, digital platforms are seen as the backbone of service, products, and operations of modern organizations [48]. Beyond the capability's ability to allow the IT unit to appropriate value through firm-level sensing, seizing, and reconfiguring activities, the dynamic digital platform capability also allows IT units to:

- Create new and unique value creation paths [48],
- Refine operational efficiency [48],
- Provide access to external resources and capabilities [48], and
- Enable more participating engagement for example innovation sharing [48], [60]–[62]

The three zero-order capabilities are based on the expectations to handle turbulent environments [48]. A description of each capability is given below.

IT infrastructure functionality

The capability's main goal is to ensure that adequate IT functionality is provided and is defined as "*the capacity of an organization's IT infrastructural components to support daily business activities*" [48]. As the definition indicates, business processes have become heavily dependent on IT operations and require superior IT infrastructure functionality to effectively exploit opportunities and successfully realise ambitious strategic objectives [48].

IT integration capability

The IT integration capability indicates the capacity of and IT unit to adapt the compatibility of the existing IT infrastructure to ensure smooth intra- and inter-firm coordination [48]. The intra-firm integration relies on the IT unit to break down the different departmental system silos and to develop, connect and streamline company-wide processes [48]. The inter-firm integration refers to a company's ability to effectively exchange information in a timely manner with external value chain partners [48].

IT infrastructure flexibility

The final zero-order routine that forms part of the dynamic digital platform capability group-set is, IT infrastructure flexibility, which aims to maintain an company's resilience to disruptions and satisfy IT infrastructure scaling needs [48]. These scaling needs include extending the nature and scope of technological capabilities to stay adaptive [48].

Li and Chan [48] define this capability as "*the extent to which an organization's existing IT infrastructural components can readily be scaled, reconfigured, and aligned to meet different business objectives and technology requirements*" [48].

The three zero-order capabilities included in the primary dynamic digital platform capability give a good indication of what is necessary to implement platforms in a company and how to divide the activities required to run the IT infrastructure from a capabilities perspective. The work conducted by Li and Chan [48] is a culmination of IT literature and dynamic capabilities, but as stated in the introductory section of this paper, technology platforms require companies to adopt a different business model to that of traditional linear businesses and the DITC framework does not bring into consideration this fact. Additionally, the DITC framework does not bring into consideration the platform ecosystem and the importance of successful governance thereof. The framework addresses how a technology platform should be implemented and still adopts a supportive perspective on the businesses processes and does not address the enabling nature of technology platforms on a business's capabilities.

3.4.6. Conceptual Analysis Conclusions

The conceptual analysis of the primary studies led to the researcher gaining a more in depth understanding of technology management capabilities, by identifying and defining important concepts surrounding TMC and its relations with technology platforms. The analysis aided in determining which further research avenues should be followed and understanding how technology platforms are addressed in existing TMC literature. There are multiple limitations pertaining to this systematized literature review. The first is that a single online research database, Scopus, was used to conduct the search. This was due to Scopus yielding enough studies to answer the research questions of this review and help familiarise the researcher with the research landscape, identify key concepts and act as a guide for further research avenues. The point of this systematized literature review was to limit bias when identifying and analysing primary studies, but it did not eliminate it, due to the review being conducted by a single researcher.

3.5. Chapter 3 Summary

The systematized literature review underlined the importance of understanding not only technology management capabilities, but also its supporting activities and how the processes/routines in each KNIT management set are intertwined in a multidimensional structure. The three management capabilities and their identified routines will aid in determining which type of practical tools should be considered during the further literature investigation. By analysing the existing TMC literature that addresses technology platforms the researcher could identify the need for research regarding the management of technology platforms and platform ecosystems from an enabling perspective and adopts TMC concepts. Key authors in the research area were also identified during this review whose work should be considered during the conceptual literature review in Chapter 4.

The eight main conclusions that can be taken away from the systematized review are: (1) the key concepts identified, (2) the most frequently reoccurring concepts, (3) the hierarchal structure of dynamic capabilities, (4) the need to identify practical management tools to be implemented during TM routines, (5) the gap in existing literature within developing countries, (6) the identified TM routines, (7) technology platform as an infrastructure capability, (8) the importance of functionality, integration and flexibility of technology platforms. These eight conclusions form the building blocks for further research and are illustrated in Figure 3.11.

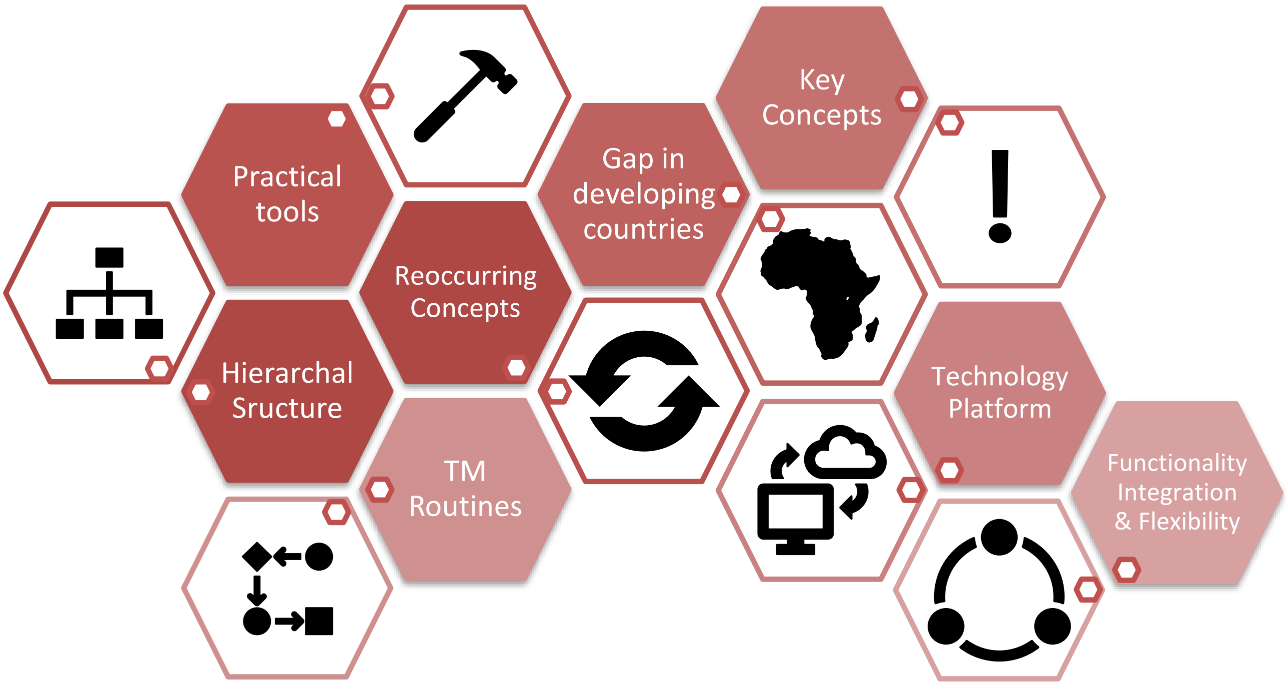


Figure 3.11: Further Research Building Blocks

The first and second building blocks concentrate on identifying the reoccurring and key concepts from the primary studies. These concepts will act as crucial elements to include in the proposed framework. The three most reoccurring concepts identified were strategy, competition, and innovation. The researcher used it as a basis to further investigate and identify the key concepts of technology management capabilities and their relation to technology platforms. The third building block embodies the substantiated gap in the existing literature where research is needed on technology management capabilities within developing countries.

The next five building blocks all relate to the crucial background information needed to create a framework that integrates technology management capability literature with technology platforms. The analysis of the data revealed that the capabilities within a company are ordered in a hierarchal structure where higher order dynamic capabilities are required to create, organise, and manage lower order normal capabilities.

The review helped the researcher identify current technology management routines which are widely referred to in the existing literature and can be implemented in the framework. Although the existing research is extensive in arranging these routines in unambiguous frameworks, there is no research that has been conducted where they are integrated with practical management tools and techniques.

Final two building blocks connect technology platforms with technology management capabilities, where platforms are defined technology infrastructure capabilities themselves and contain lower order capabilities regarding the functionality, integration, and flexibility of the technology platform. These building block also includes the interconnected relationships between TMC and technological capabilities that should be taken into consideration. The following chapter includes the conceptual literature review that discusses these concepts more in depth.

Chapter 4

Conceptual Literature Review

Chapter 4 key objectives:

- Give a clear description of technology platforms and surrounding ecosystems,
- Identify existing management tools for technology platforms,
- Define dynamic capabilities,
- Clarify the difference between dynamic and normal capabilities,
- Discuss how technology management is a dynamic capability,
- Investigate the roles of supporting capabilities,
- Highlight the influence of different capability relationships,
- Identify and discuss technology management routines,
- Discuss capability maturity and measurement,
- Investigate the different views of TM in developed and developing countries,
- Investigate existing technology management tools,

Chapter 4 forms the second half of the theoretical phase of this study and includes the conceptual literature review. During this review, the fundamental concepts related to technology platforms, their surrounding ecosystems and management considerations are identified and discussed, and the concepts identified during the systematised literature review are elaborated on. The chapter opens with an in-depth discussion about technology platforms, their surrounding ecosystems and identifying existing management tools. It continues by forming an understanding of what dynamic capabilities are and how they relate to the business management processes. Subsequently, technology management as a dynamic capability is examined. This leads to analysing the roles of knowledge management and innovation management as supporting activities in relation to technology management and identifying various technology management routines. The chapter concludes with a look at the concept of capability maturity, its relation to TM and manner of measurement, and existing technology management tools and techniques.

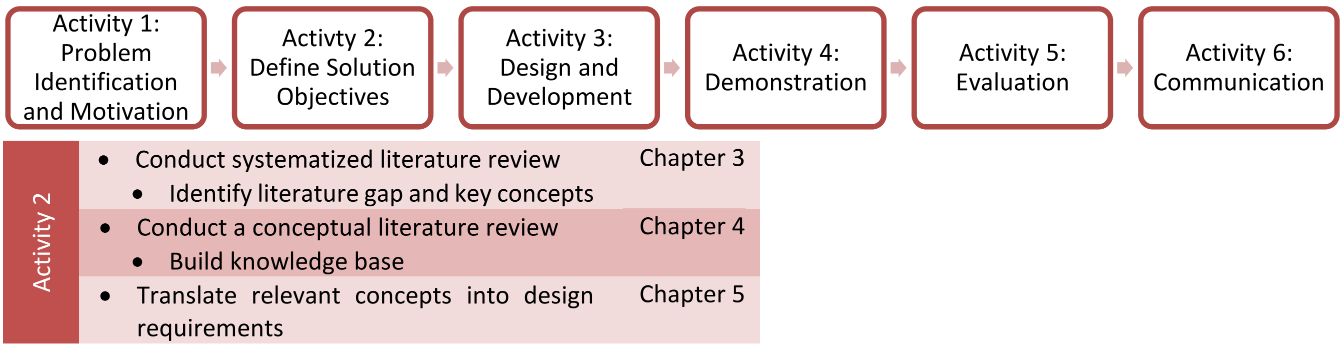


Figure 4.1: Research Context Diagram - Chapter 4

4.1. Technology Platforms

4.1.1. Platform Perspectives

From existing literature there are two perspectives of platforms that are commonly used, namely an economic or transactional view, or an engineering or technological view [63], [64]. The economic or transactional perspective focuses on platform competition, where the platform performs as a channel of communication and facilitates interactions between various categories of consumers [63]. The value generated on these platforms are based on the platform's pricing strategy [5], [63]

This view is summarised by Parker et al. [5], who define an economic of transactional platform as, "*a business based on enabling value-creating interactions between external producers and consumers. The platform provides an open, participative infrastructure for these interactions and sets governance conditions for them. The platform's overarching purpose: to consummate matches among users and facilitate the exchange of goods, services, or social currency, thereby enabling value creation for all participants*" [5].

The engineering or technological perspective on the other hand focuses on platforms as being purposefully designed, modular, technological architecture [63]. Here the main focus is on platform innovation where the platform acting as a base where innovation occurs on its modules [63].

Research conducted by Tiwana et al. [65] focus on platforms from an engineering or technological perspective and define them as a, "*software-based platform as the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate*". Examples of such platforms are Apple's iOS and Mozilla's Firefox browser [65]. An issue with this view is that it only addresses a platform as a piece of software and does not bring into consideration the platform as a business model [66].

Herman [22] continues by comparing the two platform perspectives as shown in Table 4.1 below.

Table 4.1: Platform Perspective Comparison [63], [66], [67]

	TECHNOLOGY/ENGINEERING PERSPECTIVE		ECONOMIC/TRANSACTIONAL PERSPECTIVE	
Purpose(S)	Value co-creation, innovation		Matching users, facilitating exchanges	
Platform Examples	Closed development	Fitbit, Salesforce	Payment platform	Paypal, Snapscan
	Controlled development	iOS, Windows	Product/services market platorm	Amazon, Ebay, Uber, Airbnb
	Open development	Linux, Android	Social networking platform	Facebook, Linkedin, TikTok
Relevant Variables	Openness, control, boundary resources, innovation rate, platform adoption, platform stickiness		Market sides, network effects, competitive strategy, platform adoption	

As these two views dominates platform literature Schreieck et al. [67] analysed the existing research and noted that both views did not encapsulate the full scope of platform ecosystem design and governance.

They found that research adopting the economic/transactional view focused less on control, openness, and technical design and the research adopting the engineering/technological view did not address pricing, revenue sharing or competitive strategy [67]. They conclude their research by recommending these two views be integrated stating that no platform-based business can be completely described by a single one of these perspectives [67].

This integrated sentiment is echoed by the research conducted by Gawer [63], who identified a commonality between the two perspectives in that value is created through economies of scope in supply and/or in demand [63]. They conclude their research by rather conceptualizing a platform from an organisational perspective which includes three critical components, namely:

- Platforms form an evolving organisation with the aim to coordinate innovative agents who compete [63].
- The value created through the platform is based on enabling and harnessing economies of scope [63].
- A modular technological architecture is used as the platform structure [63].

4.1.2. Platform Types

A global survey conducted by Evans and Gawer [68] shows that there are mainly four types of platforms. These four types are classified as namely transaction platforms, innovation platforms, integrated platforms, and investment platforms [68] and are described below.

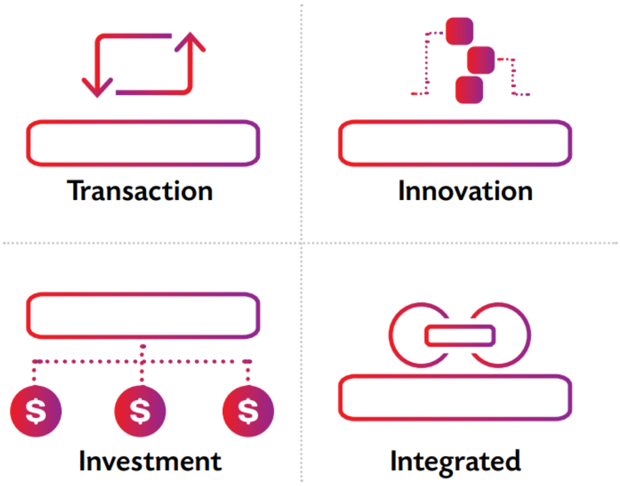


Figure 4.2: Four Platform Types (Copied from [68]**)**

Transaction Platforms

Evans and Gawer [68] define a transaction platform as "*a technology, product or service that acts as a conduit (or intermediary) facilitating exchange or transactions between different users, buyers, or suppliers.*". This type of platform correlates with the economic/transactional perspective of platforms as discussed in Section 4.1.1.

Innovation Platforms

Innovation platforms provide a foundation where multiple firms can interact within a loosely organized innovative ecosystem to develop complementary technologies, products or services [68], and correlates with the engineering/technology perspective of platforms Section 4.1.1.

Integrated Platforms

Integrated platform acts as both a transaction platform and an innovation platform [68]. Apple can be used as an example of utilizing integrated platforms by "*matching platforms like the App Store and a large third-party developer ecosystem that supports content creation on the platform*" [68]. This type of platform correlates with the integrated perspective proposed by Schreieck et al. [67]. Evans and Gawer [68] add that both transaction- and innovation platforms are moving towards becoming integrated platforms.

Investment Platforms

Investment platforms consist of "*companies that have developed a platform portfolio strategy and act as a holding company, active platform investor or both"* [68].

4.1.3. Technology Platforms within this Study

As per the recommendation of Schreieck et al. [67], this study adopts the integrated platform approach. This approach was chosen for three reasons. The first is due to the fact that the existing literature for both transactional and innovation platforms lack crucial concepts needed to understand how platform-based businesses run [67]. Secondly, investment platforms are not relevant to this study. Finally, as most transactional and innovation platforms are moving towards becoming integrated platforms [68] the research conducted during this study will have a larger contribution to platform literature.

The definition that will be used throughout this study is that of Gawer and Cusumano's [69] which states that platforms are technologies "*that act as a foundation upon which external innovators, organized as an innovative business ecosystem, can develop their own complementary products, technologies, or services*" [69], where technologies refer to software platforms. Therefore, for the remainder of this study, technology platforms will be synonymous to software platforms.

Section 4.2 looks at the "*innovative business ecosystem*" and the different actors that form part of it.

4.2. Platform Ecosystems

4.2.1. Business Ecosystems and Software Ecosystems

A business ecosystem, as defined by Rong [70], is "*a loosely connected business community composed of different levels of organisations such as industrial players, associations, governments and other relevant stakeholders, who share a common goal and co-evolve, with the purpose of dealing with uncertain business environments*".

Figure 4.3 on the following page shows the different business ecosystem characteristics in an interactive framework as proposed by Peltoniemi [71].

From the framework, business ecosystems are characterised by large number of participants who are interconnected, where they share each other's fate and having interactions between them that can either be competitive, cooperative or both [71]. The individual firms are capable of conscious decisions on their own behalf and take advantage of other participants and their capabilities to be innovative and gain commercial success [71]. Finally, a business ecosystem can be seen as a dynamic structure as it is linked to its environment which tends to change rapidly and unpredictably [71].

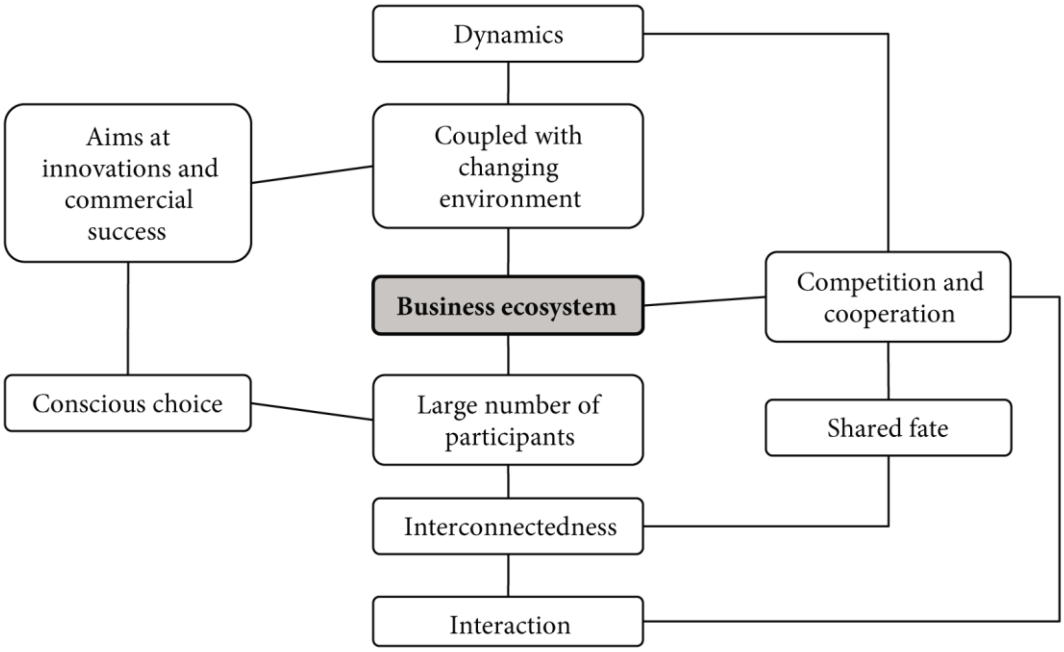


Figure 4.3: Business Ecosystem Characteristics (Copied from [71]**)**

To determine how well the ecosystem is functioning the business owner should look at the 'health' of the ecosystem [72]–[74]. Iansiti and Levien [74] defined three metrics by which the ecosystem health can be measured which are widely used [71]–[73]. The three metrics are robustness, productivity and the ability to create niches and opportunities for new ecosystem participants [74].

Software ecosystems (SECO's) form a subset of business ecosystems [73]. Jansen, Finkelstein and Brinkkemper [75] define a SECO as a "*set of actors functioning as a unit and interacting with a shared market for software and services, together with the relationships among them. These relationships are frequently underpinned by a common technological platform or market and operate through the exchange of information, resources and artifacts*" [75].

4.2.2. Software Ecosystem Characteristics

As stated earlier, software ecosystems form a subset of business ecosystems [73]. This is due to software ecosystems sharing many characteristics with business ecosystems, but also having differing features. Software ecosystems not only consist of the participants/actors and their connections, but also include the software involved [73]. As this is the case, both the software components and the participants/actors can influence the ecosystem health [73]. Referring Jansen et al.'s [75] definition of a SECO, due to the ecosystem consisting of a set of actors that function as a unit Jansen and Cusumano [73] argue that the success of a product software company now depends on both its own development quality and the way it manages its relationships [76].

The governance of a software ecosystem is usually the responsibility of one or more coordinating parties who profit when the ecosystem thrives [73]. Baars and Jansen [77] define SECO governance as the "*procedures and processes by which a company controls, changes or maintains its current and future position in a SECO on all different scope levels*". In most cases, the underpinning technological platform on which the ecosystem is based is also controlled by these same coordinating parties [73]. Jansen and Cusumano [73] go as far to say that the role of these technology platforms in software ecosystems are 'undeniable' [73].

This role is evident as platform governance is required for the ecosystem to function together as a unit and equally how the value of the platform increases as more complementary services are added and more users are attracted [69], [73].

Jansen, Finkelstein and Brinkkemper [75] argue that the actors within a SECO should be divided into three levels, namely the software ecosystem level, the software supply network level, and the software vendor level. For their research, Koch and Kerschbaum [78] refer to a similar number of actors for a software ecosystem perspective surrounding smartphones, but rather name them the platform owner, app developers and end-users. For this study the three level perspective will also be implemented as recommended by Jansen et al. [75], but the naming convention used by Koch and Kerschbaum [78] will be adopted due to its simplicity.

4.2.3. Software Ecosystems within this Study

As Gawer and Cusumano's [69] definition for a technology platform includes, "*…external innovators, organized as an innovative business ecosystem…",* and that, in this document, a technology platform is synonymous for a software platform, the researcher will view the platform ecosystem as a software ecosystem that develops around a technology platform. Researchers widely adopt this perspective to try and understand the operation of the interconnected firms via a common technological platform [79].

Thus, further in this document, platform ecosystem will be synonymous to software ecosystem.

Additionally, based on the research conducted by Jansen and Cusumano [73] the governance within the ecosystem will be the responsibility of a single entity, namely the platform owner.

4.3. Technology Platform Actors Governance

The success of technology platform is directly linked to overall health and evolution of the surrounding ecosystem which is dependent on the management of complex relationships between the participants/actors [74]. Due to the ecosystem building around the platform it is the responsibility of the platform owner to govern these relationships and maintain the ecosystem health [75].

Although the platform owner needs to govern the relationships between the different actors, they also need to allow a degree of freedom for value creation between the developers [80], [81]. Iansiti and Levine [74] adds that, "*Outside complementors will be attracted to the platform if there is option value in the complements, provided the platform owner does not expropriate all the value they create*." Thus, the platform owner needs to distribute the value created by the developers instead of taking it all for themselves.

To further understand the value creation and distribution within an ecosystem Koch and Kerschbaum [78] argue that for in terms of user and open innovation, the app developers and end users form the most important actors in the ecosystem. By adding the end-user perspective, the researcher can also trace the value creation and delivery from the platform to the final users [22].

Therefore, for platform management it is important to understand how the different actors (Platform owner, developers, and end users) benefit from adopting the platform and becoming part of the platform ecosystem. In their book Tiwana [8] proposes different channels of value that the three ecosystem actors can benefit from and is given in Table 4.2 below.

Table 4.2: Ecosystem Actors Platform Adoption Benefits

ECOSYSTEM ACTOR	VALUE GAINED FROM PLATFORM ADOPTION
Platform owner	More distributed channels of innovation.
	Majority of risks are transferred between ecosystem participants.
	Capturing the long-tail (Selling low volumes of hard-to-find items to many customers).
	Competition is more sustainable.
App developer	Technological foundations that facilitate app development.
	Lower market entry barriers for developers due to shared foundation provided by platform.
	Access to larger prospective customer pool.
End user	Service customization based on user needs.
	Faster development of innovative products/services.
	Increased competition between rivals.
	Decreased search and transaction costs.

4.4. From Linear to Platform Management Strategies

As stated in Section 1.3, platforms require unique management strategies due to their variation from traditional linear businesses strategies of upstream value creation and downstream value consumption [5].

The linear business strategies have dominated various industries for decades [4]. The companies that utilize this plan create value by implementing a linear series of activities where resources act as the input at the one end of the chain [4]. These resources then undergo a series of transformations through activities and come out as a higher valued output at the other end of the chain [4].

Although linear business strategies have shown their applicability, they do not address all the considerations for a platform business [66]. Van Alstyne et al. [4] list three key variations between linear and platform business strategies as shown in Table 4.3. The three variations are between the two strategies' view of competition, value creation optimization, and value maximization [4].

Table 4.3: Linear- and Platform Business Model Key Variations [4]

	LINEAR BUSINESS MODEL	PLATFORM BUSINESS MODEL
View of competition	*Resource control:* Gain advantage by controlling scarce resources.	*Resource orchestration:* Gain advantage through larger community interactions.
Value creation optimization	*Internal optimization*: Optimize chain of product activities to increase output.	*External interaction*: Facilitate interactions between external producers and consumers.
Value maximization	*Focus on customer value*: Maximize the lifetime value of individual customers.	*Focus on ecosystem value*: Maximize the total value of the expanding ecosystem.

Research conducted by Herman [22] further shows how platform businesses differ from linear businesses. Their findings are given in Table 4.4.

Table 4.4: Difference between Linear and Platform Businesses

DIFFERENCES	REF.
Digital technology affects value creation and distribution within the company.	[68], [82]
Outcomes from value creation between multiple stakeholders can exceed typical industry boundaries.	[8], [82]
The capacity to collect a large amount of data.	[5], [82]
The importance of feedback for platform performance and evolution.	[69], [82]
Interactions within the ecosystem affects value creation and distribution.	[8], [82]
Level of competitiveness measured by resource orchestration rather than resource control.	[4], [68], [82]
Platforms have the ability to cater to multiple user groups.	[8], [83]
Platforms facilitate interactions between external producers and consumers to create value, rather than creating value upstream and distributing it downstream	[5], [83]
Platforms have the ability to scale rapidly.	[4], [5], [8]
Both complementary products and services and users increase the value of a platform.	[5], [65], [69], [73]
Where software applications are developed on a platform, the platform acts as the resource to create value and the applications delivers value.	[84], [85]

By understanding how vastly different linear and platform businesses and business strategies are, it is clear that a business model or management tool should be created that is specifically catered for platform businesses. The next section identifies and discusses existing management tools for technology platforms.

4.5. Existing Platform Management Tools

For their research Herman [22] identified and analysed several existing frameworks, models and tools (FMT) for platforms in order to create a framework for technology platforms in the South African health context.

Each of the identified FMTs either focused on platform management and design or management of the surrounding ecosystem. The distribution of the identified tools is given below followed by a brief summary of each in the subsequent sections.

For platform management and design six FMT's were identified. These include the *Platform Design Framework* developed by Tura et al. [86], *Platform Innovation Kit* developed by Walter and Lohse [87], *Platform Design Toolkit* developed by Cicero et al. [88], *A framework for studying platform evolution* developed by Tiwana et al. [65], the *Open Software Enterprise Model* developed by Jansen et al. [89] and *the Boundary Resources Model* developed by Ghazawneh and Henfridsson [9].

For surrounding ecosystem three FMT's were identified. These include *the framework for ecosystem governance* developed by Baars and Jansen [77], *the governance model for ecosystem health preservation and improvement* developed by Jansen and Cusumano [73] and *the software ecosystem strategy assessment model (SECO-SAM)* developed by Van Den Berk et al. [90].

4.5.1. Platform Innovation Kit

The platform innovation kit developed by Walter and Lohse [87] helps businesses to initiate, design, launch and scale network-based business models. The three life stages of ventures are covered by the toolkit, namely: Ideation & Validation, Prototyping & Launch, Growth and Maturity. The toolkit consists of 3 major components. The first is the innovation-plan that will guide businesses step-by-step from ideation to scale, that consist of 11 canvases distributed as shown in Figure 4.4. The second component is a set of over 12 canvases to help facilitate discussions and teamwork. Finally, the last is an assessment component where businesses can compare their platforms to 20 best practices to help prioritise their next steps.

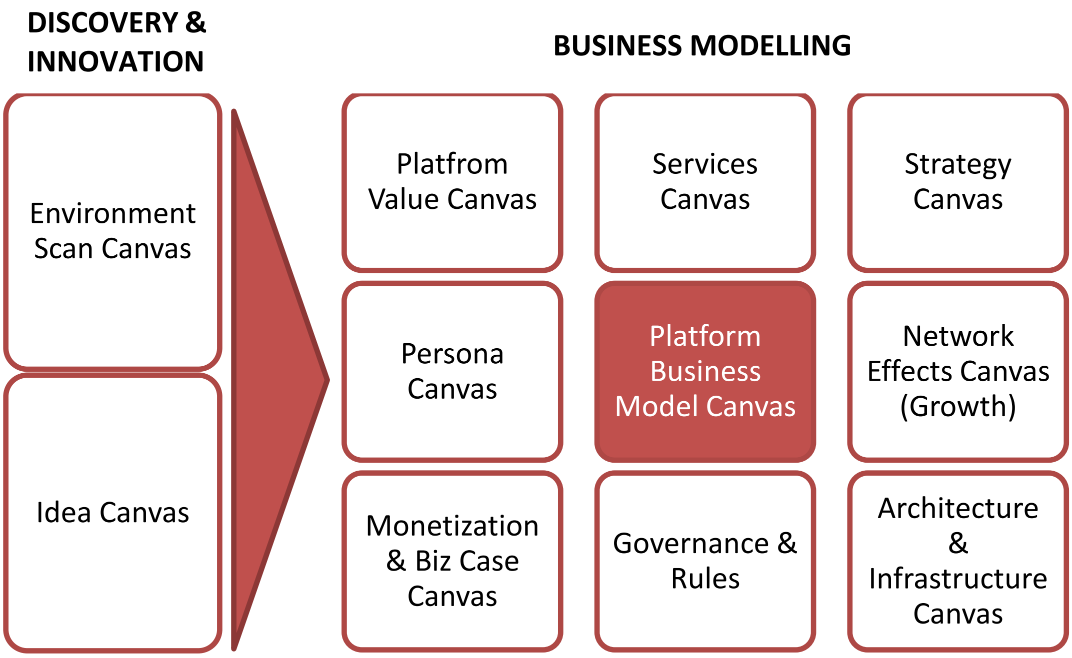


Figure 4.4: Platform Innovation Kit Canvas Overview (Copied from [87]**)**

4.5.2. Platform Design Toolkit

The Platform Design Toolkit developed by Cicero et al. [88] is made of a logical framework and a set of design canvases that helps businesses, with the aid of a facilitation guide, to design platform strategies, -products and -organisations.

Each canvas has its own function helping businesses to,

- Reflect on a specific ecosystem and align it with their platform strategy,
- Create a visual representation of the entities' potential, goals and challenges,
- Identify necessary channels and relationships,
- Aid in managing entities in the ecosystem to reach the overarching ecosystem vision,
- Create a platform business model,
- Identify and validate the riskiest assumptions regarding their business platform.

The Platform Design Canvas developed by Cicero et al. [88] gives an overview of the design process and considerations, and acts as a tool to quickly recap the ecosystem potential, and the platform strategy.

4.5.3. The Platform Design Framework

The study done by Tura et al. [86] focuses on the early-stages of platform launch and takes an explicit design perspective to platforms, addressing how platforms and their related value creation are designed, and the challenges, process and outcomes of these designs. The overarching framework for platform design involves four elements, namely: platform architecture, value creation logic, governance, and platform competition. They conclude the applicability of the framework with an empirical illustration of design choices in the Mobility-as-a-Service (MaaS) platform DORA (Door-to-Door Information for Airports and Airlines).

4.5.4. A Framework for Studying Platform Evolution

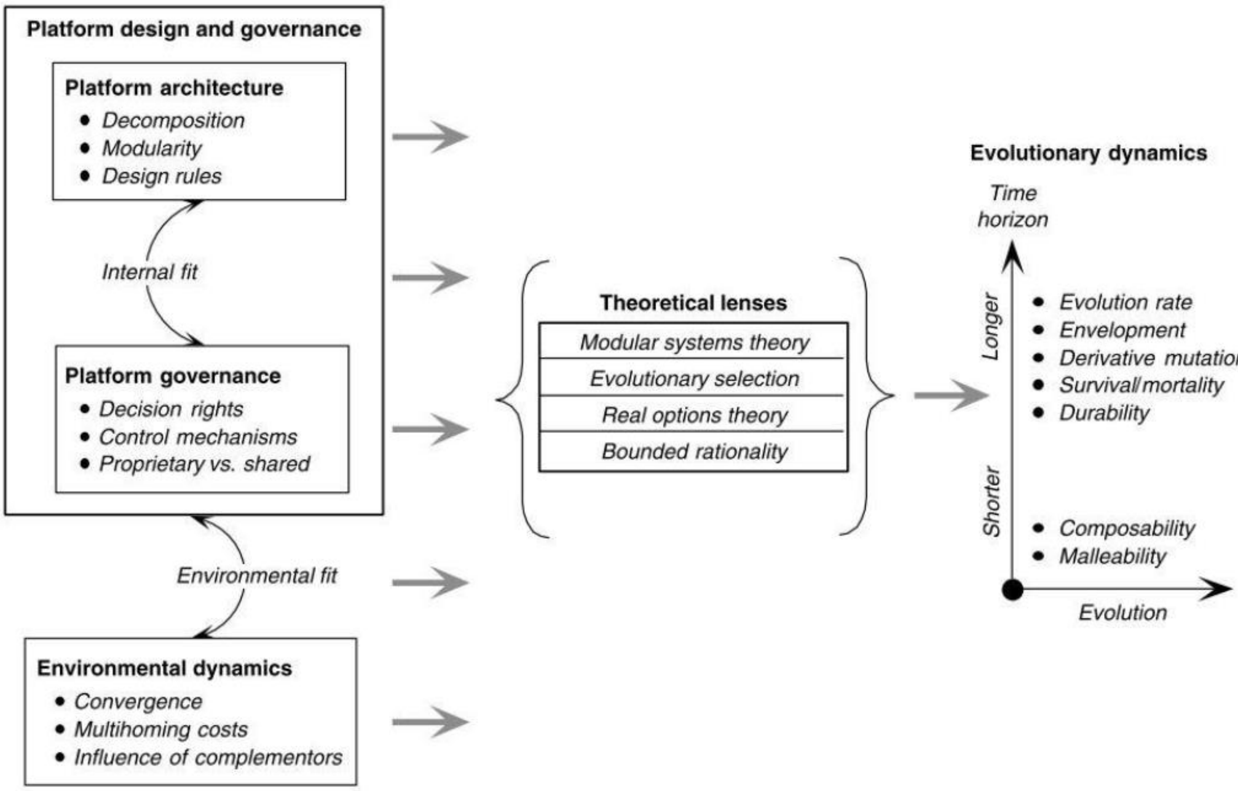


Figure 4.5: Framework for Studying Platform Evolution (Copied from [65]**)**

The study done by Tiwana et al. [65] aimed to deliver a framework that is focused rather on the developer 'level' of software-based platforms, where the platform variability involves the developer and end-consumer. The framework consists out of three sections. The first refers to platform design, governance and environmental dynamics. The second section includes four theoretical lenses which could be used for further research within this area. They are Modular Systems theory, Evolutionary selection, Real Options theory and Bounded reality. The final section consists of five long-term and two short term evolutionary dynamics criteria suggested by the researchers. The long-term criteria include evolution rate, envelopment, derivative mutation, survival and durability. The short-term criteria include composability and malleability. The developed framework is shown in Figure 4.5.

4.5.5. The Boundary Resources Model

Boundary resources (or application programming interfaces) are crucial for cultivating platform ecosystems through third-party development [9]. Ghazawneh and Henfridsson [9] concludes their research by proposing this theoretical model that is based on two drivers behind boundary resources design and use and their interaction with third-party development. The two drivers identified are resourcing and securing. The model consists of seven constructs that help understand decisions made by stakeholders in third-party development. The definition of each of the constructs and the relationship between each are shown in Figure 4.6.

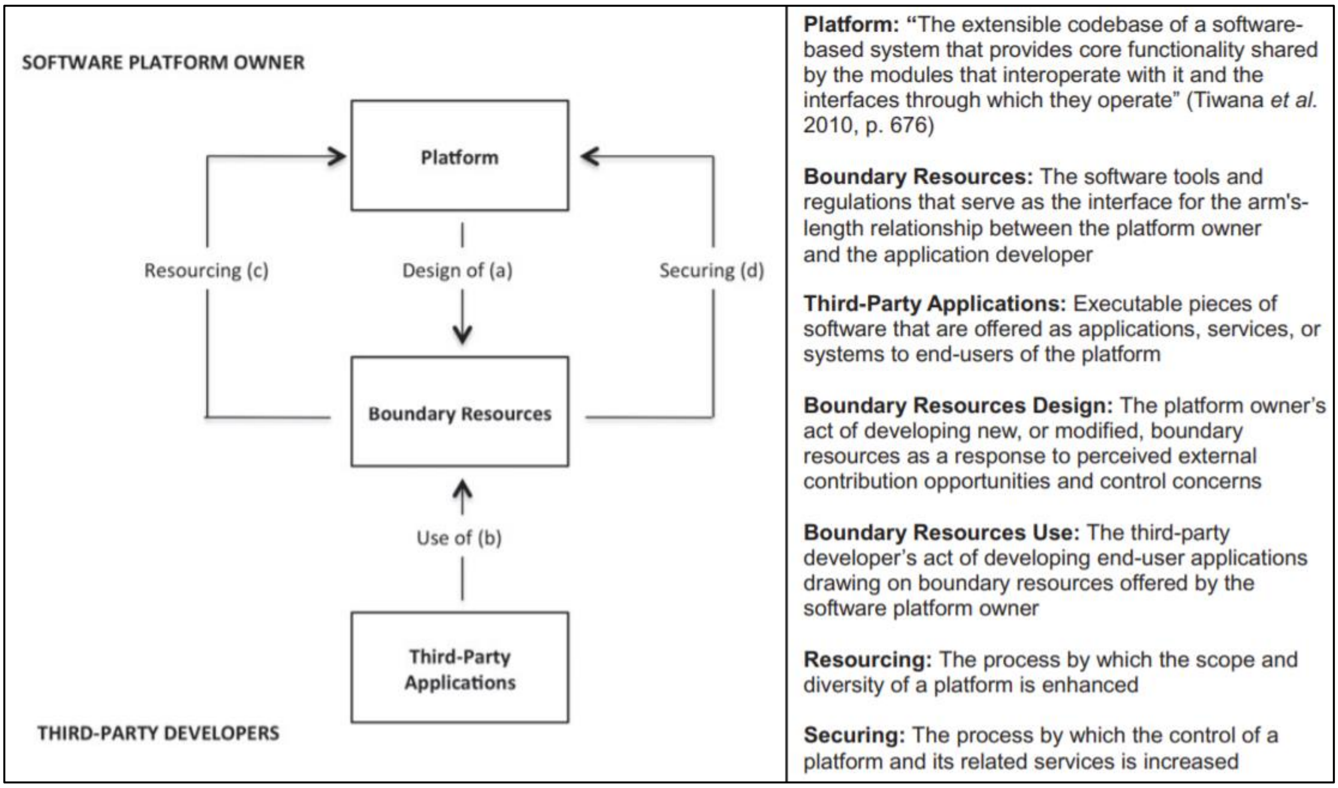


Figure 4.6: The Boundary Resource Model (Copied from [9]**)**

4.5.6. The Open Software Enterprise Model

Jansen et al. [89] produced the open software enterprise model to help software-producing organisations (SPO) determine their openness.

The model presents various openness options in a two-dimensional framework, consisting of actionable phrases to help businesses determine where to enhance and/or reduce openness. The first dimension is the management dimension that is sub-categorised into three levels namely the strategic, tactical and operations of the businesses. The second is the SPO practices dimension, derived from existing product software and SPO business process models and is sub-categorised into five levels namely the governance, research and development, software product management, marketing and sales, and consulting and support services.

4.5.7. The Framework for Ecosystem Governance

The framework for ecosystem governance was developed by Baars and Jansen [77] to help SPOs analyse and enhance their software ecosystem (SECO) in a structured way, with the main goal to improve the ecosystem health and performance. The framework has a practical structure, subdividing the main segments into various concepts and thought-provoking questions. The two main segments are governance and governance structure. The government segment places focus on the SECO processes and procedures, while the governance structure segment emphasises the SECO control, responsibility and measurement.

4.5.8. The Governance Model for Ecosystem Health Preservation and Improvement

Jansen and Cusumano [73] created a two-dimensional governance model for platform owners to determine the propriety of their SECO governance and to help formulate maintenance strategies that would ultimately lead to an improvement of SECO health. The model goes a step further by including the end-customers as part of the SECO. The first dimension consists of ecosystem health components and the second ecosystem coordinator types. The ecosystem health components, namely riche creation, robustness and productivity are linked to corresponding governance tools. The two types of ecosystem coordinators are software service platform and standard, which are subdivided into community and private entity categories. The standard ecosystem coordinator refers to the standardised interfaces enabling communication and information exchange and not a software platform.

4.5.9. The Software Ecosystem Strategy Assessment Model

Van Den Berk et al. [90] developed the SECO-SAM to define the key SECO characteristics. Ecosystem strategy is seen as an extension of platform strategy and unlike the other models, the SECO-SAM is arranged as a hierarchical tree where ecosystem health concepts are linked to human health. The main branches are four health influencing concepts, namely biology, lifestyle, environment and health care organisation. These four main concepts then branch down to various SECO characteristics.

4.5.10. Analysis of a Framework for Technology Platforms in the South African Health Context

Herman's [22] work to develop a framework for technology platforms and their surrounding ecosystems in the South African health context included extensive systematic- and conceptual literature reviews which led to an in-depth understanding of what is required to manage these platforms. The preliminary framework they developed was rigorously validated and subsequently updated using case studies and questionnaires completed by industry leaders.

The researcher has identified the research conducted Herman [22] as a reliable base to identify which concepts are critical for managing technology platforms and their surrounding ecosystems. The key concepts are disturbed throughout three canvases.

Each canvas represents the ecosystem actor that has to be kept in mind when addressing the management activity, namely platform owner, platform developer and platform user.

The key concepts are further distributed between primary and secondary categories with accompanying questions to guide the platform owner. Due to the repetition of certain terms (for example ecosystem) throughout the three canvases' categories, the questions are critical to differentiate how each key concept should be approached regarding each ecosystem actor.

A simplified version of each of the canvases are given below in Table 4-5 to Table 4-7.

Table 4.5: Simplified Platform Owner Canvas [22]

PLATFORM OWNER		
PRIMARY CATEGORY	**SECONDARY CATEGORY**	**CATEGORY CONCEPTS**
Platform Owner Firm Design	Vision	Scope, Goals, Vision, Measurement, Core functionality, Core interaction, Stability, Openness, Financials
	Integral Organisation	Key resources, Conflict management, Processes, Culture, Values and beliefs, Platform firm support
	Operations	Research and development, Support and services, Marketing and sales, Risk management, Reputation management, Investments
Platform Design	Technology Infrastructure	Stability, Scalability, Modularity, Interfaces, Interoperability, Toolkit, Openness, Feedback methods, Application type, Programming languages, Marketplaces/ distribution channels, Data privacy and security, Data types, Data governance and storage, Security, Key activities, Providers, Platform security, Platform support, Hardware requirements
	Rules and Regulations	Proprietary vs shared, Intellectual Property, Licencing, Standards
Platform Ecosystem Design	External Environment	Key trends, Market forces, Industry forces, Competition, Value chain, Macroeconomic forces
	Ecosystem	Key actors, Entry barriers, Role in ecosystem, Responsibility, Technical and socio-organisational barriers, Decomposition, Decision rights, Ecosystem health, Expectation management
Evolution		Resourcing, Securing, Sustainability, Life cycle

Table 4.6: Simplified Platform Developer Canvas [22]

PLATFORM DEVELOPER		
PRIMARY CATEGORY	**SECONDARY CATEGORY**	**CATEGORY CONCEPTS**
Entry Barriers	Technology	Accessibility, Programming languages, Toolkit, Developer type, Stickiness, Homing costs, Documentation, Standards

		and protocols, Support, Usability, Developer satisfaction, Developer context
	Mission	Trust, Reputation, Credibility, Loyalty, Fairness
	Value Configuration	Value creation, Value distribution, Pricing strategy
	Ecosystem	Market size, Markets, Envelopment, Diversity, Industry specific resistance
Ecosystem		Tensions, Partner interests, Network effects, Encourage innovation, Co-evolution, Attraction
Technology Infrastructure		Interfacing/compatibility, Feedback, HW and SW integration, Marketplace requirements, Leveraging, Developer practice, Vulnerability
Control	Rules and Regulations	Policies, Intellectual Property, Data privacy and security, Data governance
	Performance (Formal & Informal)	Control mechanisms, Design rules, Goal congruency, Monitoring and evaluation, Track user loyalty, Review process/content regulation
Support	Community Support	Online communities, Ability to share and innovate
	Platform Support	Migration convenience, Internal customer support, Design guidelines, Debugging aids, Testing support

Table 4.7: Simplified Platform User Canvas [22]

PLATFORM USER		
PRIMARY CATEGORY	**SECONDARY CATEGORY**	**CATEGORY CONCEPTS**
Technology		Application type and use, Data governance, Rules, regulations and standards, Interoperability, Intellectual Property
Proposition	Financial	Value creation and distribution, Investments and monetisation, Expected returns
	Operation	Feedback, Ecosystem communication, Monitoring and evaluation
	Evolution	Sustainability, Vision, Co-evolution, Reuse of products, Platform strategy
Context of Use		Organisational context, Physical context, Social context, Task characteristics, User characteristics, Country differences, Geographical context, Accessibility, Hierarchical user levels
Operation	Deployment	Setup or infrastructure costs, Adoption, Change management, Reliability and performance, Data quality, App deployment training, Support, Communication channels, Trust, Product champion
	Feedback	User data feedback, Quick updates

	Privacy and Security	Laws and regulations, Data privacy and security, Data governance
Interface	Usability	Learnability, Understandability, User requirements
	Design	Visual aspects, Level of exposure, Pricing, User comments, Other marketplace-related factors

By analysing the framework developed by Herman [22] recurring elements it had in common with the previously identified FMTs were noted. The first component that stood out was the overall layout of the framework, where the concepts were distributed throughout different canvases as with the *Platform design toolkit* and the *Platform innovation kit*.

The canvas approach has a more significant impact as it is easier to traverse and find the relevant concepts and how they link with each other. Another practical observation included the questions used to explain the different concepts used throughout the different canvases, this feature appeared in multiple of the other FMTs.

The four concepts that appear the most throughout the three canvases are: (1) Technology infrastructure, (2) Ecosystem, (3) Rules and Regulations, (4) Evolution. With technology infrastructure considerations appearing across all three canvasses, it is evident that a multistep approach is required for the technology design of the platform, where not only the requirements of the platform owner are taken into consideration, but also those of the developers and the end-users.

Ecosystem only appears between the platform owner and the developers, canvases, but different approaches are adopted between the two. From the platform owner's perspective, the activities surrounding the platform ecosystem considers what the ecosystem will look like i.e., who the key actors will be within the ecosystem and their roles, and what the entry, technical and socio-organisational barriers will be for these actors. From the developer's perspective the focus shifts to managing the relationships between the different developers within the ecosystem and how to attract new developers.

Rules and regulations are also repeated across all three canvases, amplifying the need for a platform owner to be aware of all the different stumbling blocks they might face trying to implement their platform and attract both developers and end-users. Finally, the focus surrounding evolution is clearly split between the platform and the developers/end-users. From the platform owner's perspective, the focus is aimed at how to facilitate evolution of the platform and the ecosystem. For the developers and end-users this focus shifts to encouraging co-evolution between the different ecosystem actors.

Other key components that stood out to the researcher is how the framework clearly distinguishes between the internal and external environments of the platform ecosystem, the importance of implementing the right entry barriers, the management of relationships between the ecosystem actors, and how the ecosystem health metrics defined by Iansiti and Levien [74] (productivity, robustness and niche creation) are used to determine the health of the ecosystem.

The insights gained during this analysis will aid the researcher in developing the preliminary management tool. By analysing the framework created by Herman [22] various concepts were identified that are critical to manage platforms and platform ecosystems. Furthermore, by adopting the lenses of the different ecosystem actors when addressing the technology platform concepts, the researcher can ensure that preliminary management tool will include all the necessary activities.

The following sections address technology management capabilities and concepts identified during the systematized literature study. By gaining an in-depth understanding of TMC concepts the researcher can aim to implement the theory to develop a management tool for technology platforms and surrounding ecosystems.

4.6. Dynamic Capabilities Theory

4.6.1. Defining Dynamic Capabilities

With ever growing competition, companies are constantly pushed to keep their edge on their competitors and remain relevant within the field. One of the main issues that they face is the ability to generate a sustainable competitive advantage. The Resource Based View (RBV) has been identified and adopted for years as a method to address this issue [91]. This theory argues that due to resources being valuable, non-substitutable and scarce, they are the only source of sustainable competitive advantage [91]. Teece at al. [92] argues that the problem with the resource based theory lies in that resources aren't always readily available and thus can't be truly sustainable. To address this shortfall, they propose addressing dynamic capabilities as an expansion of the resource based view and rather place emphasis on the processes that are implemented to create, organize, maintain and renew resources [92].

Due to dynamic capabilities broad and complex construct, various definitions have arisen throughout management literature [48]. The term spans various strategy research domains, including, but not limited to identifying organizational routines, garnering a competitive edge or defining managerial decision processes [48]. Li and Chan summarised all the various ways that dynamic capabilities have been defined throughout the years and noted eighteen different definitions. They continued by noting that the most frequently adopted definition of dynamic capabilities is that of Teece et al. [92], defining it as the "*ability to integrate, build, and reconfigure internal and external competencies to address rapidly-changing environments*", and so, keep their competitive advantage. This is the original definition of dynamic capabilities [48] and traces of it can be seen in all the definitions that followed [48]. Due to it being the original and its frequency of use, this definition will be adopted throughout this study as well.

The strategic perspective of dynamic capabilities was conceptualized by Teece et al. [92] in order to address two key aspects that were not covered by the existing management strategies at that time. By being 'dynamic' a company has the capacity to recondition its abilities in order to conform to a changing business environment [13], [92]. It also refers to the ability of a company to implement certain innovative responses when market shifts are time sensitive and difficult to predict with rapid technological change [92]. The term 'capabilities' addresses the second key aspect by emphasizing where a company's strategic management processes should be focused. The management strategy should rather lie in effectively modifying and incorporating internal and external resources, abilities and activities to achieve congruence with the altering business environment [92]. The dynamic capabilities perspective is most relevant in a Schumpetarian innovation-based competition environment [92].

4.6.2. Hierarchical Structure

The lack in consensus on how to define dynamic capabilities is not the only source of confusion, but also the inability to agree on how to address the relations between dynamic and operational capabilities (routines) [48], [93].

Multiple examples of existing literature propose addressing this second issue with an emerging phenomenon where capabilities are structured in a hierarchy format [93]–[95], that is dependent on four critical aspects: (1) the organisational process and routines that form part of a company's capabilities are rooted in knowledge, (2) An initial organisation of a firm's routines and resources form the input of dynamic capabilities, (3) dynamic capabilities encompass the processes that focus on transforming a company's knowledge routines and resources, (4) the output of dynamic capabilities is a reordered configuration of these operational routines and resources [93].

Winter [94] proposes that this hierarchal structure be defined by organising capabilities in a progressing order. The base 'level' or zero-order capabilities are defined as the highly patterned and repetitious operational routines that are integrated within a firm's processes [48], [93]–[96].

These zero-order capabilities can also be defined as a firm's ordinary capabilities [93]–[96]. It is widely understood that these routines lie at the root of dynamic capabilities theory [23]. Levin and Barnard [46] identified some of the definitions used to describe routines and is listed in Table 4.8 below.

Table 4.8: Organisational Routines Definitions Identified by Levin and Barnard [54]

NO	DEFINITION
1	Organizational routines are defined as 'the regular and predictable behavioral patterns within firms that are coping with a world of complexity and continuous change'.
2	Routines are a coordinated, repetitive set of organizational activities.
3	Routines are often seen as the building blocks of organizational learning and knowledge management.
4	Routines can be designed specifically to enhance innovation and thereby form the basis for dynamic capabilities.

Dynamic capabilities encompass the higher-order 'levels', with first-order capabilities mainly focusing on the processes that create, rearrange or evolve a company's ordinary capabilities [93]–[96]. The efficiency of first-order dynamic capabilities may diminish as the ordinary processes evolve or novel situations arise, requiring second-order dynamic capabilities to create or adjust first-order dynamic capabilities in order to adapt [94], [95].

The lifespan of second-order dynamic capabilities is directly linked to their necessity. As the efficiency of first-order dynamic capabilities are restored and able to address new market changes, or if the second-order dynamic capabilities are unsustainable, the second-order capabilities become unnecessary and a company can return to only focusing on first-order dynamic capabilities [94], [95]. Figure 4.7 on the following page illustrates a typical capability hierarchy structure.

By understanding the different levels of dynamic capabilities, it is surmised that they can be conceived as not only a firm's competencies, but also its embedded routines and activities [13]. With this definition, technological capabilities can include both dynamic and operational capabilities that consist out of multiple routines/activities to achieve the variety of tasks needed to manage technology [13]. Centindamar et al. [13] used this understanding to explain how not only technological capabilities, but also technology management capabilities are dynamic, as discussed in the following section.

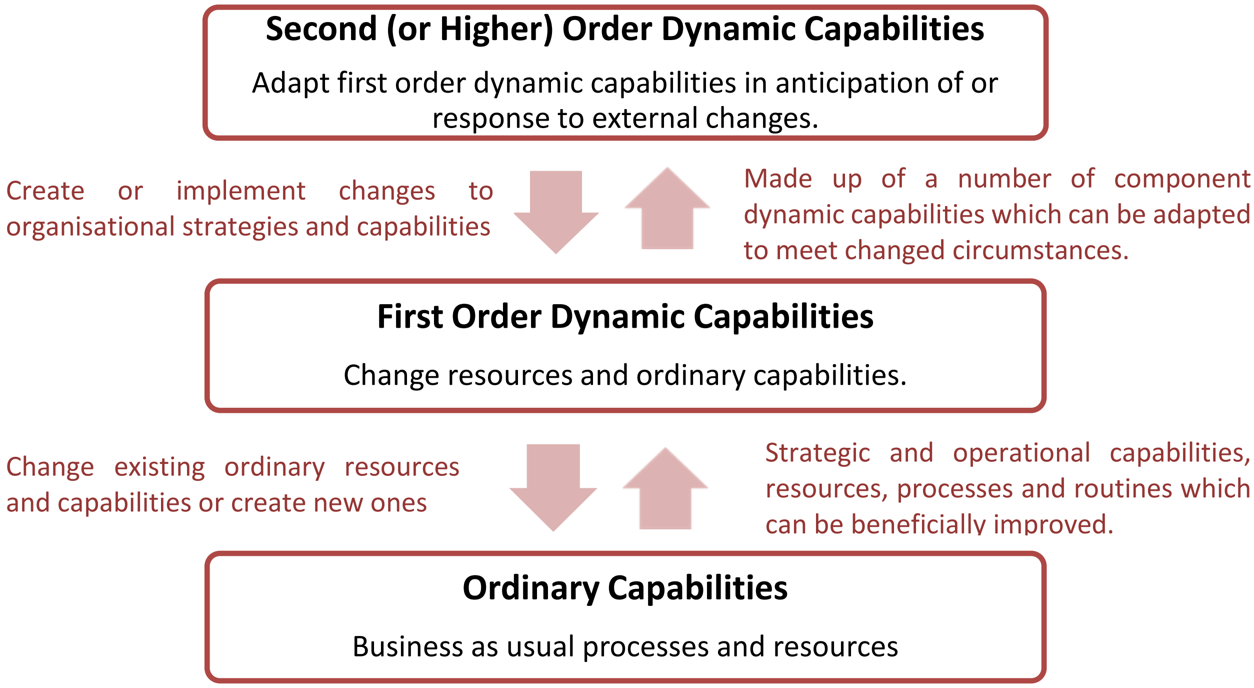


Figure 4.7: Hierarchal Structure of Capabilities (Adapted from [95]**)**

4.7. Technology Management as Dynamic Capability

Over the past 30 years technology management has become a self-sustained discipline, with initial studies mainly focusing on the research and development (R&D) activities within a company [13]. This view of TM has evolved immensely to being more strategic within three dimensions [13]. The first dimension includes the scope of TM not only focusing on R&D, but also having a corporate and strategic focus [13]. The second dimension includes how technology is portrayed more as a source of value within a business [13]. The final dimension includes associating TM with product development and the development and integration of technologies within a firm [13].

A definition frequently used to describe technology management is that it is "*a process, which includes planning, directing, control and coordination of the development and implementation of technological capabilities to shape and accomplish the strategic and operational objectives of an organization*" [11]. As stated in Section 1, this holistic understanding of TM brings into account both the 'hard' aspects of technology, such as science and technology, and 'soft' dimensions that include the technology application processes [13]. The main problem with the definition is that it is static as it does not differentiate between the managerial and technical issues associated with TM [13].

Centindamar et al. [13] argue that by analysing TM processes through the scope of dynamic capabilities, managers can gain the ability to capture new opportunities created by continuous technological change and effectively convert it into value for their firms. They list three reasons why dynamic capabilities could enhance the understanding of technology management, namely:

- Firstly, the ability to continuously generate new products, services and process changes are more crucial to sustaining long-term firm performance than specific technological innovations [97].

- Secondly, it is now possible to observe the dynamics that place within an organisation by changing the focus from highly aggregated and static models to making capabilities the unit of analysis [13].
- Thirdly, the dynamic capabilities theory sees the market and product as objects of strategic transformation and not just as a given, stressing the key role of strategic management to "*integrate, build, and reconfigure internal and external competencies to address rapidly-changing environments*" [92].

By drawing on the understanding that a capability consists out of repeatable routines that are intrinsic to a firm, so too can TM activities be regarded as capabilities due to each activity being related to technological capability, who in turn are comprised of one or more processes/routines/competencies [13]. While the processes within a company are described as a means to achieving a managerial objective, throughout the existing literature the term 'activity' is used interchangeably with process or routine [13].

4.8. Technology Management Activities

In 1995, Gregory [58] developed a model for technology management grouping technology management activities into five categories: *Identification, selection, acquisition, exploitation and protection*. These five categories have been extensively used throughout existing literature [10], [13], forming the base for various TM frameworks. A further activity, *learning*, was added by Cetindamar et al. [13] after indicating that all existing activity models at that time fell within a range of those six activities. Cetindamar et al. [13] tabulated their findings and is presented in Table 4.9.

Table 4.9: Technology Management in Existing Literature by Cetindamar et al. [13]

Cetindamar et al. [13]	**Gregory** [58]	**Rush et al.** [97]	**NRC** [11]	**Sumanth** [13]	**Dogson** [13]	**Cotec** [98]	**Roberts** [99]	**Levin & Barnard** [46]
Identification	Identification	Search, Awareness	Identification, evaluation	Awareness		Scan	Recognition of opp.	
Selection	Selection	Strategy, select-assess			Strategy	Focus		
Acquisition	Acquisition	Acquisition, building competencies	R&D	Acquisition, advancement	collaboration, R&D, NPD	Resource	Idea formulation, problem solving, prototype solution	Producing knowledge and transforming into working artefacts
Exploitation	Exploitation	Implementa-tion, exploitation	Integration, Implementa-tion, obsole-scence	Adaptation, abandonment	Commercia-lization, operation	Implement	Commercial development, utilization, diffusion	Matching artefacts with user requirements
Protection	Protection							
Learning		Learning				Learn		Org support (performance, personnel, all)

The six technology management categories as proposed by Cetindamar et al. [13] will be adopted in this study.

The definitions of each are as follows:

Identification

The identification activity is the ability to identify relevant technologies that can contribute to the value of the business [13], [58]. These could either be external technologies that are existing or emerging, or internally generated [58]. The scope of the identification process includes monitoring the market changes for emerging trends, not limiting the activity to solely technological developments [13]. The identification activity can also include the widening of the company network to include external resource or allies that would aid in the processes [58]. Important processes included in the identification activity are search, data collection, intelligence processes and auditing [13].

Selection

The selection activity involves the action of choosing which of the identified technologies are to be supported and promoted within the company [13], [58]. It considers the relevant strategic issues such as determining the extent of human or financial resources required, or how the selected option will limit future options [58]. An effective selection activity is supported by a company's assessment and appraisal capacity [13] and the criteria will be defined by various sources [58].

Important processes included in the selection activity are defining the company's technology strategy, conducting competence analysis of the company's capabilities and mapping the product 'trajectories' to determine a feasible timeline in which the selected technologies should be developed [58]. As Gregory [58] states, "*The essential task is to clearly set out the relative importance of identified technologies to the business*". The selection activity aligns technologies with the company's business strategy which preludes it, during which the strategic objectives and priorities are set out [13].

Acquisition

The acquisition activity includes the decision process to appropriately acquire and implement selected technologies [13], [58]. Technologies can either be acquired internally through conventional R&D activities, or externally [58]. There are various ways to acquire technology externally, including licensing from technology owners, forming joint venture arrangements with partners to further develop the technology, or completely procuring the technology holding company [58]. Each acquisition alternative needs to be scrutinised to determine their strengths and weaknesses which forms the supporting rationale behind the particular acquisition approach [58].

Exploitation

The exploitation activity includes the systematic conversion process of acquired technologies to generate profit or other benefits for the firm [13], [58]. Although exploitation is mainly concerned with commercialisation, it forms a wider managerial function [13]. The three aspects that need to be considered during exploitation is the technology implementation methods, the successful integration of new technologies into the existing processes and maintaining critical technologies' relevance [58]. The technology implementation methods vary with every technology acquisition source [58] as the path to technology assimilation from the internal R&D to manufacturing looks completely different to the path from external companies to the internal manufacturing department. The successful implementation, integration and maintenance of ensures the maximum 'return' and high cost recovery of the acquired technology [58]. Further processes include phased developments, refining processes and marketing [13].

Protection

This activity is concerned with protecting the knowledge embedded in the employee expertise, products and manufacturing systems [13], [58]. Strategic decisions need to be made in order to keep a competitive advantage, for example withholding features of products that may increase its functionality but give too much information away regarding the knowledge it represents [58]. It can be critical in such cases to protect the product knowledge, especially if heavy investments were made in order to create it [58]. Staff retention is also critical for a company's knowledge base [13]. The most common methods to protect knowledge is through patenting and licensing [58].

Learning

The learning activity is concerned with post-project reflection of processes and projects in order to incorporate successes in future projects and avoid future failures [97]. This final link in the product development is critical to building the firms technological competencies as it may lead to an improvement in effectiveness and efficiency of processes and garner strategy formation for future endeavours [13], [97]. Learning aligns with knowledge management [13] where it utilises internal processes to capture relevant knowledge from experience gained during its own projects and also projects led by competitors [97].

4.9. Supporting Management Capabilities (SMC)

Research done by Cetindamar et al. [13] shows how the evolution of the perception of technology management has made its concepts increasingly intertwined with those of innovation management and knowledge management. As this research overlap has become more exasperated and terms between technology-, innovation-, and knowledge management research are used more interchangeably, confusion ensued [13]. Clarification between technology, innovation and knowledge is required to understand how they overlap and their relation to each other [13].

4.9.1. Innovation Management

Innovation as a theme comes across consistently in all research literature, but at its core innovation is providing something new, should this be a new product, process or service, in such a way that the novelty is not limited to the firm, market or world [100]. By understanding innovation as such, it is clear that it encompasses much more than just being limited to technology. Innovation within an organisation can be driven by, and be implicit in, various aspects such as marketing or finances [100].

Lawson and Samson [101] define innovation capability as a higher-order integration capability [102]. As discussed in Section 4.6.2 in this study this means that the innovation capability can be seen as a dynamic capability and has the ability to bring about change and manage this change in lower order capabilities. As with TMC, the innovation capability of a firm contains core elements and processes that can be implemented within any firm [101]. The research conducted be Lawson and Samson [101] identified seven core elements that form innovation capability and have been widely used in following innovation capability literature [103]. The seven elements identified were vision and strategy, harnessing the competence base, organisational intelligence, creativity and idea management, organisational structure and systems, culture and climate, and management of technology [101].

Vision and strategy are critical to create a sustainable innovation culture within a company and are required to ensure that interest and attention within do not become too dispersed [101]. An innovative vision is the articulated target that defines organisational attention within all sections of a firm to commonly strive for [101].

The innovation strategy is then required to direct this organisational attention to achieve these targets [101]. To harness the competence base a company has to effectively direct resources through strategic resource management, encourage risk taking an entrepreneurship by employing a variety of funding channels, ensure the support of key individuals at multiple stages of the innovation process, and implement new and upcoming technology[101]. Lawson and Samson [101] adopt the definition for organisational intelligence described by Glynn [104] as "*the capability to process, interpret, encode, manipulate and access information in a purposeful, goal-directed manner, so it can increase its adaptive potential in the environment in which it operates*". It includes the ability to gather and internalise information of both customers and competitors to generate a competitive knowledge base [101].

Continuous emphasis should be placed on creativity and idea management throughout the innovation process [101]. Creativity can be defined as the generation of innovative ideas which, if managed effectively, can culminate significant process improvement or transform business strategy [101]. The favourable environment cultivated by the organisational structure and systems of a company are crucial to the success of the other innovative components [101]. Where permeable business boundaries that enforce less barriers separating functions and product groups are combined with reward systems and 'stretch' goals, the innovation processes of a firm thrive [101].

Second to last element, the culture and climate, includes a firm's ability to tolerate a manageable level of ambiguity, empowering employees by respecting and investing in them, institutionalising free time for employees to be creative, and facilitating open communication throughout the firm [101].

Finally, the management of technology element emphasizes the role of technology for innovation. To be innovative, a firm must have the ability to link their core technology strategies with both their innovation- and business strategies [101].

As suggested by Lawson and Samson [101], Djoumessi et al. [103] conducted further research to refine, validate, and test the seven concepts. They concluded that the seven dimensions of innovation capability can be refined into three dimensions, namely: institutionalising innovation, implementing innovation and stimulating innovation [101].

It is critical to understand why technology management capabilities do not include innovation capabilities, which can be summarised into two dilemmas. The first is concerned with innovation capability being a higher-order capability with its own core elements that interact with technology management activities [13]. The required technological knowledge and method of interaction is dependent on the type of innovation [13], [105].

The second dilemma is concerned with technology management activities involving some form of innovation element in itself [13]. Identification, acquisition and selection can all be classified under the vision and strategy innovation element, while learning and protection correlates with organisational intelligence.

The relationship between innovation and technology management is discussed in Section 4.9.4. Because the aim is the formulate a technology management tool, innovation management will only be regarded as a supporting activity with minimal technology management routines as discussed in Section 4.11.

4.9.2. Knowledge Management

Knowledge as a whole includes three concepts that reside within the mind: know-what, know-how, and know-why [106]. Know-how reflects its cognition or recognition; know-how describes its ability to act and the know-why includes the understanding behind it all [106]. The main objective of knowledge management is to create and distribute value within and outside a firm by utilising its knowledge resources [106]. It is a process where organisations aim to identify, generate, circulate and implement knowledge throughout the firm [13].

The concept of Knowledge Management (KM) has been identified and widely used as a method to improve the competitive ability of a company [13], [49], [107]. Although there is an abundance of research done related to knowledge management, existing literature is unable to find consensus around the terminology with different concepts being used interchangeably [107].

Table 4.10 below shows the varying terminology used in existing research for the various knowledge management processes.

Table 4.10: Knowledge Management Process Terms in Existing Literature

Li & Han [49]	**Caputo, Garcia-Perez, Cillo, Giacosa** [108]	**Beesley & Cooper** [107]	**Durst & Edvardsson** [109]	**Ologbo & Nor** [110]	**Sisson & Ryan** [111]
Knowledge Creation			Knowledge Identification	Knowledge Discovery	Accumulate
	Knowledge Creation	Knowledge Creation	Knowledge Creation		
Knowledge Organization	Knowledge Acquisition	Dissemination	Knowledge Retention	Knowledge Capture	Organize
	Knowledge Documentation				
Knowledge Transfer	Knowledge Transfer	Knowledge Transfer	Knowledge Transfer	Knowledge Sharing	Reason
		Knowledge Adoption			
Knowledge Application	Knowledge Application	Knowledge Utilisation	Knowledge Utilisation	Knowledge Application	Use

The lack of consensus has led to confusion among researchers in the field and the broader business community [107]. For this study the four knowledge management processes as defined by Li and Han [49], listed in Table 4.10, will be adopted. The definitions for each of the processes include all the elements described in the existing literature identified during this review and further related to technology platforms that form a crucial part of this study.

Knowledge creation is the ability to identify and exploit new and valuable observations, data, or facts to generate information in a format that is usable to a firm [49], [107], [108]. This process is mostly driven by curiosity, or as a response, to a problem [107]. The two forms in which knowledge can manifest within a firm are tacit and explicit [49], [107]–[110]. Explicit knowledge is easily available to individuals within a company, while tacit knowledge is found within the individuals and created through personal experience and can be difficult to impart to others [107].

Knowledge organization includes codifying and storing of knowledge into information that is meaningful and readily available to individuals within a company [49]. It is also crucial that the stored knowledge is retained and maintained in order to stay valuable [49], [109]. Knowledge retention also includes keeping individuals with certain skillsets (tacit knowledge) within the company [109].

Knowledge transfer is the process of transforming and absorbing knowledge by individuals within a company [49], [109]. Without a successful delivery process, the true potential of knowledge cannot be realised [112]. The transfer processes can be subdivided into three steps. The first is to find the required knowledge within the stored location, the second includes the communication process where the knowledge can be successfully distributed throughout the company, and finally, the knowledge is absorbed by the individual with the help of appropriate technology and measures within the company [49]. These three steps can be summarised as knowledge acquisition, knowledge diffusion and knowledge absorption, respectively [49].

Knowledge application is the effective implementation of the acquired and absorbed knowledge [49]. It is argued that the competitive advantages linked to knowledge management are due to the application of knowledge and not the knowledge itself [49], [107], [108]. The knowledge application process includes the integration of new knowledge with an individual's existing knowledge base to solve new and novel problems and generate new ideas [49]. The level of how effectively the new knowledge is implemented is crucial to the company's knowledge management capability [113].

As with innovation management and technology management, knowledge management has been defined as a dynamic process [13], [23], [49]. These four activities do not happen in turn, but interchangeably [49]. Through effective synthesis of -, and collaboration between, the four processes knowledge management capabilities improve an organisation's performance [49].

The relationship between innovation and technology management is discussed in the following section. Because the aim is the formulate a technology management tool, knowledge management will only be regarded as a supporting activity with minimal technology management routines as discussed in Section 4.11.

4.9.3. Project Management

A third and final supporting activity is identified by Cetindamar et al. [13], which is project management. They refer to project management as the "*managerial activities associated with all types of projects*" [13]. Project management concepts do not necessarily overlap with TM concepts as with innovation- and knowledge management, but rather are required to guide technology management activities as each can be seen as an individual project [13]. The necessity of project management is also flexible as smaller companies with fewer projects do not need steadfast project management processes, while it is critical for larger companies that have multiple overlapping projects [13].

4.9.4. Relationship between TM Capabilities and Supporting Management Capabilities

By examining the scope of knowledge management and innovation management above, it is clear that the two can classified as individual capabilities. Further analysis of knowledge- and innovation management's respective activities shows how, although being individual fields, knowledge- and innovation management capabilities overlap with technology management capabilities. This overlapping relationship is illustrated in Figure 4.8 on the following page.

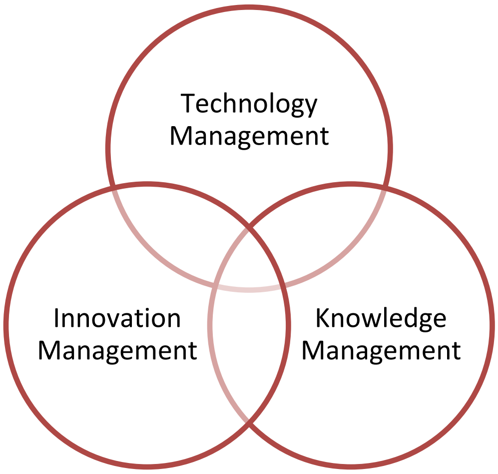


Figure 4.8: The Relationship between Technology-, Knowledge-, and Innovation Management [13]

Cetindamar et al. [13] proposes that the relationship between the primary management capabilities can be translated into their respective activities, as illustrated in Figure 4.9.

By analysing the technology management process framework proposed by Gregory [58], it can be seen that they do not explicitly link TM activities with each other. This non-linearity approach is echoed by Cetindamar et al. [13] who's model aims to avoid a static framework for TM processes and distinguishes between core TM activities and supporting activities.

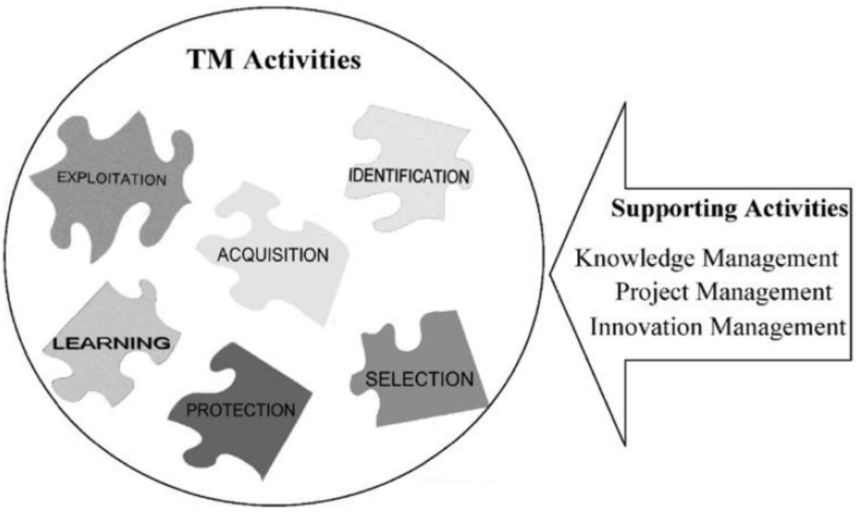


Figure 4.9: Relationship between TM Activities and Supporting Activities
(Copied from [13]**)**

This general model reflects the dynamic nature of TM activities by representing them as malformed puzzle pieces. Although it aims to avoid a hierarchal connection between the six TM activities, it supports the hierarchy theory of dynamic capabilities by grouping them in the same level with each having their own routines.

4.10. TMC and Technological Capabilities (TC) Relationships

The purpose of this section is to shine light on the intricate relationship between technology management capabilities and Technological Capabilities (TC). To understand the coupling relationships between technology management capabilities and technological capabilities it is required to understand what exactly technological capabilities are. The technological capabilities of a company encompass the knowledge-based resources within a company [48], [53]. These tacit resources are embedded within a firm's equipment, personnel and organisation [48], [53].

Existing research can be divided into three categories on how the relationships between TC and TMC are addressed. The first category includes studies that argue that the technological capabilities in a firm are key to guiding the development of TMC [114], [115]. The second category consists of literature that has a stark contrast to the first, where they argue that TMC acted as TC's catalyst, improving its efficacy and enhanced further development [13], [116]. The final category includes studies that have the view the TMC and TC are interdependent throughout their development [10], [117], [118]. Throughout a complex adaptive system, coupling refers to the occurrence where two or more subsystems act interdependently, involving different elements or functions within the subsystems, in order to co-exist and coordinate with each other [53], [119], and so forming Multidimensional relationships within the system between the distinctive elements [53].

For the product innovation system, the technological capabilities of a company only form the base of knowledge and cannot directly participate in the product innovation activities themselves [13], [116]. Technology management capabilities thus are required to catalyse the development and transformation of the technology knowledge, in order to implement and foster in new product designs [13], [116]. Although technology management capabilities are the key to the product innovation system, the technological capabilities provide the necessary knowledge to plan, develop and implement TMC elements [114], [115]. Thus, technology capabilities not only enables the technology management capabilities, but also forms to the premise of the role of TMC in the project innovation system [114], [115]. The result is that, within the product innovation system, TMC and TC are interdependent subsystems and are coupled.

Liu et al. [10] prove this interdependency during the new product development (NDP) process. The NPD can be divided into three distinct phases [120], namely: the (1) concept development stage, the (2) product development stage, and the (3) market development stage [120]. The concept development stage consists of processes where new product ideas are generated and refined, the markets are analysed and in response the products are prepared accordingly [120]. The product development stage is where the actual technical product is developed and includes testing the prototype and the market reaction [120]. The final stage, market development, is the more the after-sale support stage from market launch to personnel training [120].

Figure 4.10: NDP Stage Progression

For every stage there is a specific combination of TMC dimensions and TC components that is crucial to the stage efficiency [10].

In their paper Liu et al. [10] used the terms technological capability and technological knowledge interchangeably and listed four components throughout which the knowledge within a firm is distributed, namely: (1) human capability, (2) equipment capability, (3) information capability, (4) and organisation capability [121]. Each component is self-explanatory regarding which technological knowledge it encompasses, except for information capability which consists of the technological knowledge encapsulated within a firm by its collection of standards- and specification documents and manuals [121].

Wu et al. [117] continue by classifying the five technology management processes identified by Gregory [58] (identification, selection, acquisition, exploitation, and protection) into three dimensions, namely: (1) technology resource management, (2) technology organisation management, and (3) technology quality management. Technology resource management is a company's ability to gather, progress, distribute, apply and protect technological knowledge [117]. Technology organisation management is the company's capability to control the flow of technological knowledge within a firm and ensure that it is applied effectively [117].

Finally, the technology quality management is a company's ability to ensure that the technological knowledge application is applied correctly and predictably [117]. Liu et al. [10] proved that there are multiple TMC dimension and TC component combinations for each NPD stage that share core conditions. By analysing the core conditions, they could determine which TMC dimensions and TC components are critical for each stage. The core conditions for every stage are illustrated in Figure 4.11 below.

Figure 4.11: NDP Stage TMC and TC Combinations

By examining Figure 4.11 the multidimensional nature of the relations between technology management capabilities and technological capabilities becomes evident with how TMC dimensions and TC components are prevalent in multiple stages of the NDP lifecycle, without combinations being repeated. This variation of combinations shows how not only technology management capabilities are dynamic, but so too its collaboration with technological capabilities.

Wu et al. [53] builds on the work done by Liu et al. [10] with the aim of explaining the relationships within a system. They propose that there are two types of relationships that form between the subsystem elements. These relationships can either form on the inside or outside of the subsystem. Due to the external and internal nature of the relationships between the subsystem elements, there are four types of coupling that form and are listed in Table 4.11.

Table 4.11: Four Types of Coupling Relationships between TMC and TC Elements

Type of Coupling Relationship	Distribution of Relationships between Elements
Loose coupling relationship	Elements couple loosely within own subsystem and couple loosely with elements in another subsystem [53].
Internal loose & external tight	Elements couple loosely within own subsystem and couple tightly with elements in another subsystem [53].
Internal tight & eternal loose	Elements couple tightly within own subsystem and couple loosely with elements in another subsystem [53].
Tight coupling relationship	Elements couple tightly within own subsystem and couple tightly with elements in another subsystem [53].

Wu et al. [53] continues by adding a fourth technology management capability dimension, technology culture management, which includes the cultivation and management of corporate culture and the corporate culture strategy [53]. Figure 4.12 illustrates a conceptualisation of a system containing TMC and TC subsystems with their elements through an NKC model proposed by Wu et al. [53].

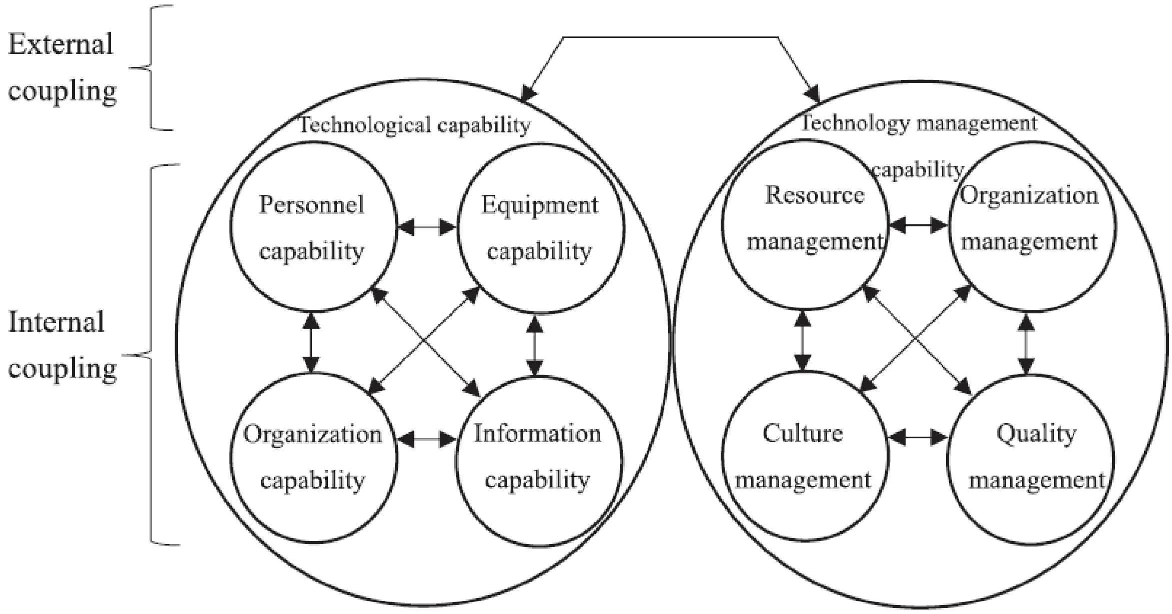


Figure 4.12: NKC Model of TMC and TC in the Product Innovation System (Copied from [53]**)**

The NKC model proposed by Wu et al. [53] shows the different coupling relationships that are possible between TMC and TC elements. The N in NKC denotes the number of elements within a subsystem, so for both the TMC and TC subsystems N is equal to four. K is the amount of internal coupling relationships an element can have at a time, with both subsystems having a minimum K value of one and a maximum K value of three. Finally, C represents the number of external coupling relationships an element can have at a time, making both subsystems have a minimum C value of one and a maximum C value of four. The NKC model is based on the widely used NK model that was originally developed to track the evolutionary patterns in biological systems [122] and then later implemented in the study of corporate management [123].

The NKC model can be used to determine if subsystem elements are tightly or loosely coupled. If a subsystem element has a high K value, then it has a tight internal coupling relationship, but if it has a low K value then it has a loose internal coupling relationship. The same goes for the C value, if a subsystem element has a high C value, then it has a tight external coupling relationship, but if it has a low C value then it has a loose external coupling relationship.

The research conducted by Liu et al. [10] shows when these coupling relationships form during the new product development lifecycle and the research conducted by Wu et al. [53] aims to explain how we can address and determine the layout and interactions of the subsystem elements within a system. Both prove the multidimensional nature of the interaction technology management capability elements/routines/activities have with the supporting management capability elements/routines/activities within a firm.

4.11. Technology Management Routines

As stated earlier organizational routines can be defined as "*the regular and predictable behavioural patterns within firms that are coping with a world of complexity and continuous change*" [124] and are regularly referred to as the building blocks of knowledge management and organisational learning [46]. This notion is echoed by Zollo and Winter [125], who's research quelled debates about how routines can be repeatable and predictable, but still facilitate innovation. Their argument is based on routines being specifically designed to foster and enhance innovation, which in turn forms the basis of dynamic capabilities [125].

Answering calls for an overarching framework for technology management, Levin and Barnard [46] created an analytically rigorous and practical framework for TM routines situated within the resource-based view of the firm. Their research aimed on identifying and describing the major TM routines in large companies [46] and has been identified to be relevant for small to medium-sized enterprises (SMEs) as well, with SMEs only having a limited amount of resources for technology management [126]. They used the data collected from field visits, working sessions with various technology managers and an extensive literature study to develop the framework [46]. Due to the input by multiple technology managers the routines were defined in a manner that is relevant and practical with some being presented in general terms and others more thoroughly delineated [46]. The result of the intensive research done by Levin and Barnard [46] were twenty-seven routines that they divided into four dimensions. The first three partially overlapping dimensions were suggested by Pavitt [124] for dividing innovation and are:

- Producing scientific and technological knowledge
- Transforming knowledge into working artefacts, conceding that although it may be technological possible it may not be practically feasible [46]
- Matching artefacts with user requirements, being internal (process innovation) or external (product innovation) [46]

The fourth dimension was added by Levin and Barnard that cuts across the three other categories, namely:

- Organisational support routines

The framework developed is presented in Figure 4.13 on the following page.

Producing scientific and technological knowledge

a) Ideation ('creative process' to develop new product/process)
b) R&D environmental monitoring (scan and analyse the external environment, especially technology)
c) R&D technology strategy (plan progression of technology to be developed by R&D)
d) R&D portfolio management (evaluate portfolio of R&D projects to achieve desired balance along different dimensions)
e) Intellectual property management (manage patents, copyright, trademarks, standards)
f) Post-project audit (discuss and disseminate lessons learned)

Transforming knowledge into working artefacts

g) Technology roadmapping (develop a plan for what technologies will be needed to support a given product/process in the future)
h) Product line planning (develop a plan for future direction of product line/platform)
i) Product portfolio management (evaluate portfolio of products to achieve balance along dimensions)
j) Feasibility (investigate the market and technical feasibility of an idea)
k) Project execution (planning, designing, staffing, and managing – the 'actual work' – of a project)
l) Technology transfer (shift ownership of artefact and accompanying knowledge)
m) Technology adaptation (absorb and adapt a technical artefact and accompanying knowledge)
n) Post-project support (provide support to adopters of technology)

Matching artefacts with user requirements

o) Business unit environmental monitoring (scan and analyse competitors, suppliers, customers, technologies, regulators, etc.)
p) Corporate environmental monitoring (scan and analyse competitors, suppliers, customers, technologies, regulators, etc.)
q) Business unit business strategy (develop business unit's plan and budget)
r) Corporate business strategy (develop company's overall plan and budget)
s) Technology needs assessment (determine what technologies current and future customers want)
t) Business unit technology strategy (determine the role of various technologies in a business unit)
u) Corporate technology strategy (determine role of R&D and technology in company)
v) Initial programme/project selection (determine if a programme/project should be funded)
w) R&D funding (determine how to fund R&D efforts)
x) New business unit development (determine when a new set of products/technologies/markets warrant the formation of a new business unit)

Providing organisational support

y) Performance management (measure and manage performance)
z) Personnel management (hire and develop skilled personnel)
aa) Technology alliance management (identify, develop and manage strategic partnerships and consortia)

Figure 4.13: Framework of Technology Management Routines by Levin and Bardnard

(Copied from [46]**)**

The graphic representation of the dimensional blocks alignment in the framework indicates the agreed upon notion that TM routines do not operate in a linear sequence and that innovation can originate from any 'starting point' [46]. The layout of the framework also represents how, within each category, the routines are connected through iterative processes and how, for different viewpoints, innovation originates and moves through the dimensions [46].

Innovation within the framework is discussed from the viewpoints of technologists, marketers and technology managers. Technologists advocate that a 'technology push' approach should be adopted, where innovation originates within the '*Producing scientific and technological knowledge'* dimension (left side of framework) and move over to *'Matching artefacts with user requirements'* dimension (right side of framework) [46]. The marketers on the other hand advocate that innovation follows a 'market pull' approach by originating on the right side of the framework and moving over to the left [46].

Finally, technology managers advocate an 'inside-out' approach where innovation originates within the *'Transforming knowledge into working artefacts'* dimension (middle of the framework) , where the technology- and market-oriented spheres overlap, and move outward to both the other dimensions [46]. Each of the twenty-seven routines identified by Levin and Barnard are described in the subsequent sections.Producing Scientific and Technological Knowledge

In addition to the overarching innovation dimension in which the routines fall, they can also be divided into routine-type subcategories. For the '*Producing scientific and technological knowledge'* category routines can either be planning- or management-routines as illustrated in Figure 4.14.

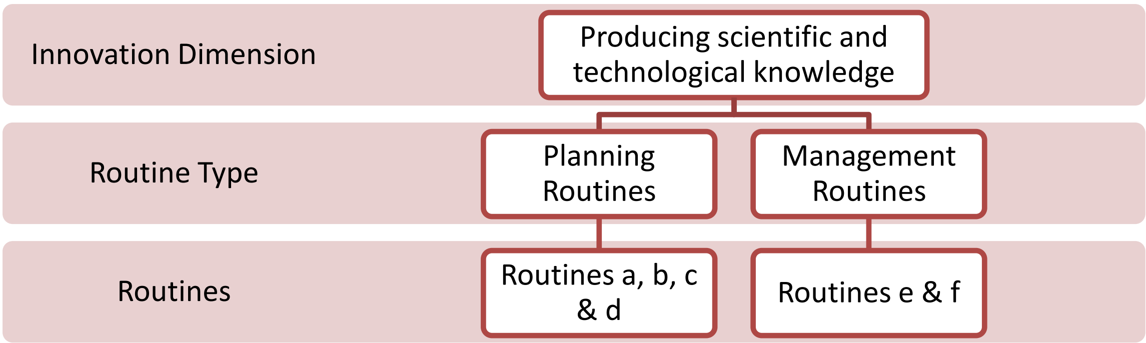


Figure 4.14: Producing Scientific and Technological Knowledge Routine Distribution [46]

a. Ideation

Defined as "*the creative process of developing a new idea or technical solution to a problem*", the Ideation routine is most reliable on R&D [46]. Although it is supported by various planning-related activities and knowledge management processes, central to this, and all the other support routines, is managing the tension between providing a supportive structure and leaving space for creativity [46].

b. R&D environmental monitoring

The external technological environment has to be constantly scanned to identify wider scientific advances [46]. The two issues that arise during this routine is the necessity to find connection points between R&D and business units who are more time sensitive, and the ability to manage a process that does not have concrete deliverables [46].

c. R&D technology strategy

As the most concrete deliverable of the R&D process, the R&D technology strategy consists of defining the scientific and technological areas to be focused on, the timeline and validity of technology plans, the level of education the R&D department is to provide to the company [46]. The formation of the company's R&D portfolio is a result of this routine [46].

d. R&D portfolio management

R&D portfolio management acts as the bridging routine between strategy and R&D projects by defining the desired balance among the various technologies and scientific fields [46]. This balance among R&D projects is heavily influenced by the number of stakeholders interested in the results of this routine and difficulty to identify project evaluation objectives [46]. To ensure the integrity of this process all projects should be evaluated, incremental and radical innovations should be balanced, and research programmes should be developed [46].

e. Intellectual property management

The management of existing assets that are codified for external parties in order to increase the potential of organisational learning [46].

f. Post-project audit

The post project audit is defined as "*the analysis of root causes of both good and bad outcomes*" and focuses on the potential of organisational learning, but more from a learning-by-doing viewpoint.

4.11.1. Transforming Knowledge into Working Artefacts

For the '*Transforming knowledge into working artefacts'* dimension routines can either be categorised as planning- or execution-related routines as illustrated in Figure 4.15.

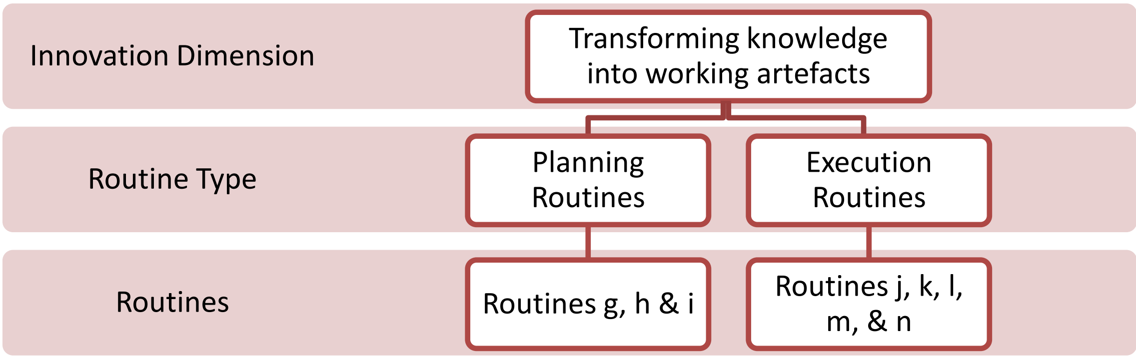


Figure 4.15: Transforming Knowledge into Working Artefacts Routine Distribution [46]

g. Technology roadmapping

Technology roadmapping is the process of identifying and developing the technological capabilities needed to support future processes and product lines [46]. It is described as the most important planning-related routine as it highlights the source of the required technology, how it will be supplied to the business unit, the expected hurdles, and resources required [46].

h. Product line planning

The business unit is responsible for providing a platform definition plan and timetable to clarify the future direction of the company's product lines or platforms [46]. This is achieved by translating the business drives into product parameters [46].

i. Product portfolio management

The process of evaluating products by business unit managers in terms of sales, investment criteria, product platforms and technology choices [46]. The results of routine feed into product line planning (h) routine [46].

j. Feasibility

Feasibility studies are typically first step in the execution-related routines that relate strongly to project management activities and involve both technical -(done by R&D) and business feasibility (done by business units) [46]. The key to successful feasibility studies is repetition [46]. This is because innovation is an iterative process and ensures that good ideas are not cut off by too much detail during the initial phases [46].

k. Product execution

The product execution routine relies on the integrated management of multiple projects' timelines and includes the planning, designing, staffing and managing of activities [46]. The main challenge regarding this routine is successfully aligning R&D projects (that typically take longer than planned or become redundant) with business unit projects [46].

l. Technology transfer

The artefact and its accompanying knowledge can be transferred from its development unit (typically R&D) to other units by means of delivering a prototype, training business unit personnel, temporarily transferring R&D personnel and other means [46]. The biggest challenge experienced during this routine is the inability of the R&D units to relinquish full control of the project [46].

m. Technology adaptation

The received artefact and accompanying knowledge need to be absorbed and adapted by the receiving unit [46]. It is critical that the receiving units prepare to effectively adopt the new technology and can be achieved by developing new skills, practices or distribution channels [46]. For technology transfer and adaptation process it is beneficial that a strong partnership exists between the R&D units and the business units [46].

n. Post-project support

The final step in integrating new knowledge is continuous post project support [46]. This routine should not be seen as an ad-hoc problem solving process, but rather a support structure to share knowledge, resolve questions and provide additional help [46].

4.11.2. Matching Artefacts with their User Requirements

For the '*Matching artefacts with their user requirements*' dimension routines can either fall under environmental monitoring or strategy formation categories as illustrated in Figure 4.16.

o. Business unit environmental monitoring

Moorman [127] defines Business unit environmental monitoring as "*bringing information about the external environment into the boundary of the organization*". This is achieved through the analysis of multiple actors including competitors, suppliers, customers, etc.

p. Corporate environmental monitoring

Rather than focusing on the products and customers, observations from multiple business units are gathered and integrated. A key consideration to keep in mind during these observations is the level how centralised the processes of information gathering, consolidation and integration should be [46].

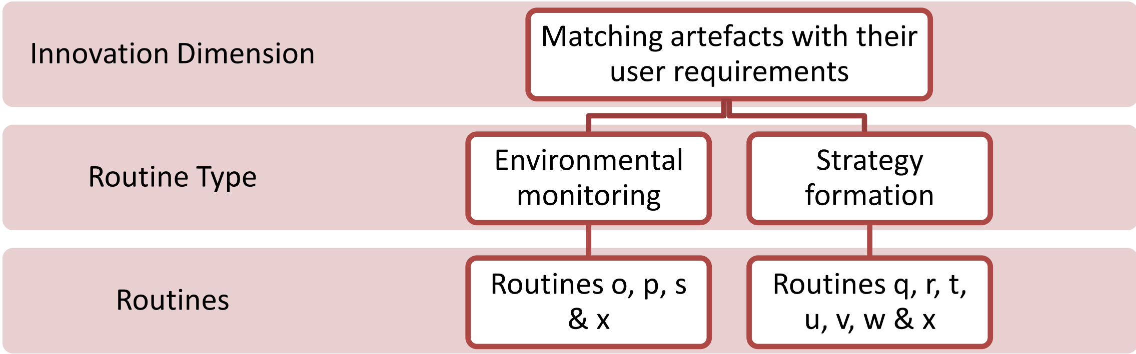


Figure 4.16: Matching Artefacts with Their User Requirements Routine Distribution [46]

q. Business unit business strategy

Business strategies formulated by the business unit in the form of plans, sales forecasts and budgets [46]. These plans and processes should be integrated with those of other business units and the corporate strategic requirements [46].

r. Corporate business strategy

Defining the overall vision and goal, while keeping true to the organisation's structure and culture and trading off between centralised – and decentralised business units and processes [46].

s. Technology needs assessment

The process of determining which technologies are currently or might in the future dominate the market pull by business units and R&D [46]. For radical innovation this process is governed by R&D, while during incremental innovation only adequate communication is necessary between a business unit and R&D [46]. To support this routine focused technology councils of managers from various functions within (or occasionally from outside) the organisation should be formed [46].

t. Business unit technology strategy

The information gathered during technology needs assessment is used to formalise a technology strategy by the business unit that is aligned with its goals [46].

u. Corporate technology strategy

The technology strategy formulated at corporate level which includes the technological focus areas, technology acquisition processes, marketing programmes, and production decisions [46].

v. Initial programme/project selection

The process of deciding whether a project should get funding or not. This routine is referred to as the 'official' start of the project and forms the centrepiece of TM, guided by the firm's portfolio goals (the firm's needs) and shaped by technology roadmapping (the firm's abilities) [46].

w. R&D funding

Levin and Barnard [46] define this routine as "*managing the level, frequency, and flexibility of funding so that both the need for stability and continuity in research efforts, and also responsiveness to business unit concerns, can be ensured*".

x. New business unit development

The process of broadening the company's abilities and products by not just focusing on one part of the market and keeping with changing market trends [46]. It is critical that the routine is coordinated with merger and acquisition activities and that constant communication is maintained with potentially affected existing business units [46].

4.11.3. Providing Organisational Support

The final dimension, '*Providing organisational support'* is not subdivided and it routines are only categorised as organisational support routines [46]. These routines are generally concerned with general managerial capabilities of the company, such as personnel, performance and technology alliance, and cut across the top three knowledge-related dimensions [46].

y. Performance management

The main goal of this routine is to reconcile the different performance management requirements of the three knowledge-related categories through measurement and management processes and developing appropriate incentive schemes [46].

z. Personnel management

Personnel management includes the hiring, training and retaining capable employees [46]. Personnel management differs from human resource routines firstly due to the intellectual freedom scientists and engineers require [46]. Secondly, specific plans need to be defined to mitigate the tension between the creation of knowledge and its commercial application [46].

aa. Technology alliance management

This routine cuts across all organisational units and involves "identifying, developing, and managing the firm's strategic partnerships and consortia" [46]. The strategy formation routines act as inputs for technology alliance management, which in turn feeds into the technological planning routines [46].

4.11.4. Relationship between TM Routines, TM - & Supporting Activities

Based on the dynamic capabilities theory and the hierarchal structure thereof, Cetindamar and Unsal [23] developed a practical framework in which they distributed the identified twenty-seven TM routines between TM activities and supporting activities.

In addition to the supporting activities discussed in Section 4.9 of this report '*Strategy Management'* was added to organise strategy related routines [23]. A further addition is the knowledge management routine as none of the twenty-seven routines identified by Levin and Barnard [36] could be grouped in the KM activity [23].

Table 4.12: TM Capabilities Framework by Cetindamar and Unsal [23]

Technology Management Activities					
Identification	**Selection**	**Acquisition**	**Exploitation**	**Protection**	**Learning**
R&D environmental monitoring	Technology roadmapping	R&D technology strategy	Product portfolio management	Intellectual property management	Post-project audit
Business unit environmental monitoring	Technology needs assessment	R&D portfolio management	Technology adaptation		
Corporate environmental monitoring	Business unit technology strategy	Technology transfer	Post-project support		
		R&D funding	Business unit business strategy		
			Product line planning		

Table 4.13: TM Capabilities Framework by Cetindamar and Unsal [23] **(Continued)**

Supporting Management Activities			
Strategy Management	**Innovation Management**	**Project Management**	**Knowledge Management**
Corporate business strategy	Ideation	Project execution	*Knowledge management*
Corporate technology strategy	Feasibility	Performance management	
Technology alliance management	Initial project/ programme selection	Personnel management	
	New business unit development		

The research done by Cetindamar and Unsal [23] also yielded a cluster analysis of the different TM routines.

The routines were grouped into three clusters where each cluster represents an interlinked set of routines that are spread throughout the core TM activities and supporting activities [23].

Table 4.14: Cluster Analysis of TM Routines by Cetindamar and Unsal [23]

Cluster 1: Technology Development Processes	
• R&D environmental monitoring	• R&D technology strategy
• Business unit environmental monitoring	• R&D portfolio management
• Corporate environmental monitoring	• Technology transfer
• Technology roadmapping	• R&D funding
• Technology needs assessment	• Corporate technology strategy
• Business unit technology strategy	• Technology alliance management
Cluster 2: Technology Exploitation and Innovation Processes	
• Product portfolio management	• Ideation
• Business unit business strategy	• Feasibility
• Product line planning	• Initial project/programme selection
• Intellectual property management	• New business unit development
• Corporate business strategy	
Cluster 3: Project Management Processes	
• Technology adaptation	• Performance management
• Post-project support	• Personnel management
• Post-project audit	• Knowledge management
• Project execution	

This cluster analysis helps understanding the interrelations between the core TM activities and routines and supporting activities and routines. Research done by Centidamar and Unsal [23] showed that companies in different industries tend to focus on different clusters.

4.12. Technology Management in Developing Countries

Technology Management as research field is mostly discussed in existing TM literature for developed countries [128], but there are studies that analyse the challenges which developing countries face regarding the implementation of technology management strategies.

4.12.1. TM Literature in Developing Countries

Multiple studies have found that there are differences between the topics investigated in developed and developing countries [13], [129]–[131]. Although the topics investigated are different between developed and developing countries, a comprehensive bibliometric analysis conducted by Cetindamar and Pretorius [129] shows that the TM literature written in developing countries are mainly based on knowledge and theories generated in developed countries. Developing countries' researchers implement the theories created in developed countries to understand the issues specific to their own country [129]. This is done by combining three major bulks of literature related to:

- "*RBV/core competencies and organizational learning*" [129],
- *"Evolutionary theorizing about economic change and growth"* [129], and
- "*Technological capabilities, technology transfer and industrialization in developing countries*" [129].

Further, various studies show that there is an uneven distribution of TM studies between developing countries [13], [129]. This uneven distribution is a result of knowledge spillovers from developed countries, the number of researchers having international networks, and technology leapfrogging [13].

- Knowledge spillovers – are a result of foreign direct investment in a country [13], with some countries (China for example) getting more foreign investment than other [13]. Local firms become more aware of international technological developments as they expand beyond domestic markets [13]. Both the technology spillovers and enhanced awareness increase academic interest [13].
- The number of researchers having international networks – influence the amount knowledge spillover to a country [13]. The more researchers with international links the higher the rate of knowledge spilllover [13].
- Technology Leapfrogging – by becoming technology leaders which increase re academic interest in the country [13].

4.12.2. TM Application in Developing Countries

The number of technology management tools and techniques used in firms are dependent on three factors [132], namely the hierarchical level of the chief technology officer (CTO) within the company, their field of education and size of the firm [132]. By implementing technology management tools and techniques they increase the extent in which they reach their growth targets [132].

Although this positive linear relationship exists, Murad and Khan [133] indicate that the innovation and technology environment in developing countries are problematic. They list the reasons for this as:

- Poor business models [133],
- Political instability and governance conditions [133],
- Low education levels [133],
- Underdeveloped physical infrastructure [133], and
- Lack of solid technology based on trained human resources [133].

In South Africa specifically the main two problems that the country faces is with determining what type of technology is appropriate and secondly the management of the technology after it has been introduced [134]. A final distinction between developed and developing countries is made by their attitude towards high-technology (HT) and low-medium technology (LMT) sectors. The leading economies in developed countries can be seen as the innovators in the HT sector, while the catching-up economies in the developing countries take on the role as imitators [135].

4.13. Capability Maturity

Wu and Yu [52] define maturity as "*the quality or state of being mature*". They apply this definition to technology management and conclude that technology management maturity refers to the "*effectiveness and perfection degree for an organization to identify, develop, manage, and control its technological capability*" [52]. A capability with a lower maturity is seen as consisting of processes that are more ad-hoc rather than defined, while a higher maturity means that the process are measured and optimized [23]. A company's capability maturity gradually progresses through subsequent levels of competencies from a lower level to a higher one throughout a process's lifecycle [136].

Maturity models are used to measure the different levels of capability maturity throughout the company [23], [52], [55], [136]. The capability maturity model (CMM) developed by Carnegie Mellon University's Software Engineering Institute is one of the earliest recorded formal maturity models and is still frequently used to assess capabilities in information technologies [23], [136]. Paulk et al. [137] defined the six stages of capability maturity in the field of information technology. These stages and their explanations are given in Table 4.15 below.

Table 4.15: IT Capability Maturity Stages and Explanations

MATURITY STAGE	EXPLANATION
Initial (Chaotic, AdHoc) [137]	Initial use of a new process, unplanned implementation [137].
Managed [137]	Agreed metrics are set out along which the process is managed[137].
Defined [137]	The process is identified as a standard business process [137].
Quantitatively Measured [137]	The outputs from the process are quantitively measured to analyse process performance [137].
Optimized [137]	Process optimization and improvement is included in the management practices [137][23].

What makes CMM so popular to use is that it can be applied to different disciplines other than IT [23]. Due to the CCM being well-known and ability for it to be applied to different disciplines Unsal and Cetindamar [23] propose that it be used to measure the maturity of TM routines. They continue by linking more mature TM capabilities with higher firm performance, making it crucial for a company to know and manage the maturity of its TM capabilities.

CMM requires technology managers to assess and rate their management processes based on the different levels given in Table 4.15 above. Once the maturity of a capability is determined the technology manager can determine if attention is required at the specific routine in order to improve its maturity or maintain it.

4.14. Technology Management Tools and Techniques

Technology management should be perceived as both knowledge and a wide variety of skills [132]. One of the most critical skills is the ability to implement managerial tools in practice [132]. Although there are a large amount of studies about which strategic tools and techniques are most often used by technology managers [132], there is a constant struggle to determine if management tools truly bring value to a company with the argument arising that they stifle creative thinking and act as a crutch [138]. This quarrel was silenced by Cetindamar et al. [132] who determined that by implementing TM tools managers have greater success in reaching the growth targets for their companies.

As the management discipline has evolved two types of tools have arisen [138]. The first are general tools that are used across sub-disciplines (for example marketing and finance) and the second are specific tools devoted to particular sub-disciplines [132], [138]. The TM discipline on the other hand has not kept up with the pace, with minimal existing literature listing tools relevant to managing technology in companies and making them difficult to operationalize [132], [138].

This is mainly due to there not being consensus in the TM discipline regarding how tools are defined, with various terms being used interchangeably [132].

A widely adopted definition for tools is that of Phaal et al.'s [139] where "*tools include devices for supporting both action/practical application and frameworks for conceptual understanding*". Due to its widespread use, this definition will also be adopted throughout this paper.

Another issue that has arisen is the that the large base of available tools isn't effectively communicated to the busy industrial community [140]. These tools can vary from established software packages to general policy guideline for R&D investment or project management practices [140].

4.14.1. Technology Management Tool Design

When designing tools multiple principles of good practice need to be followed [141]. Brown [141] identified and listed such principles and states that tools should be "*founded on an objective best-practice model; simple in concept and use; flexible, allowing `best fit' to the current situation and needs of the company; not mechanistic or prescriptive; capable of integrating with other tools, processes and systems; result in quantifiable improvement; and support communication and buy-in*".

Cetindamar et al. [132] adds that the key principles of a delineating TM toolkit are simplicity and flexibility, degree of availability and level of standardization.

4.14.2. Technology Management Tool Integration

The successful integration of TM tools is crucial for how effectively they are embedded within the business processes, communicate with each other and can solve novel problems [142]. The main issue that arises during the tool integration phase is that tools are usually presented and applied in isolation, which can lead to fragmentation [143]. As organisations grow, tools can become more dispersed across different departments, leading to tools being unable to complement one another, the repeat of knowledge-creation processes, and delivering sub-optimal results [143]. By understanding the flow of knowledge and data through the technology life-cycle stakeholders can successfully integrate tools and prevent knowledge-loss [143]. Foden and Berends [143] identify the three main dimensions of technology tool integration, namely: 1) the inputs and outputs of different tools, 2) organization and ownership, and 3) timing.

Inputs and Outputs of Different Tools

When presenting a new tool into the technology lifecycle it is critical to understand which prerequisites there are to successfully run the tool [143]. Defining the inputs help determine where it is possible to implement the tool throughout the technology lifecycle by identifying prior processes/tools/systems that achieve the correct deliverables [143]. As the deliverables of previous tools form the inputs of the new tool, so the outputs of the integrated tool feed into subsequent processes [143]. Inputs and outputs can either be tacit knowledge (knowledge residing within employees' minds) or explicit knowledge (hard data) [143].

The dynamic process of technology management can be seen as multiple sequential sets of complementary knowledge-building activities that constantly feed into one another. The result is an integrated approach to technology strategy and capability development [143].

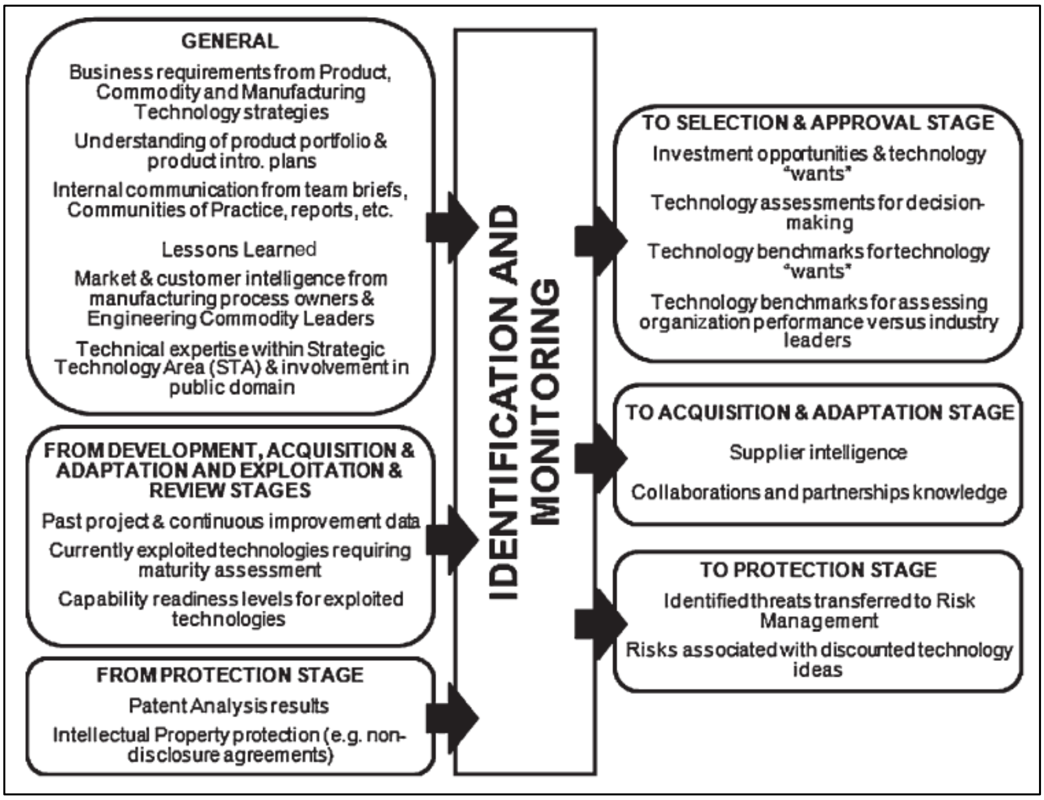


Figure 4.17: Example of Input and Output Knowledge Flow at Rolls Royce (Copied from [143]**)**

Organization and Ownership

Ambiguities and inconsistencies in organization and ownership of technology processes and tools can lead to uncertainty in who should take part in the activity and their responsibilities, frequently resulting in the duplication of work [143].

As stated earlier the tacit knowledge contained by employees act as the inputs and outputs of certain processes so it is crucial to know who should fit in where during the technology life cycle. A further benefit of specifying TM activity ownership is that it attributes to accountability and drive while harmonizing the TM process throughout the company [143].

Employees are valuable assets and their relevant knowledge and experience need to be concerted and captured through TM activities. This requires effective organization of tools, activities and people, such that the best use is made of time and resources, while supporting effective data collection within the boundaries of the activity and promoting a collaborative working environment for multidisciplinary people.

Timing

The final dimension for TM integration is timing. Effective and successful TM highly depends on implementing capabilities at the right time of the technology life cycle to prevent the misuse of tool and failure of its outputs [143]. Furthermore, knowledge and guidance are required to correctly time when to implement a capability [143].

4.14.3. Existing Technology Management Tools

Addressing the need for a list of TM tools that can be implemented in practice, Cetindamar et al. [132] sent questionnaires to fifty-two electronics and machinery firms regarding the TM tools that they implement. The identified tools were listed under eleven technology management activity dimensions, with various tools emerging in multiple activity dimensions. The eleven activity dimensions (in no particular order) were:

- Technology acquisition, transfer, dissemination
- Project management
- New product management
- Technology utilization and integration
- Technology evaluation and assessment
- Technology strategy
- Technology commercialization, marketing
- Technology planning and forecasting
- Knowledge management, organization of technological activities
- R&D management
- Technology protection, license/patent acquisition

Table 4.16 below lists the fifty tools identified by Cetindamar et al. [132] with many, like brainstorming, training and teamwork, being self-explanatory and easily implementable and others, like critical path method (CPM) and Electronic Data Interchange (EDI) needing beforehand training and experience to be successfully utilized.

Table 4.16: TM Tools Utilized in Turkish Industry [132]

TM Tools/Techniques	TM Activities
Expected value-success matrix	Technology evaluation and assessment
Brainstorming	Technology strategy R&D management
Copyright	Technology protection, license/patent acquisition
Critical path method (CPM)	Project management
Electronic Data interchange (EDI)	Knowledge management, organization of technological activities
Training	Technology utilization and integration
Excel	Project management
Utility Model	Technology protection, license/patent acquisition
Intellectual property rights (IPR)	Technology commercialization, marketing Knowledge management, organization of technological activities
Observation, tracking	Technology acquisition, transfer, dissemination
Hierarchical decision trees	Technology evaluation and assessment
Relationship management	Knowledge management, organization of technological activities
Statistical decision models	Technology acquisition, transfer, dissemination Technology planning and forecasting
Quality circles	Technology utilization and integration
Decision trees	Technology strategy

Cost-profit analysis	Technology acquisition, transfer, dissemination
Resource planning	R&D management
Benchmarking	Technology acquisition, transfer, dissemination Technology strategy
Licensing	Technology protection, license/patent acquisition
Brand registration	Technology protection, license/patent acquisition
Mathematical programming	Technology planning and forecasting
Matrix analysis	R&D management
Modelling	R&D management New product management Technology planning and forecasting
Customer reports	Technology utilization and integration
Patenting	Technology protection, license/patent acquisition
Patent analysis	R&D management
Market analysis	New product management Technology commercialization, marketing Technology strategy Technology planning and forecasting
Marketing research	Technology acquisition, transfer, dissemination
Project Review and Evaluation Technique (PERT)	Project management
Portfolio management	New product management Technology utilization and integration
Project assessment	Technology evaluation and assessment
Competition analysis	New product management
Competitive position-industry maturity matrix	Technology strategy
Risk-return analysis	New product management Technology evaluation and assessment
After sales services	Technology commercialization, marketing
Scenarios	Technology planning and forecasting
Intuitive method	Technology acquisition, transfer, dissemination
Continuous improvement	Knowledge management, organization of technological activities
SWOT analysis (Strengths/ weaknesses/ opportunities/ threats)	Technology strategy
Organizational culture	Knowledge management, organization of technological activities
Teamwork	R&D management Project management
Technology foreseeing	Technology planning and forecasting
Technology acquaintance techniques	Technology acquisition, transfer, dissemination
Technology efficiency analysis	Technology utilization and integration
Technological portfolio management	R&D management
Reverse engineering	R&D management

Expert opinion (such as Delphi)	Technology planning and forecasting
Product-technology matrix	Technology evaluation and assessment Technology strategy
Creativity tools	Knowledge management, organization of technological activities R&D management
Roadmaps	Technology planning and forecasting

Each of the tools mentioned in Table 4.16 are only related to specific TMC routines and cannot be used as a management tool to guide a company owner through the technology management process.

4.15. Chapter 4 Summary

Chapter four included the conceptual literature review and comprised five main areas of review: (1) technology platforms, (2) platform ecosystems, (3) existing platform management tools, (4) dynamic capability theory, and (5) technology management capabilities.

The culmination of the knowledge gathered during the systematized literature review in Section 3 and the conceptual literature review forms an extensive knowledge base as required for the DSR methodology set out by Hevner [27]. The following section aims to translate the knowledge gained into design requirements for the preliminary management tool.

Chapter 5

Design Requirements for a Framework for Technology Platforms that Implements TMC

Chapter 5 key objectives:

- Discuss conceptual framework features,
- Translate relevant concepts into framework requirements,
- Analise critical work to establish routines required in framework.

Chapter 5 starts by discussing the features common to conceptual frameworks. These features are then used to translate the relevant concepts identified in Chapter 3 and 4 into design requirements for the preliminary management tool. This leads to the existing TMC routine – and technology platform literature being analysed to determine which routines are critical for technology platform management. The context of Chapter 5 relating to the DSRM process and within this document, is shown in Figure 5.1 below.

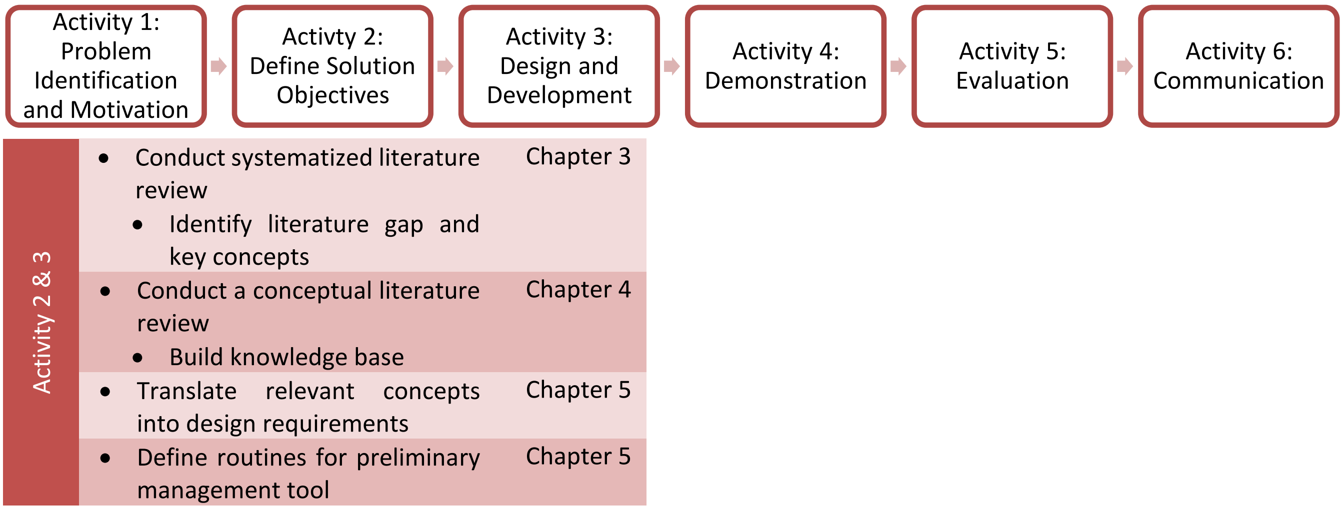


Figure 5.1: Research Context Diagram - Chapter 5

5.1. Conceptual Framework Features

A conceptual framework acts as a guide to answering the research questions of a study, an argument for a study's relevance [144], and takes the form of the researcher's "map" of the qualitative territory being investigated [145]. This map is constantly evolving as the researcher's knowledge of the research terrain improves [145].

Miles et al. [145] elaborates that a conceptual framework "*explains, graphically and/or in narrative form, the main things to be studied- for example the key factors, variables, phenomena, concepts, participants- and presumes interrelationships among them- as a network.*" The concepts implemented within the framework establish a framework-specific philosophy where each concept supports the other and articulate their respective phenomena [146].

For their dissertation Ngongoni [147] lists the key features of a conceptual framework commonly found throughout existing literature, and is given in Table 5.1 below.

Table 5.1: Key Features of Conceptual Frameworks[147]

FEATURE	DESCRIPTION	REF
Integrative	There must be a degree of coherence between the chosen concepts within the framework.	[145]
Evolving	As the study progresses, the researcher's knowledge deepens and the conceptual framework evolves, thus making it non-static.	[144], [145], [148]
Constructability	Framework development employs multi-disciplinary approaches.	[146]
Interpretative Capacity	A framework provides an interpretive approach to social reality through the "soft interpretation of intentions" rather than the "hard facts".	[146], [149]
Indeterministic	Conceptual frameworks do not enable the researcher to predict an outcome of a certain set of activities, but aid in the improving the likelihood of certain outcomes.	[146], [149]
Understanding	The goal of a conceptual framework is to provide understanding of the theory.	[145], [146]
Capacity for Modification	Conceptual frameworks can be reconceptualised and modified as the research question evolves. Further studies can result in modification as new data and publications become available after the framework's first development.	[144]

These key features form the base of any conceptual framework and need to be adhered to while designing the framework for this study. Additionally, study specific design requirements are also needed to ensure that the constructed framework is aligned with the study context.

Chapter 3 and 4 of this study formed the knowledge base as specified required for the design research methodology. A systematized literature review was conducted during Chapter 3 to identify the literature gap between technology platforms and technology management capabilities and the key concepts of technology management capabilities and supporting management capabilities. This was followed by conceptual literature review in Chapter 4 for gaining in-depth understanding of technology platforms, platform ecosystems, the management practices thereof and the key concepts of technology management capabilities. These chapters form the culminative knowledge of research theory required to form the design objectives [1], [14] as stated in Section 2.4 of this study.

As part of the design cycle, these concepts need to be translated into design requirements that the artefact, or in the case of this study, the conceptual framework, needs to adhere to.

Van Aken and Berends [39] propose that for conceptual frameworks the specific design requirements should be divided into five categories, namely: functional requirements, user requirements, design requirements, boundary conditions and attention points. A discussion of each category follows.

1. *Functional requirements* (*FR*): The core specifications of the framework regarding the performance of the designed framework [39], [147].
2. *User requirements* (*UR*): Novel requirements based on the user's perspective and planned use of the designed framework [39], [147].
3. *Design requirements* (*DR*): The entire scope of design limits which also includes elements not covered in the framework that are negotiable [39], [147].
4. *Boundary conditions* (*BC*): The unconditional requirements that the designed framework must adhere to e.g. ethical procedure or code of conduct [39], [147].
5. *Attention points* (*AP*): Specifications that are not critical to the framework, but should be noted during the design process [39], [147].

The key concepts identified throughout Chapter 3 and Chapter 4 are translated into the design requirements for a conceptual framework by following the definition of each of the five categories described above. These design requirements are given in Table 5.2 below.

Table 5.2: Framework Requirements

FRAMEWORK REQUIRMENT	ID NUM	DESCRIPTION
Functional Requirements	FR1	The framework should not just implement metaphoric symbolisms.
	FR2	The framework must include practical elements.
User Requirements	UR1	The framework must show which ecosystem actor the platform owner must keep in mind when addressing a management routine.
	UR2	The framework must give the platform owner guidance with ecosystem governance.
	UR3	The framework must aid the platform owner in designing their platform.
	UR4	The framework must aid the platform owner to identify at what stage of the platform life cycle/ level of maturity their platform is.
	UR5	The platform owner must be able to identify and evaluate their competition through the use of the framework.
Design Requirements	DR1	The framework must define the considerations for the entry barriers for platform developers and platform users
	DR2	The framework must address the different methods of value creation
	DR3	The framework must address the effect of the external environment on the platform considerations.
	DR4	The framework must be user focused.
	DR5	The framework must detail different avenues for revenue and pricing.
	DR6	The framework must focus on how to let the ecosystem evolve.
	DR7	The framework must clarify the balance required between the level of control the platform owner exerts on the platform and the openness of the ecosystem.

	DR8	The framework must specify the roles of each of the ecosystem actors.
FRAMEWORK REQUIRMENT	**ID NUM**	**DESCRIPTION**
Boundary Conditions	BC1	The framework must aid the platform owner in identifying the rules and regulations of platform ownership.
	BC2	The framework must aid the platform owner in sustaining ecosystem health.
Attention Points	AP1	The framework must aid the platform to address governance issues.
	AP2	The framework must not directly link the outcomes for the various routines as they run continuously and in parallel with one another.

5.2. Analysing Critical Existing TMC and Technology Platform Literature

The researcher decided to follow a three-step process to develop the preliminary management tool. This entailed first defining the TMC routines for technology platforms and platform ecosystems, then determining their interrelationships and how to indicate them, and finally plotting their distribution within a conceptual framework. Figure 5.2 below gives a visual representation of the three-step process followed.

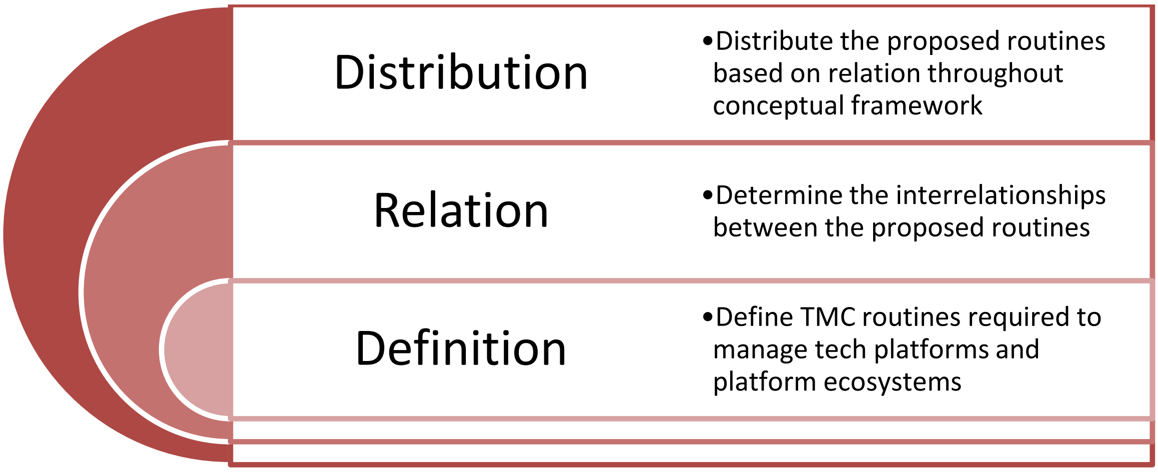


Figure 5.2 Three-Step Development Approach

This approach was followed due to the hierarchal nature of dynamic technology management capabilities. The technology management and supporting management capabilities each as a capability set form the higher order capabilities, the various TMC's and SMC's identified populate the first order capabilities level and the capability routines finally are seen as the ordinary capabilities [23], [95].

With each step down the hierarchy chain the number of capabilities increase as they divide into the different processes required to accomplish the higher order capability's goals. Thus, instead of looking at the hierarchy structure as steps, it should be looked at as a pyramid with the lower levels having a larger number of capabilities that are distributed between higher ranked capabilities, as indicated in Figure 5.3.

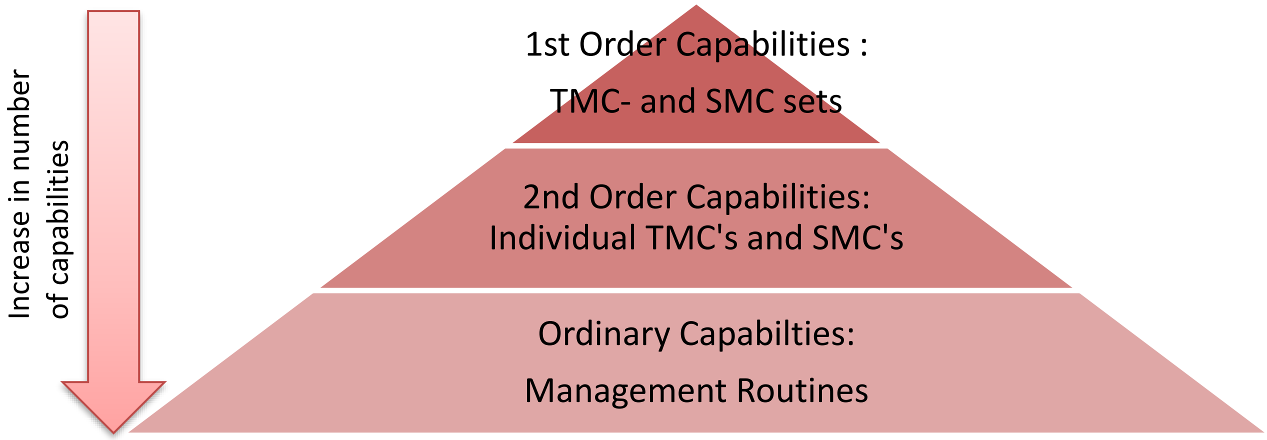


Figure 5.3: Capability Hierarchy Pyramid

By adopting this analogy, the researcher must first build the lower levels of the pyramid to support the upper ones. The analyses of the critical existing TMC and technology platform literature as discussed below formed the pyramid base development that consisted of distributing the gathered knowledge between repeatable routines that can be utilised to develop and manage technology platforms.

The analyses process consisted out of two phases. The goal of the first phase was to determine the relevance of the existing routines proposed by Levin and Barnard [46] in a platform business. This was achieved by comparing the deliverable of each routine to the processes required to manage a technology platform and platform ecosystem.

As stated in Section 4.5.10 of this study, Herman's [22] work to develop a management tool for technology platforms and their surrounding ecosystems in the South African health context included extensive systematic- and conceptual literature reviews which led to an in-depth understanding of what is required to manage these platforms. The preliminary framework she developed was rigorously validated and subsequently updated using case studies and questionnaires to industry leaders. The researcher had identified Herman's [22] research to be a reliable base to act as a summary of the key concepts for technology platform and platform ecosystem literature.

The framework developed by Unsal and Cetindamar [23] is a culmination of dynamic capability literature and the technology management capability routines defined by Levin and Barnard [46]. The concepts used within their framework are widely accepted throughout existing literature as determined with the systematised literature conducted during this study.

The second phase was guided by the conclusions drawn in the first phase and included introducing new technology management routines required for platform businesses and redefining the relevant technology management routines proposed by Levin and Barnard [46] to align with platform management in practice.

One of the research goals of this study is that the developed framework must not be industry specific. This is not the case for the management tool that Herman [22] developed, as it was specifically aimed at technology platforms within the South African health context. This was kept in mind during the distribution process. The existing literature analyses process and rational used by the researcher are discussed throughout the following sections.

5.2.1. Phase 1: Distributing Technology Platform Concepts

For their management tool Herman [22] distributed the identified key concepts for technology platforms and their surrounding ecosystems throughout three canvases. Each canvas consisted of key concepts distributed between primary and secondary categories with accompanying questions to guide the platform owner.

The researcher analysed the categories and accompanying questions and compared each to the technology management routines as defined by Levin and Barnard [46] given in Section 4.11 of this study, including the additional routines proposed by Cetindamar and Unsal [23]. By comparing each platform management concept and their accompanying questions with the existing technology management routines, the researcher could determine the relevance of existing routines within a platform business and define the requirements and activities for technology platform management as technology management capabilities. Each comparison had one of five results. The results and subsequent actions taken by the researcher are listed in Table 5.3 below.

Table 5.3: Platform Concept and TMC Routine Comparison Actions

COMPARISON RESULT	ACTION TAKEN BY RESEARCHER
The platform concepts and questions align with the technology management routine definition.	The existing technology management routine is kept, and the definition altered to be more platform specific.
The platform concepts and questions align with multiple technology management routine definitions.	The technology management routines are kept, and the concept definitions and questions under that platform category are split between the relevant routines.
The technology management routine definition aligns with multiple platform concepts' questions.	The technology management routine is replaced with new routines that are actor orientated.
The concept questions do not align with any technology management routine definitions.	Propose a new technology management routine.
The technology management routine is not relevant to platform management.	The technology management routine is removed from the framework.

Table 5.4 below shows an overview of the distribution process between technology platform concepts and technology management routines. The table is split into the three canvases as proposed by Herman [22], shown in Section 4.5.10. The first two columns include the first and second categories of platform concepts, with the third column describing the action taken by the researcher as defined in Table 5.3, and the fourth column naming the technology management routine affected, or created, by the action.

With the "Replace existing routine" action the routine given in the fourth column is the proposed routine to the replace the existing one. The effects of each of the actions are discussed during Phase 2 of the framework development process.

Table 5.4: Integration of Platform Concepts with TM Routines

PRIMARY CATEGORY	SECONDARY CATEGORY	INTEGRATION WITH EXISTING TM ROUTINES	RESULTING TM ROUTINE
PLATFORM OWNER			
Platform Owner Firm Design	Vision	Keep existing routine	Corporate business strategy
	Integral Organisation	Keep existing routine	Business unit business strategy
	Operations	Keep existing routine	Corporate technology strategy
Platform Design	Technology Infrastructure	Propose new routine	Platform infrastructure design
	Rules and Regulations	Keep existing routine	Intellectual property management
Platform Ecosystem Design	External Environment	Split between existing routines	Business unit environmental monitoring, Corporate environmental monitoring
	Ecosystem	Propose new routine	Platform ecosystem design
Evolution		Split between existing routines	Technology roadmapping, technology needs assessment
PLATFORM DEVELOPER			
Entry Barriers	Technology	Keep existing routine	Technology transfer
	Mission	Propose new routine	Relationship management
	Value Configuration	Replace existing routine	Platform funding
	Ecosystem	Split between new and existing routines	Platform ecosystem design, Technology transfer
Ecosystem		Split between new and existing routine	Ecosystem evolution strategy
Technology Infrastructure		Replace existing routine	Developer technology adaptation
Control	Rules and Regulations	Propose new routine	Developer protection
	Performance (Formal & Informal)	Keep existing routine	Performance management
Support	Community Support	Replace existing routine	Platform adoption support
	Platform Support	Replace existing routine	Platform adoption support
PLATFORM USER			
Technology Proposition	Financial	For this study, a platform user will be defined as the end-user of the technology platform. These categories are thus not relevant as they are orientated to a company that develops platform applications for clients.	
	Operation		
	Evolution		
Context of Use		Replace existing routine	User technology adaptation
Operation	Deployment	Replace existing routine	User technology adaptation
	Feedback	Propose new routine	Operation feedback
	Privacy and Security	Propose new routine	User protection
Interface	Usability	Replace existing routine	User technology adaptation
	Design	Replace existing routine	User technology adaptation

Following the distribution process, Phase 2 commenced in the following section.

5.2.2. Phase 2: Analysing Existing TM Routines

The implications of Phase 1 on each of the existing technology management routines are discussed below. Based on the information gathered during Chapters 3 and 4, the researcher further analysed each routine and their definition which either resulted in the existing routine being retained, or a new routine being proposed in its place. The routines are divided as proposed by Unsal and Cetindamar [23] throughout their corresponding technology management and supporting management capabilities.

Table 5.5: Analysing Existing TM Routines and Defining Proposed Routines from the Perspective the Platform Owner

Existing TM Capability and Routine	**Action**	**Analysing Rational of Existing Routines and Defining Proposed Routines**	**Platform Actor**
TM Capability: Identification			
R&D environmental monitoring	**Keep**	Scanning external technological environment for wider scientific advances [46]. This routine is required to identify new technologies that can be implemented into the platform, such as security, distribution channels, user devices.	***Owner***
Business unit environmental monitoring	**Keep**	This routine encompasses scanning and analysing the external environment for key trends, customer needs, market trends, competing ecosystem, the stakeholders of the platform, etc.	***Owner, User***
Corporate environmental monitoring	**Keep**	This is a "big picture" scanning and analysis routine of products, ecosystem actors and the competition to determine the impact of economic activities carried out by the platform owner and their competitors.	***Owner, Developer, & User***
TM Capability: Selection			
Technology roadmapping - Platform life cycle Roadmapping	**Keep/ Rename**	Routine to identify and develop the technological capabilities required to support future processes. The ecosystem will constantly evolve as platform developers enter and exit it. The platform owner needs to prepare for and guide this evolution with adequate planning done during this routine. Renamed to **Platform life cycle roadmapping** to prevent ambiguity.	***Owner, Developer***
Technology needs assessment	**Keep**	This routine keeps track of the platform/ecosystem evolution in order to identify the platform/ecosystem technological capabilities that need to be upgraded, replaced or discarded The output of this routine flows into the 'Platform infrastructure design' routine and 'Platform ecosystem design' routine.	***Developer, User***
Business unit technology strategy	**Discard/ Replace**	The platform infrastructure design and platform ecosystem design replace this routine as they are both strategic technological decision routines required at the ideation stage with responses on developer level as the life cycle continues.	N/A
Platform Infrastructure Design	**New**	This routine includes the actions required to design the platform and supporting technology infrastructure. This routine and the 'technology needs assessment' routine will continuously flow into each other as the platform/ecosystem evolves. As the ecosystem evolves new security protocols will maybe be necessary, or the type of scalability, or hardware requirements.	***Owner, Developer***
Platform Ecosystem Design	**New**	The decisions required to determine what the ecosystem will look like and how it will run. The platform owner must decide who the key actors are, their roles in the ecosystem, what entry barriers will be implemented, how the ecosystem health will be monitored, etc.	***Owner, Developer, User***

TM Capability: Acquisition			
R&D technology strategy	**Keep**	This routine is critical as it is the most concrete deliverable of the R&D process. A strategy is required to determine when to focus on which scientific and technological areas and the validity of technology plans. This coordinates the information gathered from multiple routines and results in forming the company's R&D portfolio.	***Developer & User***
R&D portfolio management	**Keep**	This routine includes the actions required to manage the R&D portfolio after it is formed in the 'R&D technology strategy' routine. The platform owner needs to keep a balance between the R&D projects by ensuring that the company focus is not obscured by individual stakeholders and identifying concrete project evaluation objectives.	***Owner***
Technology transfer	**Keep**	The actual technological considerations for platform entry and ecosystem entry (for example variety of developers) that need to be taken. These considerations include how developers will access the platform, what programming language will be accepted on the platform, what type of apps will the developers be able to develop, etc. This routine focuses on what will attract and keep developers.	***Developer***
R&D funding	**Discard/ Replace**	With technology platforms the different funding methods are known and do not need to be determined. It is still critical to manage where the funding comes from, thus this routine is replaced by the proposed 'Platform funding' routine.	N/A
Platform funding	**New**	With platform ecosystems there are multiple forms of monetisation and pricing strategies which can be implemented to fund the platform and sustain its evolution. Some examples include the homing costs as entry barrier considerations, intermediary client investments and monetisation of the application. This routine includes the actions required to determine which funding methods will be implemented and how they will be managed.	***Owner, Developer, & User***
TM Capability: Exploitation			
Product portfolio management - Developer portfolio management	**Keep/ Rename**	The platform acts as the result of technological and strategic inputs with the variety of apps developed on the platform by developers acting as the products used by the end-users. Thus, it is necessary to manage the diversity of developers within the ecosystem. Considerations required include how innovation will be encouraged between developers to share information and prohibit unhealthy competition. As the focus is on developers the routine is renamed to **Developer portfolio management**.	***Developer***
Technology adaptation	**Discard/ Replace**	This routine is split into Developer and User Technology Adaptation routines due to the different level of considerations that need to be taken for both. For developers, considerations include the ease-of-use of the technology that the platform itself consists of. For the user, considerations include the ease-of-use of the actual apps on the platform and how the user will be able to access these apps.	N/A
Developer technology adaptation	**New**	The technological considerations of how the developers will adopt the platform. These include how compatible the platform/ecosystem is with other platforms or systems, the method of getting feedback from developers about the platform design, the marketplace requirements for the developer's apps, how vulnerable the platform software is, etc.	***Developer***

User technology adaptation	**New**	The technological considerations of how the users will use the platform to access the developer applications (the platform app interface for example). How and where will this app be set-up and who will be using it? Can the platform owner make it easier for the user to absorb and adapt the platform app to their environment?	***User***
Post-project support	**Discard/ Replace**	Levin and Barnard's [46] explanation of this routine is the support given to the business unit by R&D in order to help understand and mitigate problems after adopting new technology. This action is covered by the proposed ‘**platform adoption support’** routine.	N/A
Platform Adoption support	**New**	The platform owner must focus on how developers adopt the platform seeing that process is not just them starting off on the platform, but also utilizing its capabilities. This routine will incorporate both community support structure considerations and actual platform tech support to help developers adopt the platform capabilities and supply multiple "tools" for debugging, tech support and knowledge sharing between developers. The routine reflects the responsibilities of the support "team" in the platform owner's company. By only having one structure it eliminates the need for more communication channels and makes it easier for the support team to connect technical problems and community problems which might be supplementing each other. Finally, the action should be done routinely and not as an ad-hoc problem-solving job.	***Owner, Developer***
Business unit business strategy	**Keep**	It is the responsibility of the platform owner to define what the internal organisation will look like. This includes how the key resources will be managed, support within the firm, conflict management and the culture, values, and beliefs of the organisation.	***Owner***
Product line planning - Platform services planning	**Keep/ Rename**	Levin and Barnard [46] define the routine as the actions required from the business unit to provide a platform definition plan and timetable to clarify the future direction of the company's product lines. As with the 'Product portfolio management' routine the platform acts as the product as a service to the developers, thus the business unit must rather focus translating business drivers into services parameters and set a clear plan of what direction the platform will evolve. The routine was renamed **Platform services planning** to align it with the new definition.	***Developer, User***
TM Capability: Protection			
Intellectual property management	**Keep**	The platform owner needs to consider what the ownership structure of the platform and its components will look like, how the intellectual property (IP) rights will be established, the licensing agreements with developers and the IT standards the platform and interfaces should adhere to.	***Owner***
Platform protection	**New**	A routine is required apart from intellectual property management to ensure that constant practices are implemented to secure the platform from bad developer behaviour that could jeopardise the stability of the platform or the ecosystem.	***Owner, Developer***
Developer protection	**New**	The rules and regulations that need to be considered in order to successfully attract developers to the platform. These include the governmental or organisational policies that the platform owner and developers should be aware of, how the platform owner should help the developers protect their IP, determining if the personal data of the developers should be protected rather than shared and who owns the data generated by the developers.	***Developer***

User protection	**New**	The platform also needs to consider the privacy and security of the end-users. This includes knowing the industry laws and regulations, the method of ensuring the privacy and security of the end-user, how the end-user's data will be stored and who will have access to it.	***User***
TM Capability: Learning			
Post-project audit	**Discard/ Replace**	Levin and Barnard's [46] define this routine as "analysis of root causes of both good and bad outcomes". It is critical for a platform to grow critical mass; thus, it is of high importance that the platform company does everything to retain developers. This routine has been split to ensure the "good and bad outcomes" are individually focused on to place emphasis on developer retention. The "good outcomes" are managed with the **Platform performance management routine** and the bad outcomes are analysed with the **Ecosystem-exit audit** routine.	N/A
Ecosystem-exit audit	**New**	This routine will include the audits conducted after a developer has left the platform. Have they left due to success or failure? Why did they succeed or fail? How can the platform be updated to promote more successes or less failures?	***Owner, Developer***
Operation feedback	**New**	This routine includes both feedback from developers and end-users. Unlike the "Post-project audit" routine, it is conducted continuously as the platform and ecosystem evolves, generating feedback on how they operate. The platform owner must consider what channels they will use and how the feedback will be implemented. Most importantly, the platform owner must determine if it is a one-way stream of information, or will the knowledge be gained result in openly shared updates to the platform (value/knowledge distribution).	***Owner, Developer, & User***

Table 5.6: Analysing Existing SM Routines and Defining Proposed Routines from the Perspective the Platform Owner

Supporting Management Capability: Strategy Management			
Corporate business strategy	**Keep**	This routine will act as almost the first step to the business plan where a broad idea is taken and systematically broken down into the "vision" questions in order to have a realistic and achievable business strategy.	***Owner***
Corporate technology strategy	**Keep**	This routine involves aspects such as how the firm pursues its technology acquisitions, its marketing programmes, technological areas of focus, and make/buy decisions. The actions taken represent the firm's technology response to user requirements.	***Owner***
Technology alliance management	**Keep**	Levin and Barnard [46] define technological alliances to be "organised around scientific research questions or new product development, and this routine involves identifying, developing, and managing the firm's strategic partnerships and consortia." These strategic partnerships can be the combination of different platforms, or various kinds of developers. This routine forms the output to of strategy routines and will act as an input to "platform life cycle planning" and other technological planning routines.	***Owner, Developer***
Ecosystem Evolution Strategy	**New**	The strategic considerations of attracting planned and potential groups of actors to the ecosystem and managing the effects of the decisions being made by the platform owner. Are there tensions being created between the owner and developers due to the decisions being made by the owner and risks taken? What are the network effects on the ecosystem? The routine also includes tracking the evolution of the platform to ensure that it is keeping up with the ecosystem evolution.	***Owner, Developer, & User***
Supporting Management Capability: Innovation Management			
Ideation	**Keep**	These routines are common to any company, but still crucial to all innovative endeavours. Ideation encourages creativity and feasibility is necessary to ensure that unnecessary risks are not taken.	***Owner, Developer, & User***
Feasibility	**Keep**		
Initial project/ programme selection - Initial ecosystem actors	**Keep/ Rename**	This routine will include the actions defining the initial layout of the ecosystem, with the platform owner deciding who the first type of developers would be operating on the platform. As the ecosystem evolves, different types of developers would enter the ecosystem, widening its capabilities. The routine was renamed **Initial Ecosystem Actors** to align it with the new definition	***Owner, Developer, & User***
New business unit development - Platform/ecosystem expansion	**Keep/ Rename**	As with Levin and Barnard's [46] definition the identification routines act as inputs to this routine, which in turn will determine if the platform needs to adapt in order to run on new types of hardware, if new developers apps should be allowed into the ecosystem, or if other ecosystems (for example competitors) should be incorporated into theirs. This routine as the actual actions taken to expand the platform/ecosystem so it will be renamed as **Platform/ecosystem expansion**.	***Owner, Developer***

Innovation sharing	**New**	This routine is required for the platform owner to actively manage innovation within the ecosystem. The management considerations have three dimensions: (a) To determine how are the developers able to be innovative (are the rules too restricting? Is there a culture of innovation?), (b) how can the platform owner share innovation with developers (how and will the new functionalities be implemented? How to prevent them from enveloping the developers) and (c) managing the effect of external innovation (will there be less risk and more R&D?).	***Owner, Developer***
Supporting Management Capability: Project Management			
Project execution - Platform execution	**Keep/ Rename**	This routine includes the management activities to integrate multiple projects' timelines and determining their planning, designing, staffing and managing activities. As the focus of the platform owner's company is the service provided by the platform the routine is renamed **Platform execution**.	***Owner***
Performance management – Platform performance management	**Keep/ Rename**	The goal of this routine is to reconcile the different performance management requirements of the various programs though measurement and management processes and develop schemes to improve performance. These measurement and management process include implementing control mechanisms to encourage desirable behaviour in developers, to define the fundamental rules the developers should obey while using the platform, aligning the goals of the developers, measuring the number of developers to see the developer growth trend, and reviewing the complementary services offered on the platform. The routine is renamed **Platform performance management**.	***Developer***
Personnel management	**Keep**	Levin and Barnard's [46] definition will remain unchanged for this routine. The actions required are hiring, training and retaining capable employees within the platform owner's company.	***Owner***
Relationship Management	**New**	Trust is a key component within a platform ecosystem. The relationship of the firm owner/developers/users need to continuously be managed. A good relationship will foster a good reputation, credibility of your platform attracting new developers and users, while also fostering loyalty and keeping them on your platform.	***Owner, Developer, & User***
Supporting Management Capability: Knowledge Management			
Knowledge Management	**Keep**	As with Cetindamar et al.'s [13] explanation a knowledge management routine is required to emphasize the importance of having active management practices to gather, arrange and distribute knowledge within the platform owner's company. Unlike with previous knowledge sharing routines where the focus is on sharing knowledge between the different ecosystem actors, the knowledge sharing activities and considerations related to this routine are solely focused on the different departments within the platform owner's company.	***Owner***

5.3. Chapter 5 Summary

In Chapter 5 the features most common to conceptual frameworks were discussed and translated into design requirements for this study. By doing so, the researcher identified and classified nineteen design requirements that the conceptual framework developed in Chapter 6 should adhere to. The researcher continued by analysing the existing literature that they deemed as critical for technology platforms and technology management capabilities. The researcher acknowledged that their choice of critical literature does give room to bias but tried to minimize this bias with the conceptual literature review and systematised literature review conducted in Chapter 3 and 4, respectively.

After analysing the existing literature, the researcher identified thirty-seven technology management routines required for technology platform management. Of these thirty-seven routines, the researcher proposed fourteen new routines, kept sixteen existing routines and re-named seven existing routines. The researcher also identified which ecosystem actor should be kept in mind during the execution of each routine. A list of the routines is given in Table 5.7 and Table 5.8 below.

Table 5.7: TMC Routines Critical for Platform Management

NUM	ROUTINE	NUM	ROUTINE
	IDENTIFICATION		**PROTECTION**
1	R&D environmental monitoring	**18**	Intellectual property management
2	Business unit environmental monitoring	**19**	Platform protection
3	Corporate environmental monitoring	**20**	Developer protection
		21	User protection
	SELECTION		**LEARNING**
4	Platform life cycle roadmapping	**22**	Ecosystem-Exit audit
5	Technology needs assessment	**23**	Operation feedback
6	Platform infrastructure design		
7	Platform ecosystem design		
	ACQUISITION		**STRATEGY MANAGEMENT**
8	R&D technology strategy	**24**	Corporate business strategy
9	R&D portfolio management	**25**	Corporate technology strategy
10	Technology transfer	**26**	Technology alliance management
11	Platform funding	**27**	Ecosystem evolution strategy
	EXPLOITATION		**INNOVATION MANAGEMENT**
12	Developer portfolio management	**28**	Ideation
13	Developer technology adaptation	**29**	Feasibility
14	User technology adaptation	**30**	Initial ecosystem actors
15	Platform adoption support	**31**	Platform/ecosystem expansion
16	Business unit business strategy	**32**	Innovation sharing
17	Platform services planning		

Table 5.8: TMC Routines Critical for Platform Management (Continued)

NUM	ROUTINE	NUM	ROUTINE
	PROJECT MANAGEMENT		**KNOWLEDGE MANAGEMENT**
33	Platform execution	**37**	Knowledge management
34	Platform performance management		
35	Personnel management		
36	Relationship management		

The design science research progression checklist items defined by Hevner and Chatterjee [14] as set out in Section 2.5, Table 2.4 that were addressed during Chapter 5 are listed below.

Table 5.9: Design Science Research Progression Checklist [14] **– Items 1, 3 & 4**

NUM	QUESTION	RESPONSE
1	- What is the research question (design requirements)?	- Nineteen design requirements were proposed and distinguished as either Functional requirements, User requirements, Design requirements, Boundary conditions, Attention points.
3	- What design processes (search heuristics) will be used to build the artifact?	- A three-step development process was followed that looked at the definition, relation, and distribution of the proposed management routines.
4	- How are the artifact and the design processes grounded by the knowledge base? - What, if any, theories support the artifact design and the design process?	- The design processes look at the technology management routines which are the activities required to develop and manage technology platforms. The processes are grounded by the knowledge base as they look at routines in the existing literature, their application within a platform business, the dynamic relations between them, and their distribution between primary capabilities.

The identified technology management routines are integrated into the proposed framework developed in the following chapter.

Chapter 6

Towards a Management Tool for Technology Platforms based on TMC

Chapter 6 key objectives:

- Develop preliminary framework,
- Discuss rational used through development process,
- Present preliminary framework as management tool,
- Verify preliminary framework.

Chapter 6 forms the first half of the Design Cycle, developing the artefact. The chapter starts by developing the preliminary management tool and discussing the rational used through development process. The preliminary framework is then presented as a management tool and verified against the design requirements for conceptual frameworks determined in Chapter 5. The context of Chapter 6 relating to the DSRM process, and within this document, is shown in Figure 6.1below.

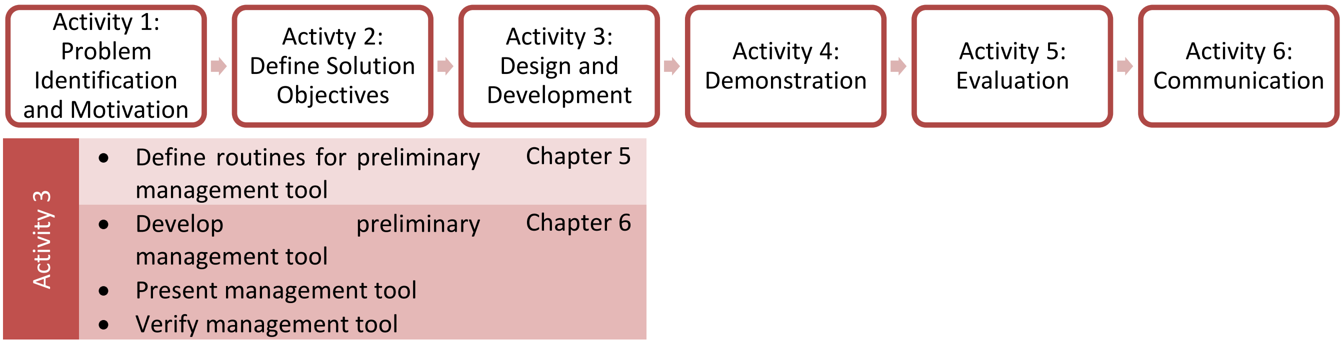


Figure 6.1: Research Context Diagram - Chapter 6

6.1. Preliminary Management Tool Development

The design requirements defined in Chapter 5 were followed to develop a framework to manage technology platforms and their surrounding ecosystems by implementing TMC and supporting routines. The preliminary management tool is split into two canvases, the first is the flow diagram canvas and the second is the definition canvas. The combination of the two canvases were analysed during the verification process to ensure that the design requirements were fulfilled.

6.1.1. Flow Diagram Canvas Development

The flow diagram canvas forms the 'face' of the management tool. A platform owner will use this canvas as the starting point to see the bigger picture of platform development/management and all the different routines required. During the development process the researcher kept in mind the interrelationships between the routines and overarching capabilities, the flow of information, the level of complexity of the user interface and how the information is connected to the second canvas.

Figure 6.2 below shows the base layout of the Flow Diagram Canvas. The different characteristics are indicated by the coloured squares and discussed below.

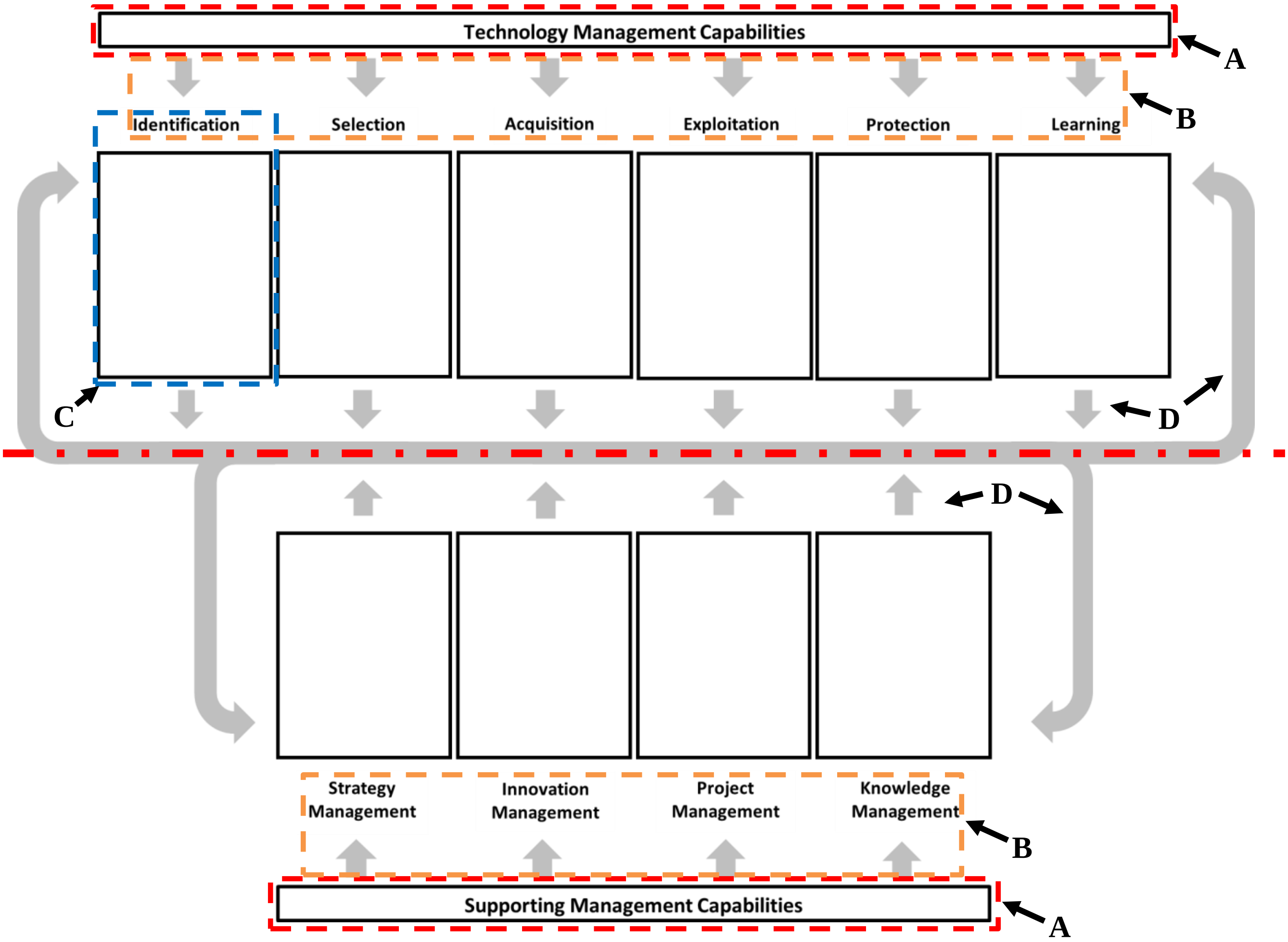


Figure 6.2: Flow Chart Canvas Base Layout

A. Higher Order Management Capabilities [Red Box]

The red boxes indicate the two higher order management capabilities, namely Technology Management Capabilities and Supporting Management Capabilities [13], [23], [58]. The red centreline highlights the divide through the middle of the diagram clearly distinguishing technology management capabilities with supporting management capabilities and their routines. For the remainder of this study the higher order capabilities will be referred to as the higher capabilities.

B. First-Order/Primary Capabilities [Orange Box]

The collective concepts that fall within the orange boxes are the first-order management capabilities. It supports the hierarchy theory of dynamic capabilities [23], [47], [48], [54] by placing them 'downstream' of the information flow and by grouping them on the same level. Further, it aims to avoid a hierarchal connection between the six TM capabilities and four supporting capabilities by not connecting them directly to each other. For the rest of this study the first-order capabilities will be referred to as primary capabilities.

C. Routine Distribution Groupsets [Blue Box]

The routines proposed in Table 5.5 and Table 5.6 are distributed between their respective primary capabilities and grouped within the groupsets (represented by boxes). These groupsets are another step down the hierarchy ladder, but unlike the relationship between higher capabilities and primary capabilities there is no distinctive 'split' between the primary capabilities and routines (zero-order capabilities). By doing so it gives the indication that each of the primary capabilities that are above the boxes forms part of the boxes within which the zero-order capabilities are grouped. These routines (zero-order capabilities) represent activities that are inherent and repeatable within a company [13], [23], [48], [54].

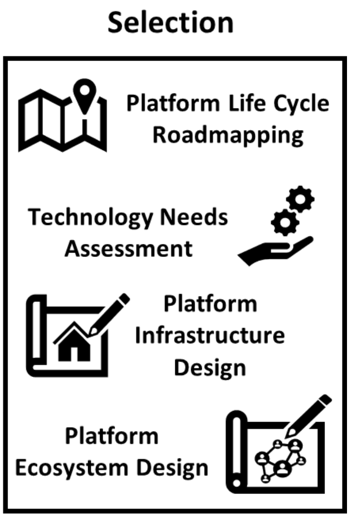


Figure 6.3: Selection Capability Routine Groupset

Figure 6.3 above shows the 'Selection' primary capability and its routine groupset as an example of the routine layout. Each routine is given an icon that will help the platform owner link the routine within the flow diagram canvas. The routines are grouped within the box and not listed so that no form of hierarchy is implied between them. Finally, by grouping the routines in a cascading manner it aligns with the dynamic nature of the routines.

D. Information Flow between Capabilities

The arrows indicate the flow of information between the different routines and link them all under one process. The cyclical nature indicates that the flow of information between the capabilities is constant where the outputs of each routine influences or forms the inputs of others.

6.1.2. Definition Canvas

The definition canvas forms the body of the management tool. The platform owner will use the flow diagram canvas as reference to where the routine falls within the platform management process and refer to the definition canvas to get a deeper understanding of what the routine entails.

During the development of the definition canvas the researcher kept in mind the communication mechanisms between the definition canvas and the flow diagram canvas, the hierarchal presentation, the ease of use of the canvas and the information required for the platform owner to successfully implement the routine.

Figure 6.4 below shows the base layout of the definition canvas. The different characteristics are indicated by the coloured squires and discussed below.

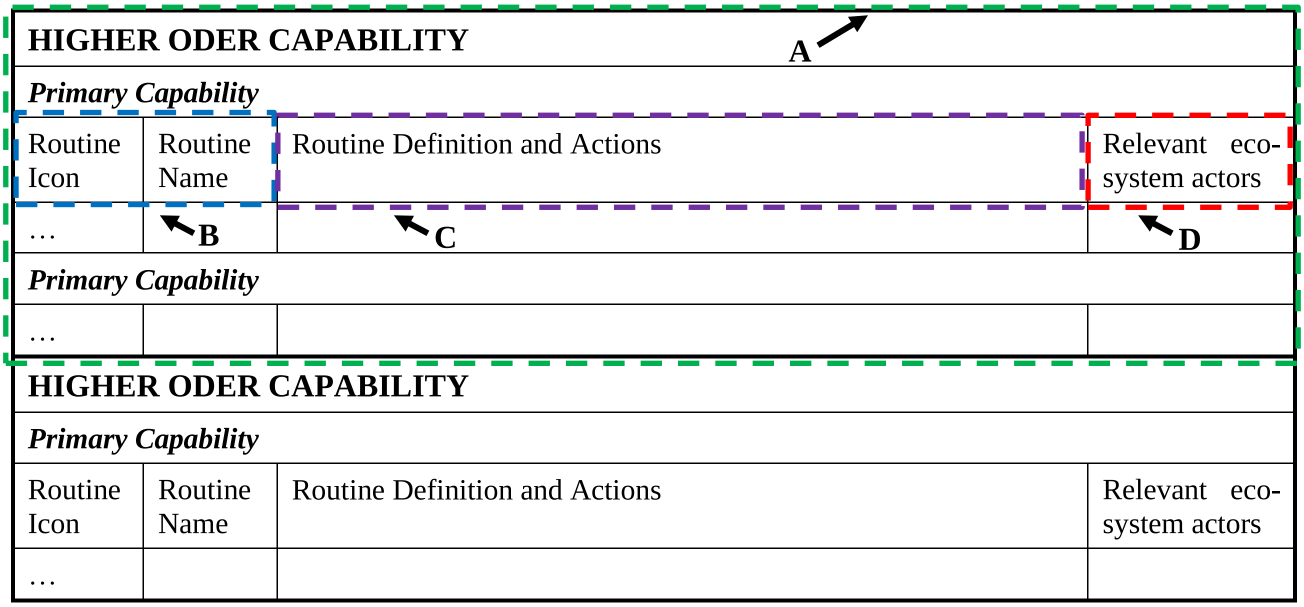


Figure 6.4: Definition Canvas Base Layout

A. Hierarchy Presentation [Green Box]

The higher order capabilities, primary capabilities and routines are listed in a descending fashion, with varying text size and boldness' to indicate the hierarchy structure as illustrated in Figure 6.3.

B. Link to Flow Diagram Canvas [Blue Box]

The first two columns contain the routine icon and the routine name to help the platform owner identify the specific routine from the flow diagram canvas.

C. Routine Definition and Actions [Purple Box]

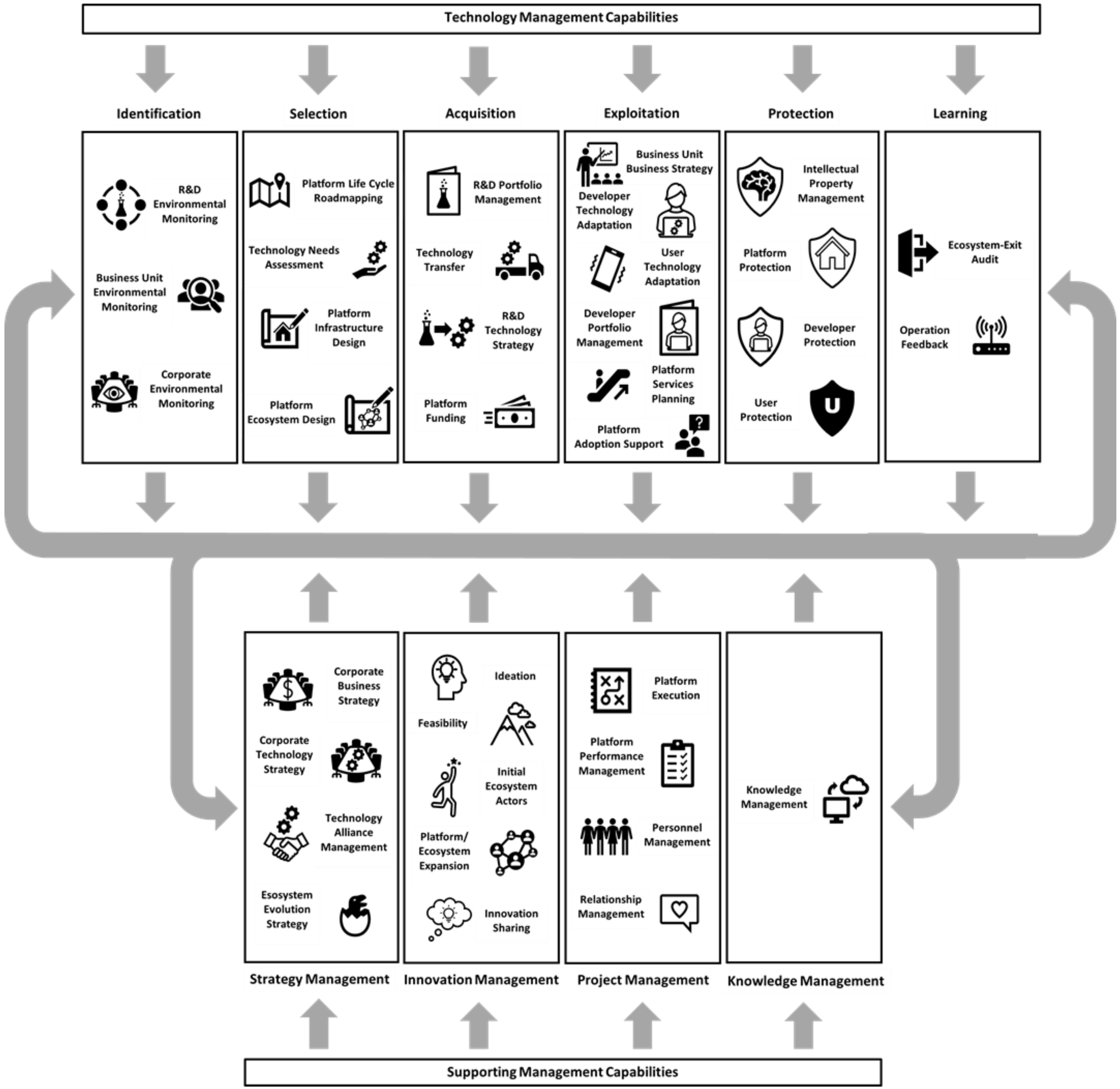
The third column contains the routine definition and actions that the platform owner can take to execute the routine.

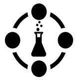
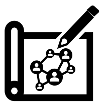
D. Relevant Ecosystem Actors [Red Box]

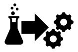
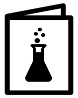
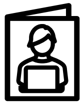
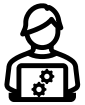
The fourth column contains the relevant ecosystem actors that the platform owner needs to keep in mind when executing the routine. These actors can either be the platform owner, developer, user or any combination of the three.

6.1.3. Preliminary Management Tool

The preliminary management tool is presented below with the flow diagram canvas followed by the definition canvas.


Technology Management Capabilities
Identification
Selection
Acquisition
Exploitation
Protection
Learning
R&D Environmental Monitoring
Business Unit Environmental Monitoring
Corporate Environmental Monitoring
Platform Life Cycle Roadmapping
Technology Needs Assessment
Platform Infrastructure Design
Platform Ecosystem Design
R&D Portfolio Management
Technology Transfer
R&D Technology Strategy
Platform Funding
Business Unit Business Strategy
Developer Technology Adaptation
User Technology Adaptation
Developer Portfolio Management
Platform Services Planning
Platform Adoption Support
Intellectual Property Management
Platform Protection
Developer Protection
User Protection
Ecosystem-Exit Audit
Operation Feedback
Corporate Business Strategy
Corporate Technology Strategy
Technology Alliance Management
Esosystem Evolution Strategy
Ideation
Feasibility
Initial Ecosystem Actors
Platform/ Ecosystem Expansion
Innovation Sharing
Platform Execution
Platform Performance Management
Personnel Management
Relationship Management
Knowledge Management
Strategy Management
Innovation Management
Project Management
Knowledge Management
Supporting Management Capabilities

TECHNOLOGY MANAGEMENT CAPABILITIES			
Identification			
	R&D Environmental Monitoring	Scanning the external technological environment for wider technology and scientific advances to identify new technologies that are disrupting the industry and can be implemented into the platform, such as security, distribution channels, and user devices.	*Owner*
	Business Unit Environmental Monitoring	Scanning the external cultural environment for key industry trends to identify the target market's characteristics, their needs, and the cultural and natural setting into which the platform is being introduced; and to identify competing platforms and ecosystems to determine what differentiates them from this platform and ecosystem.	*Owner, User*
	Corporate Environmental Monitoring	Scanning of the external economic environment to identify the upstream and downstream stakeholders or actors, the effect of economic growth on global, national, and local level on the adoption of the platform, and to determine the impact of economic activities carried out by the platform owner and their competitors on the market trends.	*Owner, Developer, & User*
Selection			
	Platform Life Cycle Roadmapping	Setting out the roadmap that shows when and how to develop identified technological capabilities that are required for future processes to maintain the constantly evolving ecosystem. Setting out includes defining the inputs and outputs of the different processes, the timeline to complete a process, and the technological requirements needed.	*Owner, Developer*
	Technology Needs Assessment	Analysing how the platform and ecosystem evolves, and identifying technologies that need to be upgraded, replaced, or discarded, for example security firmware, the type of scalability of the platform, or hardware requirements. The output of this routine flows into the 'Platform infrastructure design' and 'Platform ecosystem design' routines.	*Developer, User*
	Platform Infrastructure Design	Designing the platform and supporting technology infrastructure. Considerations include the programming language adopted by the platform, what the interface will look like, the extent of access developers have to the platform functionality, the type of data transferred and stored during the use of the platform, and scalability of the platform.	*Owner, Developer*
	Platform Ecosystem Design	Designing what the ecosystem will look like and how it will run. Considerations include who the key actors are, their roles in the ecosystem, what entry barriers will be implemented, what the technological barriers are, the organisational structure in the ecosystem, how the ecosystem health will be monitored, and how the end products/services will be distributed.	*Owner, Developer, User*

Acquisition			
	R&D Technology Strategy	Strategizing when to focus on which newly identified scientific and technological areas and determining the validity of the technology plans. Considerations include planning the progression of the technology being developed, defining the expected outcome of R&D projects, and how to transfer the information to the rest of the company.	*Developer & User*
	R&D Portfolio Management	Managing the portfolio of R&D projects to achieve a desired balance along the different organisational dimensions. Considerations include identifying who the stakeholders of the company are, how they will influence which R&D projects to follow and defining concrete project evaluation objectives.	*Owner*
	Technology Transfer	Defining the technological platform- and ecosystem entry barriers in order to attract and keep developers. Considerations include the how developers will access the platform, what type of apps will the developers be able to develop, the toolkit of complementary products provided, and the level of difficulty for a developer to leave the platform.	*Developer*
	Platform Funding	Determining the monetisation and pricing strategies to fund the platform and sustain its evolution. Considerations include the homing costs of developers, intermediary client investments, the profit distribution throughout the ecosystem, and if the revenue model should consist of a fixed amount, percentages, subscriptions, or licensing fees.	*Owner, Developer, & User*
Exploitation			
	Developer Portfolio Management	Managing the diversity of developers within the ecosystem to achieve cohesion and prevent unhealthy competition. Considerations include how innovation will be encouraged between developers, how to encourage information sharing, and defining a method to measure the satisfaction among developers regarding the platform services.	*Developer*
	Developer Technology Adaptation	Designing the technological necessities developers require to adopt the platform. Considerations include how compatible the platform/ecosystem is with other platforms, the influence of the developer hardware and software on the platform design, the developer's apps' marketplace requirements, and if a developer training tool is required for platform adoption.	*Developer*
	User Technology Adaptation	Designing the technological necessities users require from the platform to access the developers' apps. Considerations include the social, physical, and geographical context of the users, learnability of the platform app, how rapidly the platform app is updated, the navigation through the platform app, and the visual aspects of the app icon and interface.	*User*
	Platform Adoption Support	Providing ongoing support to developers during the platform adoption process. Considerations include providing documentation to describe platform use and functionality, easing the migration from competing platforms, forming a dedicated customer support team, providing debugging aids, and providing app testing support to developers.	*Owner, Developer*

	Business Unit Business Strategy	Strategizing how the platform firm's internal organisation will operate. Considerations include defining the key resources (human and technology) to realise the platform, the internal processes for optimal platform performance, how the company culture, values and beliefs influence platform management, and the support given to the internal team.	*Owner*
	Platform Services Planning	Translating business drivers into service parameters and setting a clear plan of which direction the platform will evolve. Considerations include how and when new functionalities will be incorporated into the platform and the influence of these new functionalities on developer interest to stay with the platform or migrate from a competitor's platform.	*Developer, User*
Protection			
	Intellectual Property (IP) Management	Implementing procedures to protect the intellectual property of the platform company. Considerations include the ownership structure of the platform and its components, how the IP rights will be established, the licensing agreements with developers and the security measures taken to protect the transactional and user data generated by the platform.	*Owner*
	Platform Protection	Implementing procedures to protect the platform from bad developer practices. Considerations include the level of architectural openness of the platform to developers and the security precautions taken to protect the platform against external factors.	*Owner, Developer*
	Developer Protection	Implementing procedures to protect the IP and data of the developers. Considerations include who will have access to developer data, defining who owns the data generated by the developers on the platform, making developers aware of governmental or organisational policies, and assuring developers of their data safety.	*Developer*
	User Protection	Implementing procedures to protect the personal data of the users. Considerations include following the laws and regulations related to the app industry, providing security methods that ensures the protection of the user's privacy, and determining how user data will be stored and who will have access to it.	*User*
Learning			
	Ecosystem-Exit Audit	Conducting an audit to determine the reason why developers have left the platform and ecosystem. Considerations include determining how to track user loyalty, analysing the developer successes or failures and the reasons for their success or failure, and recording the platform characteristics that led to their success/failure.	*Owner, Developer*
	Operation Feedback	Providing a channel for continuous feedback between developers, users and the platform owner as the platform/ecosystem evolves. Considerations include the method of gathering feedback, determining who is going to analyse the feedback gathered, and if it is a one-way stream of information, or distributed as openly shared platform updates.	*Owner, Developer, & User*

SUPPORTING MANAGEMENT CAPABILITIES			
Strategy Management			
	Corporate Business Strategy	Systematically breaking down a broad business idea into a realistic and achievable business strategy. Considerations include determining the areas of platform operation, what the main goal of the platform is, what the envisioned future state of the platform is, and what the key performance indicators will be to measure if the platform is evolving as planned.	*Owner*
	Corporate Technology Strategy	Determining how the firm will pursue its technology acquisitions, its marketing programmes, technological areas of focus, and make/buy decisions. Considerations include determining if R&D will be done in correspondence with developers, defining the strategies that promote platform growth, risk management, reputation management and platform re-investment.	*Owner*
	Technology Alliance Management	Identifying, developing, and managing the strategic partnerships between partner platforms, or various kinds of developers. Considerations include the managing operations taken to make the company's defined strategies routines come to fruition and translated into technological planning routines.	*Owner, Developer*
	Ecosystem Evolution Strategy	Strategizing how to attract planned and potential groups of actors to the ecosystem and managing the effects of the decisions being made by the platform owner. Considerations include identifying possible tensions between the owner and developers, the network effects on the ecosystem, and tracking the platform evolution to ensure that it matches with ecosystem evolution.	*Owner, Developer, & User*
Innovation Management			
	Ideation	Providing a platform and ecosystem that promotes innovative ideation and creativity between the developers, users, and employees of the platform firm. Considerations include determining promotion methods for innovative ideas and determining how a culture of innovation within the firm and the ecosystem can be created and sustained.	*Owner, Developer, & User*
	Feasibility	Managing how new ideas and innovative endeavours are analysed and pursued to ensure that unnecessary risks are not taken. Considerations include a method the measure the feasibility of new ideas, determining who the stakeholders are of new endeavours, and weighing the risks against the benefits before a project is initiated.	*Owner, Developer, & User*
	Initial Ecosystem Actors	Defining what kind of developers will be allowed onto the platform initially and the type of users that they will attract. Considerations include determining the geographical, cultural, and technological capabilities/restrictions of the platform, the developers, and the users.	*Owner, Developer, & User*
	Platform/ Ecosystem Expansion	Translating the identification routines into platform/ecosystem adaptation actions taken, to integrate new types of hardware and software, expand the ecosystem entry barriers and capabilities for new developer apps, and incorporate other identified ecosystems (for example competitors) into theirs.	*Owner, Developer*

	Innovation Sharing	Managing how innovation is shared within the ecosystem. Considerations include determining the level of restriction the platform rules provide, how innovative knowledge will be shared within the ecosystem so that it benefits the developers and does not envelope them, and determining the extent of influence of external innovation.	*Owner, Developer*
Project Management			
	Platform Execution	Executing the integrated activities of multiple projects' timelines by planning, staffing, designing, and managing them. Considerations include which and when the milestones of each project need to be reached as defined in the platform life cycle roadmapping routine and the strategy routines.	*Owner*
	Platform Performance Management	Reconciling the different performance requirements between developers through measurement and management processes and implementing performance improvement schemes. Considerations include implementing control mechanisms among developers, defining the fundamental rules of platform use, and reviewing complementary services offered on the platform.	*Developer*
	Personnel Management	Hiring, training, and retaining capable employees within the platform firm. Considerations include determining when to hire new employees with certain skills, implementing development programs within the firm to further employee skills, and managing a positive culture within the firm.	*Owner*
	Relationship Management	Managing the relationship between the platform firm owner, developers, and users. Considerations include fostering trust within the ecosystem between all the actors, determining how external parties perceive the platform and the platform brand, maintaining loyalty of the developers, and ensuring that the monetary and proprietary dealings within the ecosystem are fair.	*Owner, Developer, & User*
Knowledge Management			
	Knowledge Management	Continuously managing the practices that gather, arrange, and distribute knowledge throughout the platform firm. Unlike previous knowledge sharing routines that focus on sharing knowledge within the ecosystem, the knowledge sharing activities and considerations related to this routine are solely focused on the different departments within the platform firm.	*Owner*

6.2. Preliminary Framework Verification

In Section 5.1 various requirements for a framework, to be used as a management tool for the management of technology platforms and their surrounding ecosystems, were listed. These requirements were based on information gathered during the conceptual – and systematized literature studies in Chapter 3 and Chapter 4 and were used as guidelines during the development process of the preliminary framework and management tool. The various requirements were then labelled as either Functional requirements (FR), User requirements (UR), Design requirements (DR), Boundary conditions (BC), or Attention points (AP).

Further, these requirements are used as an initial evaluation method of the framework to verify that the various aspects detailed in existing literature that are critical for developing and managing technology platforms and implementing technology management capabilities have been addressed. Table 6.1 below lists the requirements defined in Section 5.1, and identifies if the requirement has been met or not and finally explains which aspect of the framework addresses the requirement.

Table 6.1: Preliminary Framework Verification

NUM	REQUIREMENT DESCRIPTION	✓/ X	MANAGEMENT TOOL ASPECT
FR1	The framework should not just implement metaphoric symbolisms.	✓	Concise wording is used, and explanations are given for each routine.
FR2	The framework must include practical elements.	✓	Practical considerations for each routine action are given.
UR1	The framework must show which ecosystem actor the platform owner must keep in mind when addressing a management routine.	✓	The actors that need to be considered during each routine are given along with the routine definition in the definition canvas.
UR2	The framework must give the platform owner guidance with ecosystem governance.	✓	The routines platform/ecosystem expansion, ecosystem evolution strategy, and developer portfolio management cover ecosystem governance.
UR3	The framework must aid the platform owner in designing their platform.	✓	The four routines under selection aid a platform owner with designing their platform.
UR4	The framework must aid the platform owner to identify at what stage of the platform life cycle/ level of maturity their platform is.	✓	If implemented correctly, the platform life cycle routine gives the platform owner the canvas to see at which stage their platform is and the strategy routines will aid in what to do next.
UR5	The platform owner must be able to identify and evaluate their competition through the use of the framework.	✓	The business unit environmental monitoring routine covers analysing the platform competition.
DR1	The framework must define the considerations for the entry barriers for platform developers and platform users	✓	The technology transfer routine specifically addresses the entry barrier considerations a platform owner needs to take.

Dr2	The framework must address the different methods of value creation	✓	For monetary value, the platform funding routine lists different revenue models. For knowledge value, multiple routines are aimed at cultivating an innovation sharing culture and creating communication channels for information sharing.
DR3	The framework must address the effect of the external environment on the platform considerations.	✓	The user and developer technology adaption and protection routines list considerations of the external environment (from social to governmental).
DR4	The framework must be user focused.	✓	Each routine is defined as an action the platform owner can take and list considerations to aid their actions.
DR5	The framework must detail different avenues for revenue and pricing.	✓	The platform funding routine lists different revenue models.
DR6	The framework must focus on how to let the ecosystem evolve.	✓	The ecosystem evolution strategy lists considerations specific to ecosystem evolution.
DR7	The framework must clarify the balance required between the level of control the platform owner exerts on the platform and the openness of the ecosystem.	✓	The innovation management routines address different methods of cultivating an open culture within the ecosystem which shares innovation and level of restriction platform rules apply.
DR8	The framework must specify the roles of each of the ecosystem actors.	✓	The actor that should be considered during each routine is specified.
BC1	The framework must aid the platform owner in identifying the rules and regulations of platform ownership.	✓	The intellectual property management routine covers the considerations that the platform needs to take.
BC2	The framework must aid the platform owner in sustaining ecosystem health.	✓	Multiple routines are listed with the aim to support platform/ecosystem adoption and maintaining good relations between developers.
AP1	The framework must aid the platform to address governance issues.	✓	The learning routines give the platform owner the tools to identify various issues, which in turn can be addressed in the technology needs assessment routine.
AP2	The framework must not directly link the outcomes for the various routines as they run continuously and in parallel with one another.	✓	The framework shows that all routines flow into the mainstream of information flow and not specifically into other routines. The routines as placed all on the same ‘level’ to not indicate hierarchy between them.

6.3. Chapter 6 Summary

During Chapter 6 the preliminary management tool was developed based on the design requirements defined, and routines identified in Chapter 5. The initial evaluation of the preliminary management tool consisted of verifying the different aspects of the tool that address the design requirements defined in Chapter 5. All requirements were addressed apart from three. All three design requirements fell within categories that are "negotiable" or "not critical" to the framework, thus their absence is not detrimental to the validity of the framework.

The design science research progression checklist items defined by Hevner and Chatterjee [14] as set out in Section 2.5, Table 2.4 that were addressed during Chapter 6 are listed below.

Table 6.2: Design Science Research Progression Checklist [14] **– Items 2, 4 & 5**

NUM	QUESTION	RESPONSE
2	- What is the artifact?	- The preliminary artifact is a management tool that can be used by a platform owner to launch and manage a technology platform and platform ecosystem.
	- How is the artifact represented?	- The preliminary management tool consists of two canvases. The first canvas gives an overview of the activities required and their interrelationships while the second gives concise definitions and considerations for each activity. There are 37 proposed routines distributed between 10 primary capabilities that form part of technology management and supporting management capabilities.
4	- How are the artifact and the design processes grounded by the knowledge base?	- Nineteen design requirements were derived from the knowledge gathered during research conducted for a systematized and conceptual literature review. The management tool was then developed in order to adhere to these requirements.
	- What, if any, theories support the artifact design and the design process?	- The theories that support the artifact design are: - Technology management and supporting management capability literature - Dynamic capability theory - Hierarchy theory of capabilities - Existing management tools and literature for technology platforms and platform ecosystems
5	- What evaluations are performed during the internal design cycles?	- The design requirements were used as an initial evaluation method to verify that the critical aspects detailed in existing literature were addressed during the development process.

Further evaluation of the preliminary management tool commences in the following chapters.

Chapter 7

Demonstration and Evaluation: Semi-Structured Interviews

Chapter 7 key objectives:

- Discuss semi-structured interviews,
- Describe the interview process followed,
- Analyze the data gathered the interviews,
- Evaluate and present the findings,
- Relate how findings affect the preliminary management tool,
- Modify framework based on findings,

Chapter 7 consists of the second part of the evaluation process, the semi-structured interviews. It commences with giving a background to methodology for semi-structured interviews, followed by the process adopted by the researcher during the interviews. The data gathered is then analysed and the findings are presented. These findings are then related to the preliminary management tool and based on this the management tool is updated. The context of Chapter 7 relating to the DSRM process, and within this document, is shown in Figure 7.1 below.

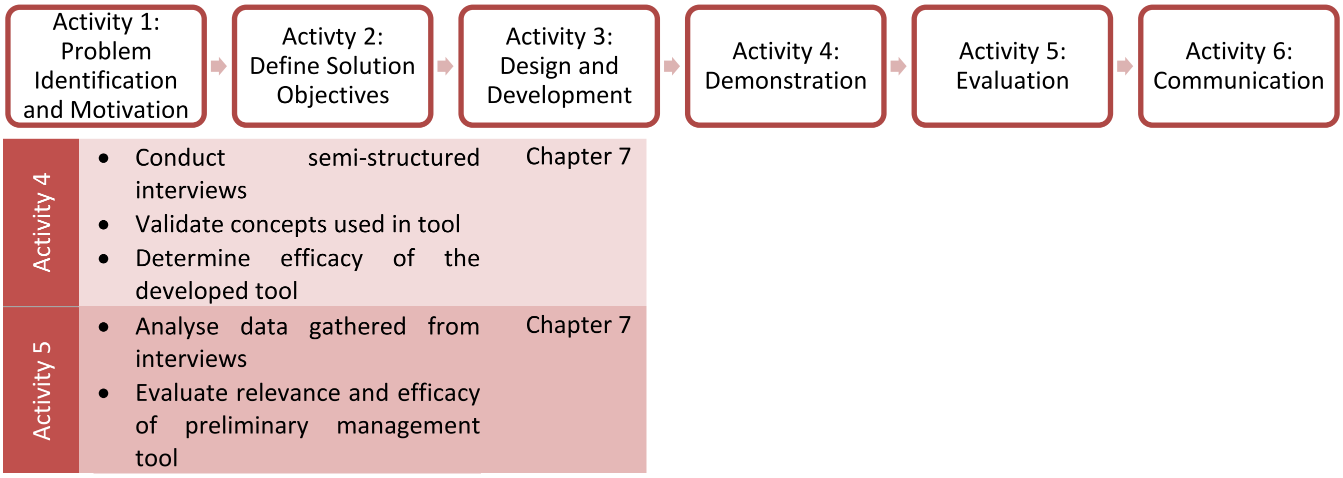


Figure 7.1: Research Context Diagram - Chapter 7

7.1. Semi-Structured Interviews & Process Followed

A more in-depth discussion of structured, semi-structured and unstructured interview types are given in Section 2.6 of this study. Semi-structured interviews are frequently used in qualitative analysis where a researcher discusses a list of key themes, issues, and questions to be covered during the interview with experts in the respective field.

After considering a structured, semi-structured and unstructured interview type, the semi-structured interviews were chosen. Unstructured interviews have the risk that the interviewees do not discuss the topics or themes related to the study research questions [36] while structured interviews do not give the interviewees opportunity to elaborate on or explain answers which are critical to gain new knowledge [29]. Semi-structured interviews are more explorative and due to the interview protocol, the data gathered during the interviews can still be compared [29]. Furthermore, it gives the opportunity for the researcher to ask follow-up questions in order to probe the interviewee for further information [29], [36].

Rabionet [36] developed a six-stage process to conduct an interview. This process was followed to develop the interview protocol and guide the researcher during the interview process. Table 7.1 below shows the different stages as set out by Rabionet [36] and their application within this study.

Table 7.1: Six-Step Interview Process and Relevance to this Study [36]

STAGE	STAGE DESCRIPTION	IN THIS STUDY
Select type of interview	Decide which type of interview structure to follow between structured, semi-structured and unstructured interviews	Semi-Structured
Establish ethical guidelines	Consider the possible consent, confidentiality, and protection issues that may arise during the interview.	Ethical clearance approved by REC, Interview consent form
Craft interview protocol	Provide interview context and develop questions and follow-up probes.	Section 7.2
Conduct interviews	Conduct interviews and determine how they will be recorded.	Section 7.3
Analyse interviews	Summarizing gathered data and data analysis	Section 7.4
Report findings	Present the results from the interview data analysis	Section 7.5

7.2. Interview Protocol

Rabionet [36] suggests that the third stage, crafting an interview protocol, should be split into two main components: (1) the interviewer introducing themselves and giving background to the study, and (2) asking the interview questions. Creswell [20] adds that the introduction component should include the standard instructions that should be followed during all the interviews. The researcher developed the interview protocol based on these two components.

The first component consisted of the interviewer introducing themselves and giving background to the study by showing the interviewees a brief slideshow. As per recommendation of Rabionet [36] the slideshow was kept as short as possible so that the interviewer can start with the questions as quickly as possible. Further background information and the interview instructions were given through the consent form which the interviewee had to read through and sign before the interview began. The second component consisted of the interviewer posing the interview questions. Within the developed management tool there are thirty-seven identified and defined technology management routines and ten technology management- and supporting capabilities, with multiple concepts that relate to each.

An impact-effort analysis was conducted during the interviews to gain quantitative data regarding the validity and efficacy of the proposed routines. The interviewer read aloud the proposed routine definition and asked the interviewee to rate the relative effort to implement each routine as well as its level of positive impact on the business. The rating ranged on a Likert scale of one to five where an impact rating of five indicates a high positive impact on the business and an impact rating of one indicated a low positive impact on the business. Similarly for the degree of effort required to implement the routine, a rating of five indicates that a high level of effort is required to implement the routine and a rating of one indicates that a low level of effort is required. The interviewees were encouraged to give their rationale behind each rating to gain further insight.

Additionally, the different technology management and supporting management capabilities were used as a roadmap to guide the researcher and formulate semi-structured questions to be asked after the impact-effort analysis of each primary capability group was completed. As the technology management and supporting capabilities also formed part of the probe, a third section of questions was introduced that consisted of overall questions that covered these topics.

This resulted in the second component consisting of an impact-effort analysis and twenty-one formulated questions. Due to the interviews being semi-structured the researcher also had scope to ask follow-up questions and discussions with the interviewee. The interview questions and slideshow are given in Appendix A and C of this study, respectively. Following the development of the interview protocol, the researcher conducted the interviews.

7.3. Conducting the Interviews

To ensure that the interviews were as comparable as possible the interviewer followed a standardised process while conducting each interview. All interviews were conducted virtually over the meeting platform Microsoft Teams to ensure the safety of both the interviewer and the interviewee in regard to the spread of the Covid-19 virus. The layout of this process is shown in Figure 7.2 below.

Figure 7.2: Process followed during Interviews

The first step was to obtain consent from the interviewee. This was done by emailing the consent form to the possible participant before the interview began. The researcher also gave the possible participant the chance to ask any questions regarding the consent form before they signed it. After the researcher obtained the signed consent form back the interview date and time was scheduled. In order to analyse the data gathered during the interview at a later stage the researcher voice-recorded the interview, which formed the third step. Following the activation of the voice recording the researcher commenced with the impact-effort analysis of each routine and the formulated questions.

If follow-up questions arose, they were asked after the rationale was given for the interviewee's ratings or one of the formulated questions. After the impact-effort analysis of each routine was conducted and the twenty-one interview questions were asked the researcher gave the interviewee the opportunity to ask any questions or highlight concerns regarding the proposed management tool.

A total of ten interviewees were questioned during the semi-structured interviews. Each interviewee was approached due to their expertise in their respective field. Due to the multidisciplinary nature of this study the researcher interviewed a diverse group of participants to validate the different aspects of the proposed management tool. The profiles of each interviewee are given in Table 7.2 below and includes their nationality, vocation, and contributing area of contributing expertise.

Table 7.2: Interviewee Profiles

INTER-VIEWEE	NATIONALITY	VOCATION	CONTRIBUTING AREA OF EXPERTISE
A	South Africa	Scholar	Technology management, Developer perspective
B	England	Technology Manager	Platform owner perspective, platform start-up
C	USA	Scholar	Technology management
D	USA	Scholar	Technology platforms
E	South Africa	Platform Owner	Platform owner perspective
F	USA	Scholar	Technology platforms, Platform ecosystems
G	South Africa	Technology Consultant	Technology management, Technology platforms
H	South Africa	Management Consultant	Technology platforms, Platform ecosystems, Technology management
I	Germany	Scholar	Platform ecosystems
J	South Africa	Scholar	Technology management

The final step in the interview process consisted of the researcher transcribing the interview into Microsoft Excel where the data was coded and analysed. The analysis process followed is discussed in the following section.

7.4. Interview Data Analysis

The following section discusses the process followed while analysing the data gathered during the interviews. The data collected during the interviews were both of qualitative and quantitative of nature.

7.4.1. Quantitative Data Analysis

The quantitative data collected consisted of the impact and effort ratings given for the proposed routines. As stated earlier, the impact and effort of each routine was rated on a scale of one to five. These ratings were all transcribed into Mircosoft Excel, and the average impact and effort rating of each routine was calculated. Following these calculations, the routines were plotted on an impact-effort matrix. This method is widely used by product managers, product owners and project managers to determine which processes are important (or risky) and where to concentrate their effort [150]. It is seen as a prioritization technique that is similar to the Eisenhower matrix [150], but is more applicable for individuals that manage larger initiatives and teams [150].

The matrix is divided into four quadrants: Quick wins (High impact, Low effort), Major Projects (High impact, High effort), Fill-ins (Low impact, Low effort) and Thankless Tasks (Low impact, High Effort) [150]. Figure 7.3 below shows the layout of a typical impact-effort matrix and the four quadrants in which the plotted routines were distributed.

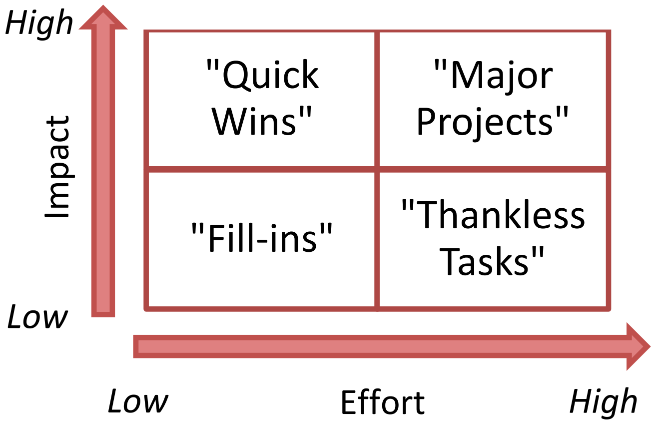


Figure 7.3: Typical Impact vs. Effort Matrix

The routines that fell within the top two quadrants, "Quick Wins" and "Major Projects", were seen as the activities that are most worth implementing due to their high positive impact on the business and reflect processes that are required within companies that utilise technology platforms. The routines that fell within the "Fill-ins" quadrant were seen as the "nice to have" activities within a company due to the low degree of effort required to implement them. The applicability of each routine within this quadrant was determined by the rationale given by the interviewees. The routines that fell in the final quadrant, "Thankless tasks", were seen as having a low level of efficacy due to their high level of effort required and a low level of applicability due to the low degree of positive impact they have on the business. These routines were re-evaluated by the researcher based on the rationale given by the interviewees and feedback given to the formulated questions to determine if their definitions can be restructured and should be kept within the proposed management tool, or not.

7.4.2. Qualitative Data Analysis

The qualitative data collected included the interviewee's rationale behind their impact-effort ratings, their answers to the formulated questions and the insights gained during the discussions thereof. To ensure that the qualitative data was analysed and presented in a structured manner, the researcher followed the six-step process for qualitative data analysis as proposed by Creswell [20] shown in Figure 7.4 below.

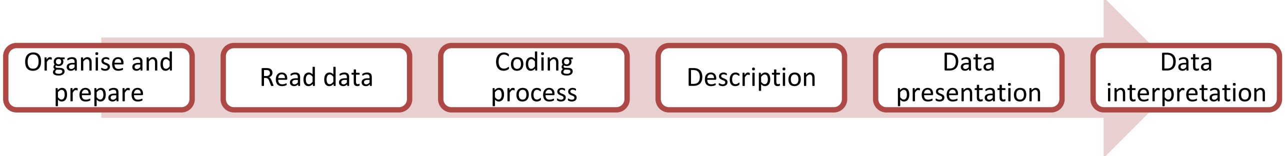


Figure 7.4: Data Analysis Process of Qualitative Data [20]

The qualitative data gathered during the impact-effort analysis of each routine was grouped under the different technology management and supporting management capabilities which the routines belonged to. This simplified structuring the data gathered through the formulated questions with the data gathered during the impact-effort analysis and resulted in the data being divided into ten parts.

An eleventh part was included that contained overall comments of the framework structure and the primary capabilities used. This structuring method was implemented to form a logical layout in MS Excel for each interview. The interview transcription process and data structuring process formed the first and second reading opportunities for the researcher.

The third step of the qualitative data analysis process set out by Creswell [20] included coding the organised data. Saldana [151] defines a code in qualitative data as "*a researcher-generated interpretation that symbolizes or 'translates' data and thus attributes meaning to each individual datum for later purposes of pattern detection, categorization, theme, assertion or proposition development, theory building, and other analytic processes*". Coding entails the process of translating the gathered data into the "researcher-generated interpretation" thereof [151]. The coding process is subjective to the researcher's analytic lens, but the filter that covers that lens and the angle from which the researcher views the phenomenon influences the how they perceive and interpret identified patterns throughout the data [151]. These patterns include: difference, similarity, correspondence, sequence, frequency and causation [151]. The number of interviews had an amount of data gathered which constituted a small-scale study for which a manual coding method was implemented as recommended by Saldana [151]. The data sample size did not demand an intense technological coding tool so the coding tool utilised was MS Excel due to the researcher's familiarity with its functionality.

Coding is seen as a cyclical process and multiple coding cycles should be utilized where the subsequent cycles further manage and refine important features of the qualitative data [151]. For this project two coding cycles were implemented to analyse the data gathered during the interviews. The goals of the first cycle were to establish the validity of concepts within the primary capability groupsets, identify disagreements, and gain additional insights of the primary capabilities by analysing the answers given by the interviewees for the formulated questions. The second cycle included establishing the validity of the concepts, identifying disagreements, and gaining additional insights of the proposed routines by analysing the rational given by the interviewees for their ratings during the effort-impact analysis through the lens of the different primary capabilities.

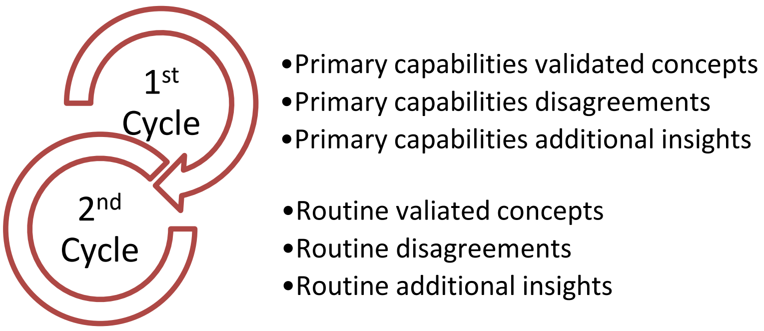


Figure 7.5: Coding Cycles Adopted during Interview Data Analysis

7.5. Results and Conclusions

7.5.1. Quantitative Analysis Results

This section discusses the results and conclusions for the quantitative data collected. The impact and effort ratings of each routine were gathered during the interviews, their averages calculated in MS Excel and plotted on an Impact-effort matrix. Figure 7.6 on the following page shows the thirty-seven proposed routines plotted within the four impact-effort quadrants.

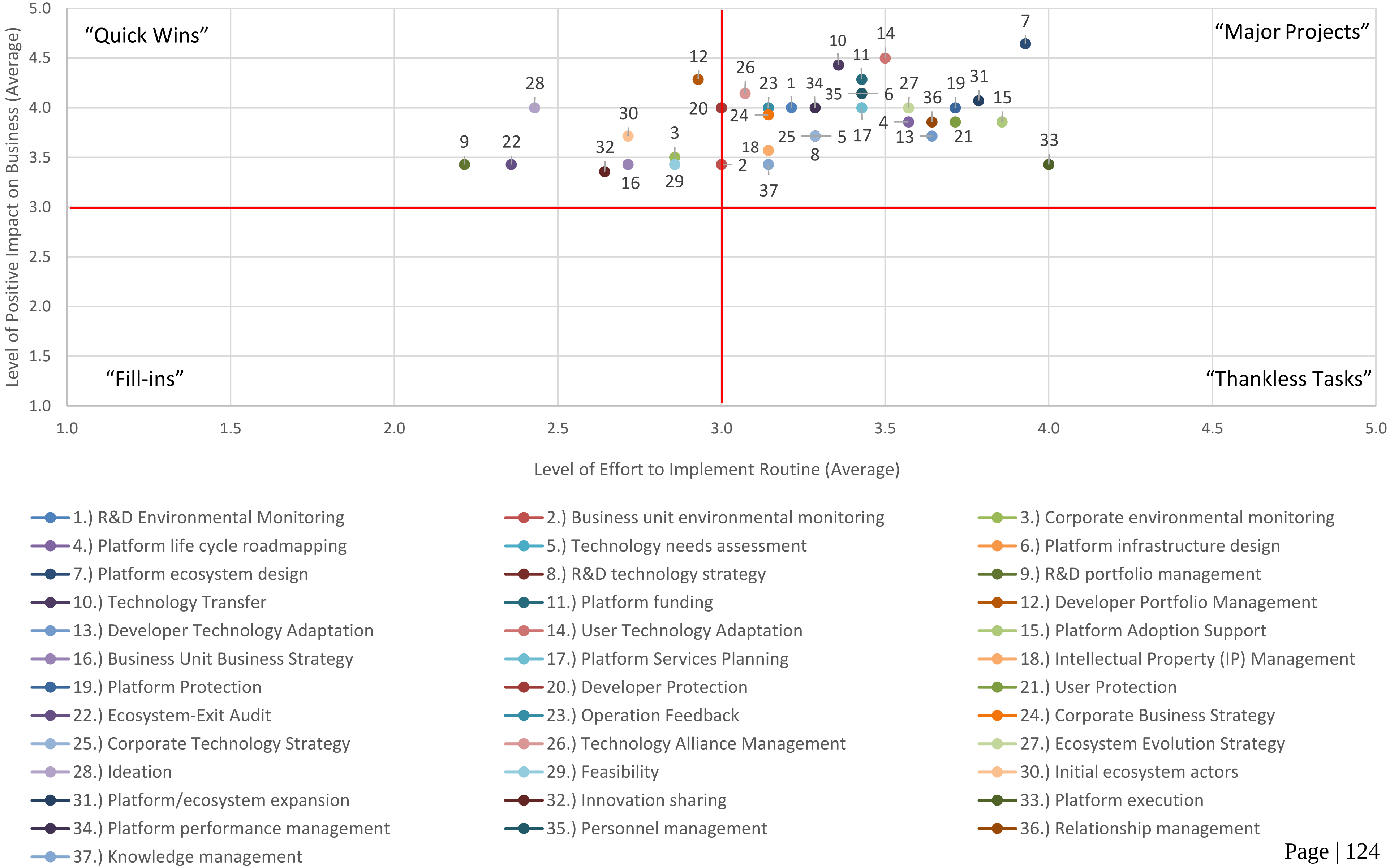


Figure 7.6: Impact-Effort Matrix of Preliminary Routines

Figure 7.6 shows that all the proposed routines fell within the “Quick Wins” and “Major Projects” quadrants. For impact, the routines are densely plotted with all the routines rated between a lower rating of 3.36 and an upper rating of 4.64 with most of the routines falling between a rating 3.5 and 4.5. The effort ratings of the routines are more widely distributed with all the routines rated between a lower rating of 2.21 and an upper rating of 4.00 with most of the routines falling between a rating of 3.0 and 3.5.

Table 7.3 and Table 7.4 show the distribution of the routines between the “Major Projects”- and “Quick Wins” quadrants respectively and where they fall within rating brackets.

Table 7.3: Impact-Effort Distribution of Preliminary Routines (“Major Projects”)

MAJOR PROJECTS	
Ratings of 3.0 < Effort ≤ 3.5 / Impact > 4.5	**Ratings of Effort > 3.5 / Impact > 4.5**
-	7.) Platform ecosystem design
Ratings of 3.0 < Effort ≤ 3.5 / 3.5 < Impact ≤ 4.5	**Ratings of Effort > 3.5 / 3.5 < Impact ≤ 4.5**
1.) R&D environmental monitoring	4.) Platform life cycle roadmapping
5.) Technology needs assessment	13.) Developer Technology Adaptation
6.) Platform infrastructure design	15.) Platform Adoption Support
8.) R&D technology strategy	19.) Platform Protection
10.) Technology transfer	21.) User Protection
11.) Platform funding	27.) Ecosystem Evolution Strategy
14.) User technology adaptation	31.) Platform/ecosystem expansion
17.) Platform services planning	36.) Relationship management
18.) Intellectual property (IP) management	
23.) Operation feedback	
24.) Corporate business strategy	
25.) Corporate technology strategy	
26.) Technology alliance management	
34.) Platform performance management	
35.) Personnel management	
Ratings of 3.0 < Effort ≤ 3.5 / Impact ≤ 3.5	**Ratings of Effort > 3.5 / Impact ≤ 3.5**
37.) Knowledge management	33.) Platform execution

Within the “Major Projects” quadrant and the whole Impact-Effort Matrix, the routines that had the highest ratings in both impact and effort were platform ecosystem design, platform/ecosystem expansion, and platform adoption support. The routine rated highest in terms of effort was platform execution.

Table 7.4: Impact-Effort Distribution of Preliminary Routines ("Quick Wins")

QUICK WINS	
Ratings of Effort ≤ 2.5 / Impact > 4.5	**Ratings of 2.5 < Effort ≤ 3.0 / Impact > 4.5**
-	-
Ratings of Effort ≤ 2.5 / 3.5 < Impact ≤ 4.5	**Ratings of 2.5 < Effort ≤ 3.0 / 3.5 < Impact ≤ 4.5**
28.) Ideation	3.) Corporate environmental monitoring
	12.) Developer portfolio management
	20.) Developer Protection
	30.) Initial ecosystem actors
Ratings of Effort ≤ 2.5 / Impact ≤ 3.5	**Ratings of 2.5 < Effort ≤ 3.0 / Impact ≤ 3.5**
9.) R&D portfolio management	2.) Business unit environmental monitoring
22.) Ecosystem-exit audit	16.) Business unit business strategy
	29.) Feasibility
	32.) Innovation sharing

The routines that had ranked the highest for impact and lowest on effort were R&D portfolio management, ecosystem-exit audit, and ideation. Out of all the routines the only routine that had an average impact rating of more than 4.5 was platform ecosystem design. The average impact-effort rating for the primary capabilities were also calculated by using the ratings of each routine that forms part of the respective capability groupset. These averages were then plotted on an Impact-Effort Matrix and shown in Figure 7.7 below.

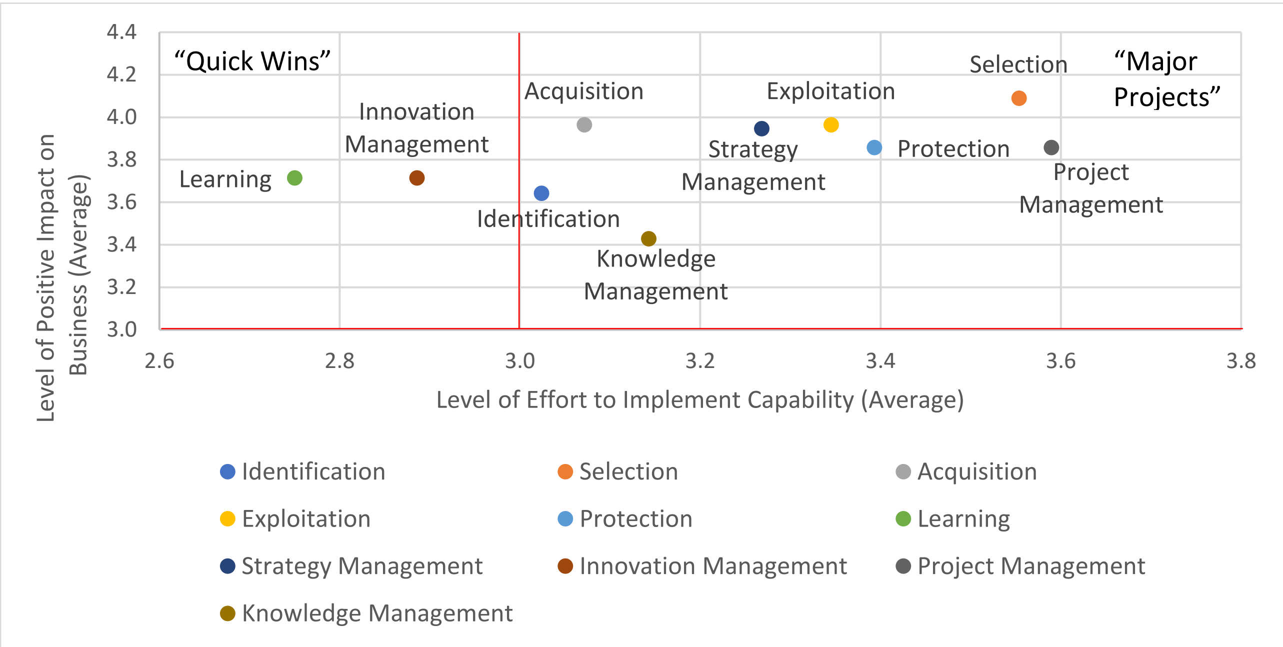


Figure 7.7: Impact-Effort Matrix of Primary Capabilities (Focused)

The distribution of the primary capabilities between the impact-effort quadrants is listed below in Table 7.5.

Table 7.5: Impact-Effort Distribution of Primary Capabilities

QUICK WINS	MAJOR PROJECTS	
Ratings of 2.5 < Effort ≤ 3.0 / Impact > 4.0	**Ratings of 3.0 < Effort ≤ 3.5 / Impact > 4.0**	**Ratings of Effort > 3.5 / Impact > 4.0**
-	-	Selection
Ratings of 2.5 < Effort ≤ 3.0 / 3.5 < Impact ≤ 4.0	**Ratings of 3.0 < Effort ≤ 3.5 / 3.5 < Impact ≤ 4.0**	**Ratings of Effort > 3.5 / 3.5 < Impact ≤ 4.0**
Learning	Identification	Project Management
Innovation Management	Acquisition	
	Exploitation	
	Strategy Management	
	Protection	
Ratings of 2.5 < Effort ≤ 3.0 / Impact ≤ 3.5	**Ratings of 3.0 < Effort ≤ 3.5 / Impact ≤ 3.5**	**Ratings of Effort > 3.5 / Impact ≤ 3.5**
-	Knowledge Management	-

Of the primary capabilities the combined average ratings of the routines within the selection groupset were the highest for both effort and impact. The project management routines had the highest average effort rating. The only two primary capability groupsets that were in the “Quick Wins” quadrant were learning and innovation management.

7.5.2. Quantitative Analysis Conclusions

With all impact-effort analysis projects there is a level of subjectivity and ambiguity regarding the ratings given. The researcher tried to minimize the level of ambiguity by giving clear definitions for both impact and effort, as well as the level subjectivity by interviewing a larger group of participants. The results that arose from the quantitative data analysis gave insight into the validity of the routines proposed within the primary management tool for technology platforms. That none of the thirty-seven routines fell within the “Fill-ins” and “Thankless tasks” quadrants indicates that the interviewees perceived the proposed routines as relevant to managing technology platforms and have positive contributions to the business.

The general feedback given by the interviewees are that the routines that fell within the “Quick Wins” quadrant should always be implemented as they deliver the most impact for the least amount of effort. These included most of the identification and innovation management routines, the ecosystem-exit audit routine from learning, both the portfolio management routines, and the developer protection routine. Of the identification routines the only one that was not plotted within the “Quick Wins” quadrant was the R&D environmental monitoring routine. This indicates that the routine requires much more effort to implement, but from the interviewee’s ratings and feedback it is also evident that it has a much higher positive impact on the company than the other two routines, deeming it just as important to implement.

For the innovation management routines most of the effort is related to creating the culture of innovation sharing and balancing control between ideation and feasibility and should be implemented from the very beginning of a company. The culture aspect is also why the developer protection routine was highly rated for impact as Interviewee F stated, "*it fosters trust within the ecosystem and makes the developers feel like someone cares about them and their work*".

From the primary capabilities perspective platform owners should focus on implementing the routines included in the learning and innovation management capability groupset as soon as possible, as well as those included in the identification capability groupset.

Within the "Major Projects" quadrant, and the whole impact-effort matrix, most of the routines were rated between 3 and 3.5 for effort. This indicates that the interviewees perceived these routines as not requiring too much effort to implement but do require careful consideration of when and how to implement them. Most of the routines from the strategy management, acquisition and knowledge management routines fell within this effort bracket. The routines that were rated highest for effort formed part of the project management, selection, and protection capability groupsets. Feedback received from the interviewees indicated that these routines require a high degree of continuous consideration. This is reflected in Platform execution having the highest rating due to the multiple processes and actors that are needed to manage and run a technology platform.

The reason why platform protection and user protection are rated higher for effort than developer protection and intellectual property management is as Interviewee G stated, "*with platform protection you always have to be one step ahead of the hackers, and you cannot take one chance to rest, because they definitely won't*" and "*...with user protection it is another ball game, you are not protecting someone's code, you are protecting their data, and that is the thing that these hackers want*". A further consideration regarding 'user protection' that requires more effort is the different laws and regulations that need to be implemented for different countries and regions.

The selection routines have the highest combined effort and impact ratings. Interviewee B stated that, "*these are the areas where if you make a mistake then your platform and business won't get anywhere*". The routine outputs form the basis of the platform and ecosystem and require a very high level of consideration and skill to implement. Between the two design routines the platform infrastructure design routine requires less effort, but only if the platform company has employees with a high degree of skill. It is also evident from the feedback given that it is relatively straight forward to implement the infrastructure design if the technology needs assessment and platform life cycle roadmapping routines were implemented correctly as both these routines indicate which and when certain technologies need to be applied. For the platform ecosystem design, it is not as straight forward with the various actors, the markets in which the platform will operate, the influence of competitors and the needs of the end users that need to be brought into consideration.

Finally, although the exploitation capability groupset on average has an effort rating between 3 and 3.5, the individual routines within the groupset are equally distributed between the 2.5-to-3, 3-to-3.5, and 3.5-and-higher effort brackets. Thus, each routine should be individually considered as the platform and ecosystem evolve and the company processes become more defined and matured.

The quantitative results gave the researcher deeper insight into which routines are critical for creating and managing a technology platform and platform ecosystem. The feedback received helped the researcher identify which routines should be primarily focused on when implementing a technology platform and which should be updated to improve their impact on the business.

7.5.3. Qualitative Analysis Results

This section discusses the two qualitative coding cycles adopted and the subsequent data analysis and results. The aim of the qualitative data analysis is to further validate the concepts proposed throughout the primary management tool, identify disagreements and missing concepts, gain additional insights regarding the primary management capabilities and routines, and discuss additions and modifications to the management tool. The ten primary management capabilities were used to arrange and code the data which allowed the researcher to easily compare the interviewee's rational and answers given during the interviews, integrate new insights, and identify patterns and themes.

First Coding Cycle

The first coding cycle included the analysis of the interviewee's answers to the formulated questions and follow-up discussions that took place. As stated earlier, the formulated questions were based on the ten primary management capabilities allowing for the data gathered during each interview to be easily compared. The purpose of the first coding cycle was to validate the objectives of each primary capability, discuss disagreements and missing concepts required to achieve these objectives, and to gain deeper insights of each primary capability. By understanding the objectives of each primary capability, the researcher could later adopt them as lenses during the analysis of the proposed routines in the second coding cycle.

Table 7.6 shows the formulated question's data gathered during the interviews tabulated as either validated concepts, disagreements and missing concepts, or additional insights. These data elements were labelled for traceability and referencing purposes as either a 'V' for validated concepts, 'D' for interviewee disagreements or missing concepts, or 'A' for additional insights to consider within each primary capability groupset. The data is presented in a concise manner and not in complete sentences.

Table 7.6: Concept Validations, Disagreements & Additional Insights - Primary Capabilities

PRIMARY CAPABILITY	VALIDATED CONCEPTS	DISAGREEMENTS/ MISSING CONCEPTS	ADDITIONAL INSIGHTS
Identification	V1- Competitors, partners, vendors are crucial focus areas. V2- Market trends and market gaps important. V3- Owner needs to understand user journey/ experience.	D1- Governments should also be seen as main focus area.	A1- Identification routines should represent PEST analysis. A2- Skillset availability major factor.
Selection	V4- Implementation timing is everything. V5- Communication between tech/customer needs and company capabilities required.	D2- Platform roadmaps should not be too long term focused. D3- Roadmap should not just focus on tech development, but also user journey.	A3- Platform base should be long term focus; platform capabilities and upgrade should be short term. A4- Roadmaps need to be agile and adaptable.
Acquisition	V6- R&D prevents disruption. V7- Funding scheme is critical as it influences speed to market, company capabilities, service/product price.	D4- Need a marketing execution routine to attract actors. D5- R&D not necessarily separate but imbedded as experimentation in development projects.	A5- Short platform life cycles benefit more from external R&D.

Exploitation	V8- Good company culture leads to good team dynamic, which lead to good service. V9- Developer services and relations intertwined. V10- User tech adaptation prevents organic rejection.	D6- Support not just required during adoption, but also during incidents. D7- Good developers do not necessarily mean good product.	A6- Companies need to keep evolving to keep market advantage.
Protection	V11- Valuation and operation protection required. V12- Protection for owner, developer, and user required. V13- Developers need to understand rules and policies. V14- Protection development is continuous and ongoing.	D8- User protection is not just about risk management but can also be sold as privacy as a service.	A7- Type of platform influences general data protection regulation. A8- Type of protection dependent on risk, time, cost.
Learning	V15- Continuous feedback and learning are important. V16- Whole ecosystem needs to benefit from learning.		
Strategy Management	V17- Key performance indicators (KPI) are essential. V18- Corporate strategy underpins technology strategy. V19- Technology strategy governs other strategies.	D9- Big areas of strategy are business, technology, evolution, and marketing.	A9- If corporate business strategy fails, all fails. A10- Alliances are second order consideration
Innovation Management	V20- Ideation, feasibility, and initial actors required. V21- Innovation is guided by company culture. V22- Guardrails and restrictions required to guide innovation in ecosystem.	D10- Should not manage innovation but manage culture. D11- Ideation in firm needs to comply with strategic objectives.	A11- The expansion considerations are seen as second order. A12- Ownership is required of innovative ideas.
Project Management	V23- Harmony is required between developers and employees. V24- KPIs are required to ensure projects/platform is on course. V25- Employee's skills need to be continuously improved.		A13- Personnel relations with ecosystem actors in beginning better, but not scalable. A14- Automated systems required on mature platform to deal with ecosystem actors
Knowledge Management	V26- KM should be done intentionally	D12- Knowledge gathering happens during execution of other routines	A15- KM processes are company size dependent. A16- Knowledge management should be broken into formal and informal processes

Second Coding Cycle

The second cycle of coding adopted the ten primary capabilities as the lenses through which the subsequent routines were analysed. The aim of the second the cycle is to further refine the qualitative data gathered for each proposed routine and determine any additional concepts that should be added to, replaced, or discarded from the management tool. By choosing the ten primary capabilities as lenses the researcher could analyse each routine from a holistic perspective within the management tool. This perspective allows the researcher to determine if the proposed routine satisfies the objectives of the primary capability, to investigate its influence within the management tool by forming either inputs or outputs for other routines, or to confirm if it addresses different consideration perspectives required for processes that run in parallel with each other.

The rational given for the interviewee's impact-effort rating per proposed routine was analysed and insights tabulated as either validated concepts, disagreements, or additional insights as with the first coding cycle. Table 7.7 below presents the insights gained of the thirty-seven routines which are distributed within their respective primary capability groupsets. As with Table 7.6 the elements included are labelled for traceability and referencing purposes with the numbering sequence continued from Table 7.6 to prevent confusion or highlight reoccurring elements. Each element was either labelled with a 'V' for validated concepts, 'D' for interviewee disagreements or missing concepts, or 'A' for additional insights to consider for each routine. As mentioned previously, the data in Table 7.7 is presented in a concise manner and not in complete sentences.

Table 7.7: Concept Validations, Disagreements & Additional Insights - Routines

ROUTINE	VALIDATED CONCEPTS	DISAGREEMENTS/ MISSING CONCEPTS	ADDITIONAL INSIGHTS
IDENTIFICATION			
R&D environmental monitoring	V27- It is important to identify new technological capabilities to implement in platform.	D13- Doesn't need to be disruptive but can be something new to improve existing systems. D14- Not a lot of differentiation in technology innovation.	A17- Difficult in the beginning to identify tech that is the right fit for the company.
Business unit environmental monitoring	V28- Important to understand if platform is meeting target market needs.		A18- Difficult to choose between staying with what is comfortable for your consumers or better for company operations/app. A19- Know which functions your end-users use.
Corporate environmental monitoring	V29- Platform Owners need to understand what is happening to their upstream and downstream stakeholders.	D15- As an earlier stage company not a lot of your strategy is contingent on understanding your involvement on market.	

SELECTION			
Platform life cycle Roadmapping	V30- Roadmap planning should be part of everyday activities.	D16- Roadmap planning should not be too far-future sighted.	A20- The Roadmap needs to be a live document.
Technology needs assessment	V31- It is necessary to plan what to implement into platform/ecosystem during design routines. V32- Security and Scalability.		
Platform infrastructure design	V33- Design considerations listed have major strategic consequences.	D17- Routine needs to more defined as an implementation routine.	A21- Add existing frameworks, information, technology that can be implemented.
Platform ecosystem design	V34- Design considerations listed are all required for platform ecosystem design.	D18- Routine needs to more defined as an implementation routine.	A22- Platform ecosystem design informs tech assessment, infrastructure requirements, and roadmap layout.
ACQUISITION			
R&D technology strategy	V35- Required for progression from R&D monitoring to R&D strategizing.		
R&D portfolio management	V36- Required to ensure validity of project and correct allocation of resources.	D19- In most platform companies it is not fundamentally about the technology, it is fundamentally about the way you create the platform ecosystem.	
Technology transfer	V37- Developer acquisition and retention are key.		A23- Entry barrier considerations can be generic or "per complementor" basis which influences effort required. A24- Entry barriers also keep the people you do not want, out. A25- Be aware of becoming a skill sourcing area.
Platform funding	V38- Considerations are crucial to business and ecosystem actors.	D20- Should be part of the strategic assessment earlier on.	
EXPLOITATION			
Developer portfolio management	V39- The business will not run without the developer community.		

Developer technology adaptation	V40- Continuous routine required that aligns design of infrastructure with associated ecosystem. V41- Training tool critical to ensure developer efficiency.	D21- It is not just about the technological ability, but also marketing strategy.	A26- Training tool leads to upskilling of developers which attracts more developers.
User technology adaptation	V42- Separate routines required for developer and end-user at same importance level. V43- Alignment with user requirements important to prevent organic rejection.		
Platform adoption support	V44- Support for migrating developers forms the last link in chain after acquisition and adaptation.		A27- Operational support is also required for when there are incidents.
Business unit business strategy	V45- Alignment is required between the resources the company allocates to operate the platform.	D22- Routine name does not fit with definition or within framework.	A28- Effort should focus on the actual operational part more than the strategizing part.
Platform services planning	V46- Aligning business requirements and challenges with platform operation to solve them.		A29- The difficulty in routine comes from aligning of business requirements with platform, but implementation is easy.
PROTECTION			
Intellectual property management	V47- Protecting the core differentiation of platform.		
Platform protection	V48- Important to protect the daily operations of the platform.		A30- Successful implementation has first-order operation protection and second-order reputational effect.
Developer protection	V49- Platforms are about trust. V50- Governmental and organisational considerations are key.		
User protection	V51- User data protection very important from a regulations and law perspective.		A31- State GDPR type considerations. A32- Laws and regulations of each country should also be considered. A33- Privacy can also be used as a core differentiation factor.

LEARNING			
Ecosystem-exit audit	V52- Routine delivers value as feedback can stimulate updates/change.	D23- Continuous feedback during operational phase more important. D24- Value dependent on developer feedback	A34- Process can be automated
Operation feedback	V53- Continuous feedback operations are required to retain developers and users and improve operations.		
STRATEGY MANAGEMENT			
Corporate business strategy	V54- Routine delivers high impact as you are choosing direction of company at high level.		A35- Should be kept simple
Corporate technology strategy	V55- Routine considerations are central to how platform will operate.	D25- Should be alignment with marketing programmes, not determine market programmes.	A36- A marketing routine is required on its own.
Technology alliance management	V56- Strategic partnerships are important for platform businesses.	D26- Alignment of existing technologies within firm also required	A37- Partnerships not only provide access to markets but can also increase speed of access to market.
Ecosystem evolution strategy	V57- There also must be cohesion between the platform owner decisions and the ecosystem actors.	D27- Other routines already discuss how strategy and plans to attract developers.	
INNOVATION MANAGEMENT			
Ideation	V58- Ideation is dependent on the culture within the company and the ecosystem.		
Feasibility	V59- Balancing act is required between feasibility and ideation.	D28- You should not waste a lot of effort before a project to determine if it is feasible.	A38- Have a streamlined low-cost experimentation loop to gather useful data to determine feasibility.
Initial ecosystem actors	V60- Initial actors' considerations form launch strategy.		A39- Effect on platform path and trajectory dependent on initial actors.
Platform/ ecosystem expansion	V61- Integrating and providing new functionalities is continuous and required to enter new markets.		
Innovation sharing	V62- Envelopment prevention has a positive impact on ecosystem performance.	D29- Innovation sharing does not promote ecosystem expansion but does provide new functionality to developers.	A40- Innovation sharing can lead to new apps developed to be utilized on existing apps. A41- API Considerations

PROJECT MANAGEMENT			
Platform execution	V63- The right considerations are required to run the platform effectively.		
Platform performance management	V64- Control mechanisms influence platform performance. V65- Measurement considerations are important.		
Personnel management	V66- Without skilled employees the platform will not run efficiently.		A42- Company reputation and funding play a role in personnel acquisition.
Relationship management	V49- Platforms are about trust.		
KNOWLEDGE MANAGEMENT			
Knowledge Management	V67- Knowledge management breaks down information silos within company.	D30- Routine requires a more practical look at knowledge management.	

7.5.4. Qualitative Analysis Conclusions

The insights relating to each of the ten primary capabilities and the subsequent routines that form part of their groupsets as set out in Table 7.6 and Table 7.7 are discussed below. The discussions include the general comments regarding the preliminary tool appearance, the primary objectives of each primary capability as perceived by the interviewees and the overarching themes adopted during the impact-effort rational discussions for each routine.

General

General comments were also discussed regarding the appearance of the preliminary management tool. The feedback received is that the six primary technology management capabilities are a good representation of the existing literature and that the four primary supporting management capabilities cover the necessary lenses required to assist them.

A general note made by the researcher is that during the impact-effort analysis the interviewees continually mentioned the sequence in which the routines were read, for example the ecosystem-exit audit routine appearing before operations feedback routine in the Definitions Canvas. During the development of the preliminary management tool the researcher purposefully did not concentrate on the sequence of the routines to reflect their dynamic nature but noticed that this caused confusion between the interviewees. As such the sequence of the routines were updated during the development of the final management tool.

A further proposal included the routines be colour coded based on the maturity of the company to indicate which routines need to be focused on initially operate the platform. The need for this modification was also reflected in the interviewee’s impact-effort ratings for the routines and the rational given by interviewees that come from a start-up background. Further comments that were noted included a routine being “fundamental” or “second order”.

Identification

The routines that form part of the identification groupset need to focus on and establish the external influences on the business processes, ecosystem actors, platform capabilities and platform uptake. The three proposed identification routines covered most of the critical environments and their considerations with platform owners needing to understand the social and cultural background of the end-users in order to plan the user journey/ experience (V3), to keep an eye on emerging and existing technology that can be implemented to improve platform operations (V27) or prevent disruption to business processes, and scan the economic atmosphere and markets for disruption to vendors (V1) or new gaps that the platform can enter (V2). Although the "corporate environmental monitoring" had a governmental consideration the general feedback received during the interviews was that a governmental and regulatory environment scanning routine should be added (D1) as these factors play a massive role in platform life cycle planning (e.g., future laws allowing for new technology use) and which technologies can be implemented by the platform capabilities (e.g., using crypto currency).

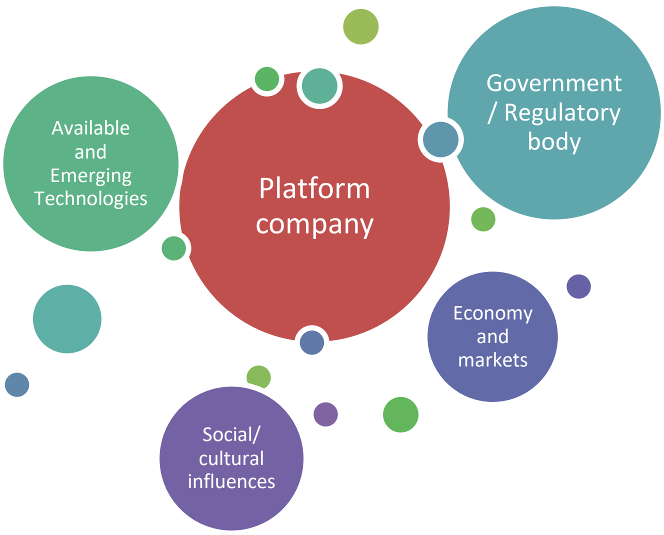


Figure 7.8: External Identification Environments

With R&D environmental monitoring it is difficult to determine what to implement in the beginning and there is a need to drown out the noise generated from different vendors (A17). After the initial scanning and implementation of technology the routine becomes easier as the platform company should not uproot everything when a new technology enters the market but should be aware of new technology that could improve existing operations or attract new actors. From the social and cultural environments perspective, platform companies love to focus on tech and sometimes miss consideration of customers, although it is critical to know what their needs are and how they change (V28). A balancing act is required between staying with technology and systems that are end-users are used to and comfortable with and implementing changes to the platform that improve the outcomes of the organisation (A18). Finally, the corporate environment needs to be split into an economic and governmental environment as each require a different set of considerations and influence the business strategies differently. At the earlier stages of the platform firm company, not a lot of the business strategy is contingent on understanding the influence the platform has on the economy (D15) but need to understand what is happening to their upstream and downstream stakeholders (V29).

Selection

As stated during the impact-effort discussions the selection routines "*are the areas where if you make a mistake then your platform and business won't get anywhere*" - (Interviewee B). The routine outputs form the basis of the platform and ecosystem and require a very high level of consideration and skill to implement. A cycle is formed where all the supporting management capabilities and other technology management capabilities routines feed into platform life cycle Roadmapping and technology needs assessment routines that are required to successfully implement the two platform design routines. In turn as the platform and ecosystem design becomes more mature and evolve it influences the business strategies, company capabilities, identification environments, etc. and the cycle continues.

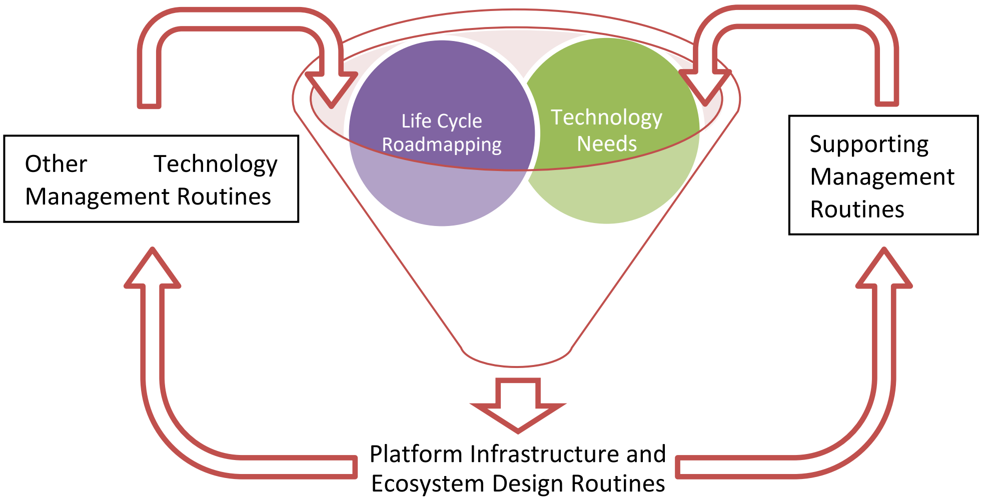


Figure 7.9: Selection Routines Visualisation

With implementation, timing is everything (V4) and planning is required to ensure the various strategies are correctly executed, but with platform life cycle Roadmapping it is necessary to not plan too far ahead as things tend to change (D2) (D16). The roadmap needs to be a live document (A20) and done iteratively (V30) to determine if the evolution path is still valid, if it should be changed, or additional deliverables need to be added. The biggest mistake will come if the companies set out roadmaps and blindly follow them. It is important for the platform owner to not just focus on the technology required to operate the platform, but also the user journey or experience they want to create when planning the roadmap (D3).

The roadmap forms the "when to implement" have of the selection routines and the technology needs assessment forms the "what to implement" (V31). With the technology needs assessment routine, the value of comes from the inputs it forms for the design routines, as Interviewee F states, "*It is doing your homework before you start doing the things that have higher value*". This is especially important for platform considerations that have a high impact on the platform's operations, for example scalability and security (V32).

Careful consideration is required as big mistakes can arise during the life cycle and needs assessment routines that flow into your design routines. Although the platform infrastructure design routine requires maximum focus, it does not require maximum effort if the company has skilled staff with the right expertise.

Additionally, platform owners do not need to reinvent the wheel, there are a lot of existing frameworks and information that are available to guide the design process or existing infrastructure that can be implemented (A21). During the platform ecosystem design the platform owner should develop the mechanisms to realise their understanding of the user journey and experience. Continuous development is required as new needs arise or to address considerations missed during the initial design with, for example, entry barriers. The ecosystem will inform the technology needs for the platform, the infrastructure required to realise them, and the layout of the evolution roadmap (A22).

Acquisition

The acquisition routines are the activities required to attract and retain the different ecosystem actors. R&D in platform companies is still critical as it prevents disruption (V6), but are not traditionally implemented as a separate department but rather imbedded as experimentation in development projects (D5). The biggest feedback received from the interviews was that a marketing routine, guided by a marketing strategy routine, is required to attract potential actors to the platform (D4).

Outputs from the R&D environmental monitoring routine flow into the R&D portfolio management routine where it can be difficult to determine the outcome of the various R&D projects. Due to this difficulty the R&D portfolio management and R&D technology strategy routines work in parallel. The portfolio management routine is required to identify the various stakeholders and their effects on the choice of projects to be pursued (V36), which in turn guides the strategy routine to determine when to focus on the various projects (V35). In most platform companies the R&D is not fundamentally focused on just finding new technology to implement into the platform, but about how the technology can be utilised to create and adapt the platform ecosystem (D19). Both the R&D technology strategy and portfolio management routines' considerations and decisions are straight forward and are critical to determine the validity of the projects. The effort required during the routines' implementation should rather be focused on where the organisation knows the identified technology plays a critical role within the platform processes.

Technology transfer is seen as an active monitoring process where the stage of development effects the developers the platform attracts and thus the entry barriers required. These considerations are key as developer acquisition and retention is critical for the platform and ecosystem growth (V37). Entry barrier considerations include level of attractiveness for the desired actors, level of difficulty to enter as a method to deter undesired actors (A24), and incentive structures to ensure a healthy level of monetization. Retention against competition is also required as the ecosystem becomes a sourcing area for other companies looking to acquire new skills (A25).

Finally, during the platform funding routine subtle reasoning is required and should continuously applied as part of strategic assessments earlier on (D20). These considerations are critical for how the ecosystem will operate and the company survival (V38). Acquisition decisions of technology, internal developers, etc. can also be based on objective driven criteria rather than return on investment (ROI) and ultimately it is just a decision that needs to be made. The funding scheme chosen ultimately has an influence on the company capabilities, which influences speed to market and service/product pricing (V7).

Exploitation

The exploitation of the developers and users in a platform company is highly dependent on the company culture which guides the dynamic between all the ecosystem actors (V8).

Good developers do not necessarily mean good services (D7) as they are intertwined with the ecosystem actors' relations (V9), as reflected in the developer portfolio management routine. Managing the developer relations is dependent on the level of maturity of sourcing processes as the effort required to manage the cohesion between the developers comes down to their personalities and the company culture. The relations side of the management plan is dependent on the platform firm's company culture, business model and organizational requirements.

To manage the developer services, the platform should be developed as open architecture from an integration perspective. If the platform is not easy to interact with, user friendly, or easy to integrate with, then the platform will not take off. The training tool consideration that forms part of the proposed routine is critical for developer efficiency (V41) and has a second effect as it upskills developers which in turns attracts more developers (A26). The proposed routine is about aligning the technology with the developer community requirements to ensure ecosystem runs smoothly and attracts more people (V40).

Symmetry is required between end-users and developers as both are ecosystem actors and are equally important and impactful to the platform firm's business (V42). Insufficient user adaptation has a profound impact, as adaptation is required to prevent organic rejection from the end-users (V10) (V43). It is important to understand the customer journey. Due to the high availability of options in platform ecosystem markets, if the end-user does not like how the platform or applications work then they can just move to another one. Additionally, the two adaptation routines should be done continuously as the platforms evolve to keep ahead of the competitors and to keep market advantage (A6).

The platform adoption support routine forms the last link in the chain after developer acquisition and adaptation (V44). Interviewee E summarised the effects of the routine as:

"*a by-product of operating practice, it is the "customer service" of the platform and a standardized procedure or documentation (for example a community forum where you can ask a question and be supported or can log a call) is required to prevent unnecessary effort.*"

Common feedback between the interviewees included the need for a further support structure for when incidents occur (A27). The support structure should include the strategies and systems put in place for when normal platform operations are interrupted due to the platform being down and the communication channels between the platform owner and ecosystem actors to identify the cause.

As stated earlier the platform and ecosystem dynamics are dependent on the company culture. The business unit business strategy routine is required to understand how the company beliefs and values influence the platform management. Alignment is required between the resources the platform firm allocates to sustain normal operations (V45). During the routine activity caution should be followed to not allocate too much effort to the strategizing part and not the actual implementation (A28).

Finally, during the platform services planning routine the platform owner should deliberate what the platform is providing from a business perspective and what the business challenges are that need to be resolved (V46). These considerations are seen as significant and complex that need to be done right. The platform owner needs to translate the market gaps identified into the right business ideas and focus on the operational challenges that need to be resolved to realise the ideas. The initial effort required to implement the routine is high, but as the platform becomes more mature it becomes fairly simple (A29).

Protection

The routines that form part of the protection groupset have two functions: protecting the normal operations of the platform and protecting the valuation of the platform firm (V11). The protection considerations also need to extend beyond the platform firms and include all the ecosystem actors (V12). From the valuation perspective the platform firm's intellectual property (IP) and the end-user's data needs to be protected to ensure value is not lost. It is important to understand how the type of platform influences the data protection considerations of the platform owner, developers, and users (A7). From the operations perspective the platform and ecosystem infrastructure need to be protected to ensure normal operations are not interrupted. A continuous (V14) balancing act is required between all the protection services based on the risks involved to the platform firm, the time required to implement the protection applications and the cost thereof (A8).

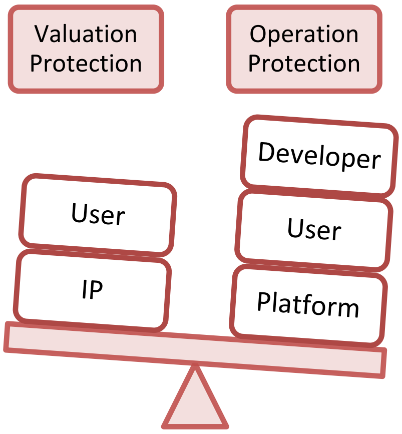


Figure 7.10: Valuation and Operation Protection Elements

IP protection processes and agreements have become standardized, and no additional creativity is required, but the routine needs to be implemented correctly as it can protect how the platform is differentiated from the market (V47). The considerations regarding the type of agreements are dependent on the platform and if the services provided were developed from scratch. With the platform protection routine there are little direct positive impacts on business operations, but rather provides a safeguard for normal business operations which is seen as critical (V48). This is reflected in Interviewee B's statement:

"*the value of the operations are based on the security of operation*".

Additionally, successful and continuous protection of platform operations also has a second-order reputational effect on how the actors within the market view the platform (A30). This reputation is further built on the trust formed between the platform owner and developers (V49) as the platform owner needs to be aware that it is not just their IP that they need to protect, but also the developer IP. It is important to set-up agreements in the beginning that include governmental and organisational considerations (V50) so that developers can understand the rules and policies of the platform (V13).

Lastly, regarding the user protection, it is not just the developers that need to protect the user data, but also the platform owner's responsibility to manage how the developers and your platform are utilizing the platform data. The standard of care and complexity of dealing with personal data of individuals is escalated in comparison with dealing with a developer's code as each country or region has their own laws and regulations that need to be adhered to (A32).

The value derived from user protection can either originate from ensuring that the company cannot be held liable for data leaks or be used as a differentiating factor where data protection is sold as a services (A33) (D8).

Learning

The two critical considerations regarding learning for a platform owner are that continuous learning and feedback is important to business operations (V15) and that the whole ecosystem needs to benefit from the learning operations (V16).

The operations feedback routine should be part of normal operation and is seen as more important than the ecosystem exit-audit routine (D23). By continuously gathering feedback and learning from it, the platform owner can improve operations and retain developers and users (V53). It is important to first analyse the feedback as not all communications are relevant and could also just be user preferences. The communication channels always need to be open and implemented as a two-way system. Although the operations feedback is seen as more important, the ecosystem-exit audit routine also delivers value as the information can be gathered through an automated survey (A34) and can stimulate updates to the platform and ecosystem (V52). The value of the routine is dependent on how the audit questions are structured, the level of trust within the ecosystem and loyalty with the developer to give honest feedback (D24).

Strategy Management

The strategy management routines underpin the strategies required for a successful platform business and define the key performance indicators (KPI) needed to reach the envisioned goals (V17). The areas of strategy included in the preliminary management tool included business, technology, and evolution, but interviewees indicated that it critically missed a fourth – marketing (D9).

Figure 7.11: Four Key Strategy Areas

The first routine, corporate business strategy, is required to choose the direction of the company which delivers a high impact to the business (V54), because if the corporate business strategy fails, then everything fails (A9). The strategy considerations are seen as hygienic decisions made at a senior level within the firm and should be kept simple, as too much complexity can slow the implementation down (A35).

The corporate business strategy directs the corporate technology strategy (V18), which in turn governs the other strategy routines within the preliminary management tool (V19). For the technology strategy, each consideration needs to work in unison and are central to how the platform will operate (V55). Interviewee E states that, "*It doesn't help you acquire tech that your developers can't use, nor does it help your marketing department market something on the platform that hasn't been developed yet. Or they market something, and you weren't aware it is being marketed and the volumes are catching you out.*" Thus, your marketing programmes should align with your technology strategy and require their own strategy routine (A35) (D25).

The technology alliance management is seen as the second step in the process between the defined the strategies and the planned operations to execute them (A10). The platform owner needs to understand and align the existing technology within the platform firm (D26) with the right type of partners to keep the company's technology footprint a little smaller by not having to do everything. These partnerships are important to the platform business and can originate from identifying certain components other companies have developed, which the platform firm cannot improve, but rather can adopt within their operations to ensure speed to market. The right alliances increase the ability to flex quickly. The benefits include quicker development, faster implementation and exploitation, higher quality services/products, and gaining access to new markets (A36).

Finally, for the ecosystem evolution strategy, although it is crucial to plan how the platform owner envisions the ecosystem to evolve, it is more important to focus on the implementation and operational part of the evolution rather than trying to form a set strategy. This is reflected in Interviewee I's statement:

"*Sometimes you just need to ride the wave and ensure your platform can keep up with the level of scalability*."

This said, it is still necessary for the platform owner to manage the evolution trajectory and it is good to understand the friction points that can arise between the ecosystem actors and the decisions made by the platform owner and what needs to be done to avoid them (V57).

Innovation Management

With Innovation management it is important to understand that it is innovation itself that needs to be managed, but the culture within the platform firm and the ecosystem that enables the innovation (D10) (V21). Innovation within the ecosystem needs to be guided by implementing guardrails in between which the actors can operate (V22), but still have the freedom to generate new ideas and have ownership over them (A12).

Ideation within the platform company comes down to the platform culture (V58). The platform owner needs to be aware that not all ideas should be implemented and that they should follow the strategic objectives of the firm (D11). Without ideation the platform, ecosystem and company will not move forward, it is a balancing act between creating the space for ideation and taking the concepts forward that will benefit the company. Additionally, ideas should not be followed if they are not feasible. The value is created during ideation, but if the feasibility operations are wrong then it can kill innovation by either overanalysing the ideas or accepting too many ideas and not following them through. Feasibility should be streamlined, with defined rules of how to test the ideas without requiring a lot of effort but gathering enough data to determine their relevance (D28) (A38).

The initial ecosystem actors are important as they will determine the initial path the platform will evolve along and its trajectory going further (V60). This is reflected in Interviewee H’s statement:

“*The path dependent argument is important, the people you have in the early stages really help you figure out and have a disproportionate impact on the trajectory of the platform*.”

The considerations mentioned in the platform/ecosystem expansion routine were seen as second order, because if the platform does not launch then it will not expand (A11). This growth is the fundamental issue for all new platforms, but if the platform is successful, it will see exponential growth over a substantial period of time and determining how to fine tune the expansion and be responsive to changes in the market is important. Additionally, innovation sharing does not necessarily promote ecosystem expansion, but could provide new functionalities to developers as they can utilise innovative applications and ideas within the ecosystem (D29) (A40). For innovation sharing decisions are required regarding the standard application programming interfaces (API), their rules, and if the APIs are the platform’s responsibility (A41).

Project Management

The project management routines are required to maintain harmony between the ecosystems actors and the platform firm employees (V23) and ensure the set-out plans are executed correctly in order to reach the defined KPIs (V24). For new platforms, personal relations between ecosystem actors and the platform employees are more beneficial as this builds trust and can bring to light new functionalities required based on the feedback and preferences of developers and users (A13). This strategy is not scalable though and should be replaced with automated systems as the platform matures (A14)

The proposed platform execution routine lists the considerations required to run the platform and its processes (V63). During the platform performance management routine, the level of control mechanisms influences the performance of the platform and the developers within the ecosystem (V64). The correct measurements schemes are important to determine the quality of the developer's apps which are dependent on rules of platform use and set boundaries (V65). Additionally, if enough effort is spent on recruiting the right personnel and attracting the right developers then the effort for this routine is lower. The efficiency of the platform performance is dependent on the level of skill the employees have(V66). The hardest part of this routine is finding capable employees and keeping them. Although there are many skilled individuals, the market competition makes it difficult to acquire them as the company reputation and ability to fund niche skills plays a role (A42).

Finally, the relationship management routine not only has an influence on how the developers and employees operate, but also on how the outside world perceives the platform. Platforms operate on the theory that the value is not coming from special technology, it is coming from the convening or the aggregation of multiple sets of stakeholders in a business relationship that is based on trust (V49).

Knowledge Management

Knowledge management is necessary to ensure that work is not duplicated throughout the platform company by breaking down the information silos within each department and giving access to information across the board (V67). The actual knowledge management processes are company size dependent as companies can implement both formal and informal knowledge management processes (A15) (A16).

By effectively implementing the knowledge management routine the platform firm's team efficiency improves and prevents repetition of mistakes learned from in the past. The most difficult part of routine is to get employees to actually share the knowledge as these processes need to be done intentionally (V26) and it is difficult for people to take ownership of this task.

Feedback received from the interviewees suggest that the routine needs be stated in a more practical manner and that more considerations are required (D30). A shared perspective included breaking down the routine into two routines with one addressing the management of tacit knowledge within the firm and the other the explicit knowledge within the firm as both require different methods of knowledge capture and sharing.

7.5.5. Updates to Preliminary Management Tool

This section lists the changes made to the preliminary management tool based on the conclusions drawn from the quantitative and qualitative data analysis. The proposed updates either consisted of structural or conceptual changes to the tool. The conceptual changes included redefining and renaming the proposed routines based on the insights gained during the interviews and adding additional routines. The structural updates include the changes made to the physical appearance of the tool. Table 7.8 presents the updates made to the preliminary management tool, the motivation behind the change and the reference behind the reasoning. The "Rationale" reference refers to the researcher having gained deeper insight into the routines and used it to modify the tool.

Table 7.8: List of Updates to Preliminary Management Tool

	#	UPDATE	MOTIVATION	REF
CONCEPTUAL	1	Change the three identification routines to reflect the four PEST (Political, Economic, Social and Technological) concepts.	The three existing identification routines covered the economic, social, and technological areas, but a fourth was required to scan the governmental/pollical environment. The PEST concepts were chosen based on their widespread use [152].	A1, D1
	2	Update ecosystem actors that are linked to the different routines.	Deeper insight was gained during the interview regarding the ecosystem actors affected by the various routines.	Rational
	3	Update definitions and names of multiple proposed routines.	Various comments received gave insight into further considerations for multiple routines, specific wording of definitions, and desired outcomes of routines.	D16, D17, D18, D25, D26, D27, A20, A21, A27, A31, A32
	4	Add an incident support routine in exploitation groupset.	An incident support routine is required to list the considerations and strategies needed when platform operations are interrupted.	D6, A26
	5	Add marketing routine in acquisition groupset.	Marketing is required to stand out in a crowded market and attract potential ecosystem actors.	D4

	6	Add a marketing strategy routine in strategy management groupset.	A marketing strategy routine is required to ensure the alignment the marketing programme with the technological capabilities of the platform.	D9, D25, A36
	7	Split knowledge management routine into tacit and explicit knowledge management routines.	There are different formal and informal practices for explicit and tacit knowledge management.	D30, A16
STRUCTURAL	8	Rearrange routines within respective primary capability groupsets.	Rearranging the routines within their respective groupsets will prevent confusion and link with the colour coding modification.	Rational
	9	Colour code routines based on effort to implement routine.	By colour coding the routines based on their effort will aid new platform owners with their resource management by allowing them to identify which routines they can implement quickly and easily, and which require more effort and resources.	Rational
	10	Marking fundamental routines based on the maturity of company.	The marked routines will aid new platform owners to focus on routines that are required from platform/ecosystem launch and which can be later implemented as the platform/ecosystem matures.	Rational, Interview feedback
	11	Add key to Flow Canvas.	A key will guide the canvas user to understand the colour scheme.	Rational

The resulting management tool now comprised forty-two routines distributed between ten primary management capabilities. The routines and primary capabilities were presented as with the preliminary management tool in a Flow Canvas and Definitions Canvas. A key was added to the Flow Canvas to guide the platform owner through the routine colour scheme.

The final management tool is presented in Chapter 8 of this study.

7.6. Chapter 7 Summary

Chapter 7 included the evaluation and demonstration activities of the study's design science research methodology. The preliminary management tool was demonstrated during semi-structured interviews with local and international experts and evaluated by conducting an impact-effort analysis of each routine during each interview and asking formulated questions.

The quantitative and qualitative data collected was then analysed and discussed. The main outcome of this chapter includes the evaluated and modified management tool which included six new routines, a colour scheme indicating which routines are fundamental from the initial stages of the platform and which only need to be considered as the platform/ecosystem matures.

The design science research progression checklist items defined by Hevner and Chatterjee [14] as set out in Section 2.5, Table 2.4 that were addressed during Chapter 6 are listed below.

Table 7.9: Design Science Research Progression Checklist [14] **– Items 5 & 6**

NUM	QUESTION	RESPONSE
5	- What evaluations are performed during the internal design cycles? - What design improvements are identified during each design cycle?	- Semi-structured interviews and impact-effort analyses were conducted. - Ten structural and conceptual modifications to the preliminary framework as a result of the evaluation process.
6	- How is the artifact introduced into the application environment and how is it field tested? - What metrics are used to demonstrate artifact utility and improvement over previous artifacts?	- Impact and effort ratings were given for each routine by local and international experts during the semi-structured interviews. - Qualitative and quantitative data gathered during the semi-structured interviews based on the validity of the proposed routines and preliminary management tool.

The final management tool is presented in Chapter 8 and forms the first half of the communication activity of the design science research methodology used throughout this study.

Chapter 8

Presentation of Final Management Tool

Chapter 8 key objectives:

- Give background on proposed management tool and
- Walk through design summary of management tool
- Discuss different elements of final management tool
- Present final management tool

Chapter 8 presents the final management tool following the updates implemented during the evaluation phase. The chapter starts by giving a brief background and motivation for the management tool, which is followed by a summary of the design process followed. The final management tool is then introduced, and its elements discussed. The structure of the chapter forms a standalone chapter and may include certain segments that have previously been discussed in this study. The context of Chapter 8 relating to the DSRM process, and within this document, is shown in Figure 8.1 below.

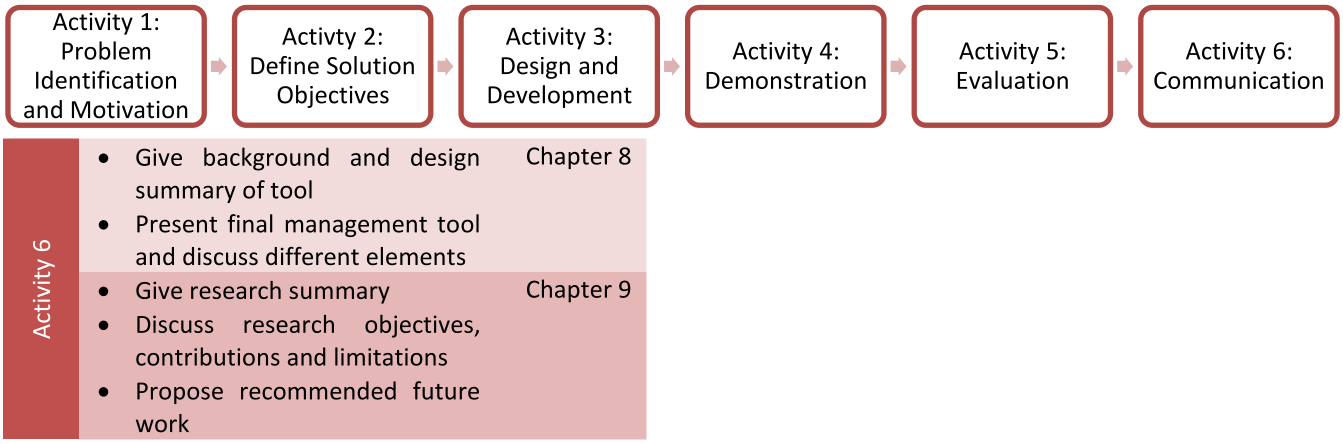


Figure 8.1: Research Context Diagram - Chapter 8

8.1. Management Tool Background

Technology platforms have been identified to provide companies the agility required to mitigate market disruption and get an edge on their competitors [3] as they provide a space to digitally connect people and resources and create an interactive ecosystem though which value can be generated and distributed [3]. These platforms have the ability to scale rapidly and efficiently, and create new capabilities for companies to capture, analyze and exchange large quantities of data [4].

Although technology platforms have been identified to give companies that competitive edge, sound management procedures and techniques are essential for to platform to flourish. This is reflected by inexperienced platform owners' inability to grow critical mass in the beginning stages of their platform [9].

It has been shown that for companies implementing technology management tools and techniques increase the extent in which they reach their growth targets [132]. Platforms require unique management strategies due to their variation from traditional linear businesses strategies [5] and the management of technology should be addressed in such a way that it captures the dynamic nature of technological advancement and the managerial aspects needed to guide this advancement [92].

This reasoning shows the need for a management tool that can aid platform owners in guiding them through the platform life cycle. The motivation for the creating a management tool based on technology management capabilities is derived from its holistic approach that brings into account both the ‘hard’ aspects of technology, such as science and technology, and ‘soft’ dimensions that include the technology application processes [13]. The capabilities perspective adopted for the management of technology is defined as the process of managing the development and implementation of technological capabilities to achieve the strategic objectives of a company [11].

By further refining technology management approach through the lens of dynamic capabilities theory, the management tool can focus on resource management that is not primarily concerned with fixed assets [13]. The aim of final management tool is to aid platforms owners by showing how and where a firm should allocate its resources to launch their platform and in time expand its ecosystem.

8.2. Management Tool Design Summary

The management tool was developed following the design science research methodology (DSRM) proposed by Peffers et al. [1]. As discussed in Chapter 2, the DSRM comprises of six activities: (1) problem identification and motivation, (2) define solution objectives, (3) design and development, (4) demonstration, (5) evaluation, and (6) communication. Objectives for each of the activities were defined based on the research objectives of this study and followed to develop the proposed management tool.

The six activities were divided between two phases with the first focusing on the building the knowledge base required to develop the management tool and the second developing the management tool. Phase 1 comprised of the first two activities where Activity 1’s objectives included giving background to the research problem, justifying the value for a solution, and defining the research objectives. The goal of Activity 2 was to identify key concepts of TM literature and the research gaps between TMC and the management of technology platforms literature and translate the gathered information into design requirements for the management tool.

Phase 2 included the final four activities where the management tool was developed, evaluated, and updated. The design requirements defined during the first phase were applied to design and develop the preliminary management tool. The tool was then demonstrated by conducting semi-structured interviews during which included impact-effort analyses of the proposed routines. Following the demonstration, the data gathered during the semi-structured interviews were analyzed and the preliminary tool updated.

Figure 8.2 on the following page shows an overview of the design process’s six activities and their subsequent objectives.

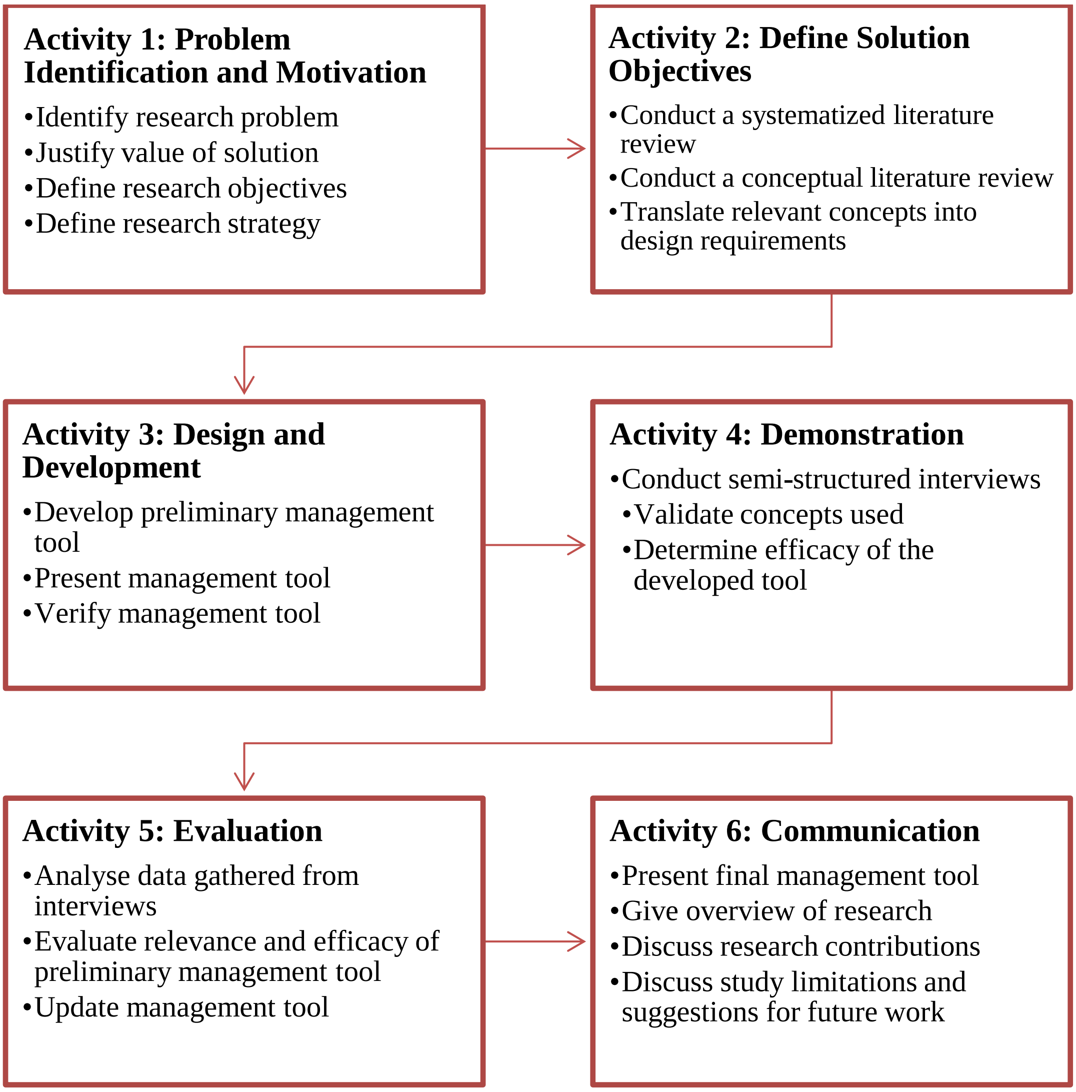


Figure 8.2: Research Design Overview

8.3. Proposed Management Tool

The proposed management tool consists of two canvases, the flow diagram canvas and the definition canvas. The flow diagram canvas gives a graphic representation of the distribution of the forty-two proposed routines within the ten respective primary management capability groupsets and the relationship between the different elements. The platform owner can use this canvas to see which routines need to be implemented for the different primary management capabilities.

The proposed routines are connected to the definition canvas that includes a concise explanation and important considerations of each. The elements of the flow diagram - and definition canvases are discussed below.

8.3.1. Flow Diagram Canvas

The flow diagram canvas represents the face of the management tool, giving the platform owner an overview of the platform management processes. The ten primary management capabilities are divided between the two higher capabilities.

The identification, selection, acquisition, exploitation, protection and learning primary capabilities form the technology management capabilities and the strategy-, innovation-, project-, and knowledge management primary capabilities form the supporting management capabilities. Each of the primary capabilities include a set of routines the platform owner needs to execute to launch and manage the technology platform and surrounding ecosystem, the distribution of the forty-two routines and the goal of each primary capability is given in Section 8.3.3. Figure 8.3 below highlights the different elements of the flow diagram canvas.

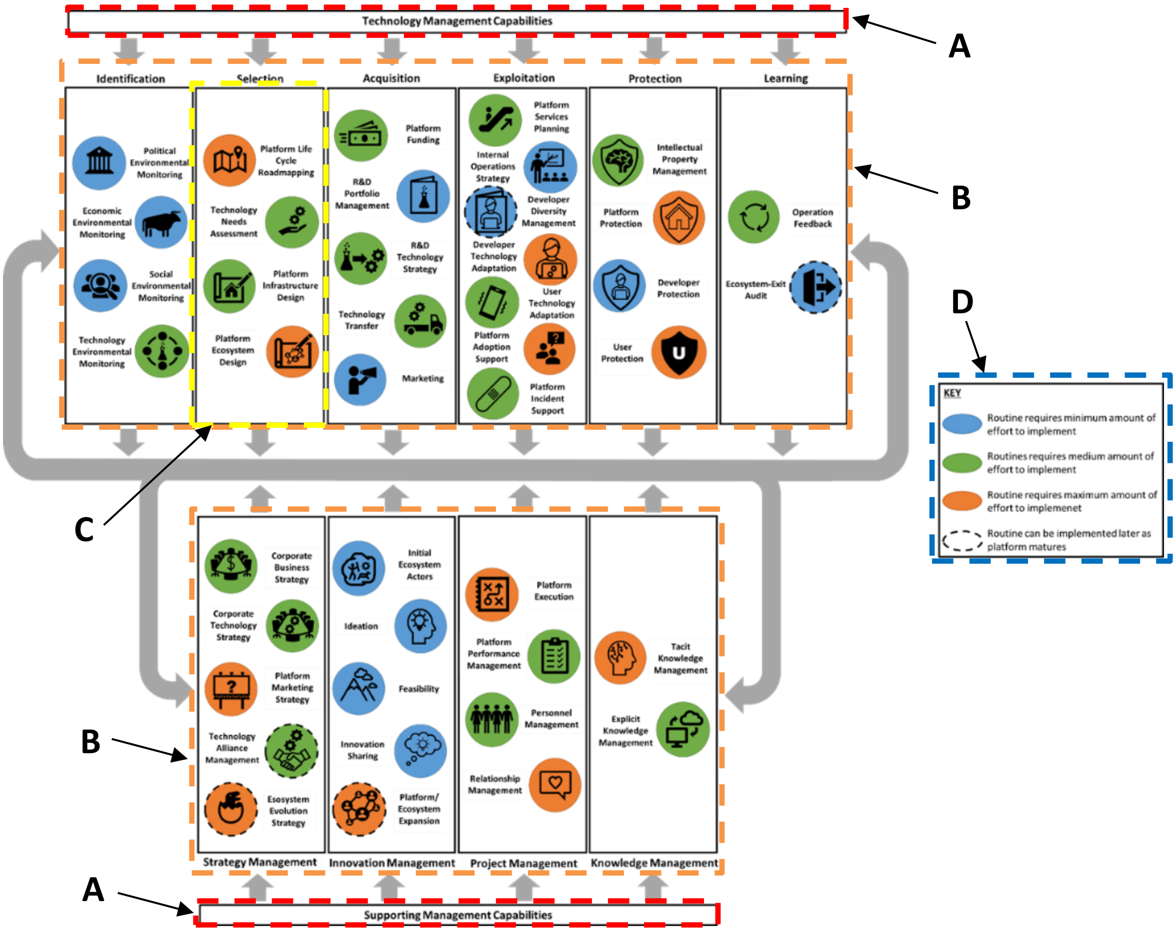


Figure 8.3: Flow Diagram Canvas Elements

A. Higher Management Capabilities [Red Box]

The red boxes indicate the two higher management capabilities: Technology Management Capabilities and Supporting Management Capabilities. They form the highest level within the hierarchal structure and the outer boundaries of the management tool with all the primary capabilities and routines falling between them.

B. Primary Capability Groupsets [Orange Box]

The collective concepts that fall within the orange boxes are the primary management capabilities and their respective groupsets. They represent the second level within the hierarchal structure and form the processes required to launch and manage a technology platform and its ecosystem. Each primary capability has an objective which can be achieved by executing the routines that form part of its groupset.

The arrows indicate how the primary capabilities run in parallel and the flow of information links them as one process. The cyclical nature indicates that the flow of information between the capabilities is dynamic and constant where the outputs of each routine influences or forms the inputs of others.

C. Routines [Yellow Box]

The proposed routines form the lowest level within the hierarchal structure and are distributed between their respective primary capabilities and grouped within the groupsets (represented by boxes). These routines represent inherent and repeatable activities that form the inputs and outputs of each primary capability. The routines are not listed but grouped in a cascading manner so that no form of hierarchy is implied between them and reflect the dynamic relationship between them. Each routine is given an icon with a colour that indicates if the routine requires minimum, medium, or maximum amount of effort to execute. Further, the icons also indicate if routine is a secondary activity and could be implemented later as the platform and ecosystem mature. These icons also link the routine with the flow diagram canvas and helps the platform owner find their explanations and considerations.

D. Management Tool Key [Blue Box]

The management tool key aids the platform owner to understand the different colours that denote the effort required to execute a routine. Blue represents a routine that requires minimum amount of effort, green represents a routine that requires a medium amount of effort, and amber represents a routine that requires maximum of effort. The key also includes the explanation for dotted outline that shows if platform owner can focus on a routine later as the platform and ecosystem mature.

8.3.2. Definition Canvas

As stated earlier, the platform owner will use the flow diagram canvas as reference to where the routine falls within the platform management process and refer to the definition canvas to determine what each routine entails and the considerations required to execute them. The different elements within the definition canvas are highlighted in Figure 8.4 below.

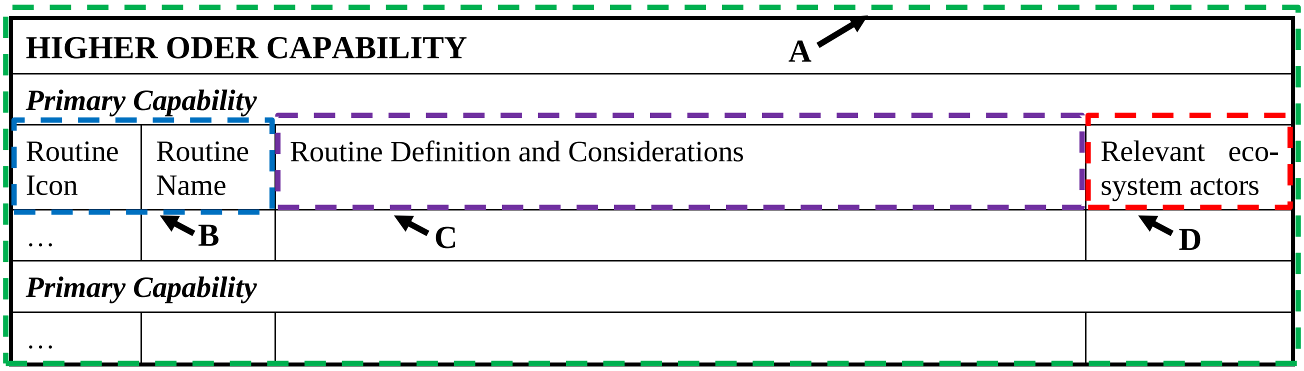


Figure 8.4: Definition Canvas Layout Elements

A. Hierarchy Presentation [Green Box]

The higher order capabilities, primary capabilities and routines are listed in a descending fashion, with varying text size and boldness’ to indicate the hierarchy structure as illustrated in Figure 8.4.

B. Link to Flow Diagram Canvas [Blue Box]

The first two columns contain the routine icon and the routine name to help the platform owner identify the specific routine from the flow diagram canvas.

C. Routine Definition and Considerations [Purple Box]

The third column contains the routine definition and considerations required to execute the routine.

D. Relevant Ecosystem Actors [Red Box]

The fourth column contains the relevant ecosystem actors that the platform owner needs to keep in mind when executing the routine. These actors can either be the platform owner, developer, user, or any combination of the three.

8.3.3. Primary Capabilities and Routines

Each of the primary capabilities and their respective routines are discussed below.

Identification Primary Capability and Routines

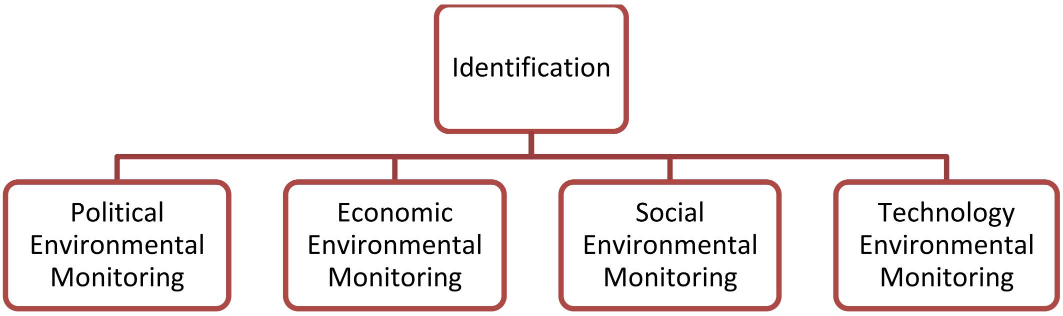


Figure 8.5: Identification Primary Capability and Routines Hierarchal Layout

The objective of the identification primary capability is to scan and pinpoint factors that can influence the platform and ecosystem positively or negatively. Within this tool the four areas that need to be continuously monitored are the political, economic, social and technology environments.

The political environment includes factors that influence the deployment of the tool, for example governmental regulations, political unrest between countries caused by trade wars and tariffs, or tax incentives to attract new businesses. The economic environment includes factors that influence the stakeholders and actors of the ecosystem, for example economic turbulences that restrict vendors or partners.

The social environment includes factors that determine the gap in the target market created by needs of the users and developers. Finally, the technology environment includes factors that influence the technology implemented to operate or upgrade the platform.

Selection Primary Capability and Routines

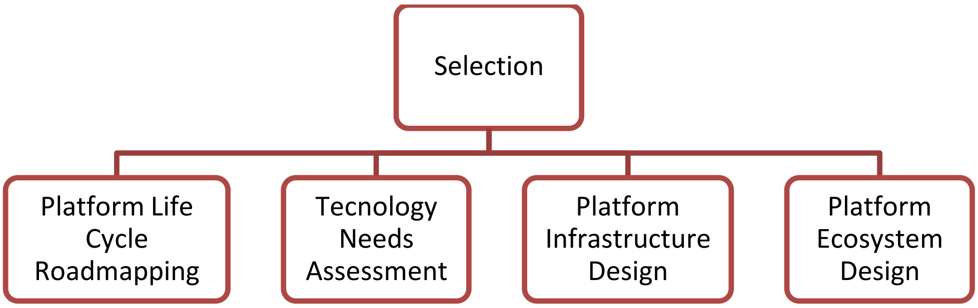


Figure 8.6: Selection Primary Capability and Routines Hierarchal Layout

The objective of the selection primary capability is to implement the information gathered throughout the different routines by setting out what is needed, when it is required, and then designing and developing the platform and ecosystem to achieve these conditions. The technology needs assessment routine forms the homework that needs to be done before new technology or processes are implemented within the platform or ecosystem, this feeds into the platform life cycle roadmapping routine, with all the other strategy routines, to determine when to implement the chosen aspects. The platform infrastructure and ecosystem design routines actualize the technology needs assessment and roadmapping routines by designing and developing the technology platform and platform ecosystem.

Acquisition Primary Capability and Routines

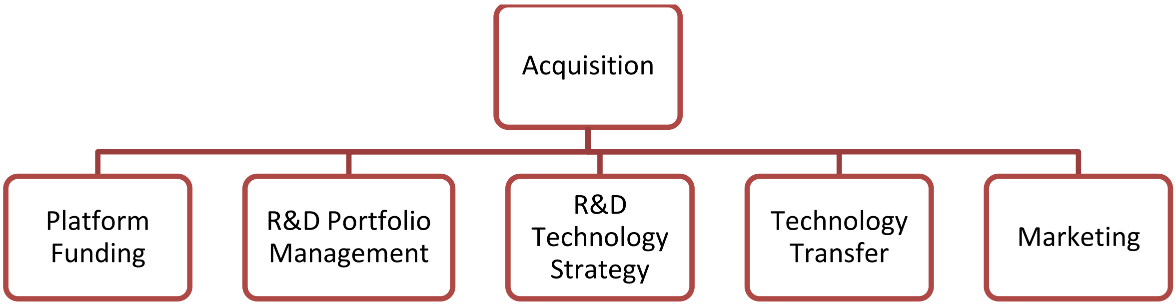


Figure 8.7: Acquisition Primary Capability and Routines Hierarchal Layout

The objective of the acquisition primary capability is to attract and retain the different ecosystem actors. All five routines within the groupset influence the platform's ability to attract and retain employees, desired developers, and end-users. The monetization scheme ultimately influences the capabilities of the platform and infrastructure as it could cap the platform development and determine the level of free services and products the platform firm provides to developers. These capabilities include which entry barriers to implement to increase the platform's level of attractiveness, increase its ability to deter undesired developers, and decrease the ability of competitors to source skills from the platform. To ensure that the correct entry barriers are implemented the portfolio management routine is required to identify the various stakeholders and their influence on the choice of projects pursued, which in turn guides the strategy routine to determine when to focus on the various projects. Finally, the platform will never be able to attract actors if it cannot "stand out" in a crowded market. The marketing routine ensures that focus is directed on effectively implementing the company's marketing strategy and gathering feedback to determine the influence of the marketing programs on the business performance and if the strategy needs to be updated or not.

Exploitation Primary Capability and Routines

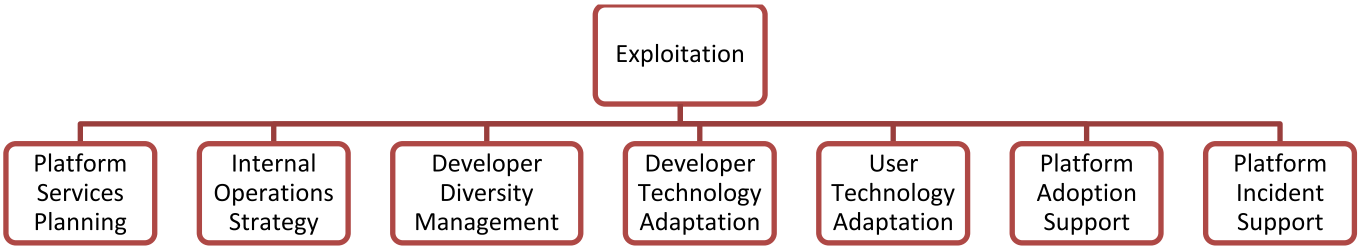


Figure 8.8: Exploitation Primary Capability and Routines Hierarchal Layout

The objective of the exploitation primary capability is to utilize and continuously adapt the platform's technology infrastructure to drive the ecosystem growth and evolution. Exploitation can be divided into three sub-objectives: managing the company and ecosystem culture, aligning the existing technology to address the needs of the developers and end-users, and providing support to the ecosystem actors.

The platform owner should first deliberate what the platform is providing from a business perspective and translate the identified market gaps into operational requirements for the platform. These considerations will influence the resource acquisition strategies. The form of the internal firm structure not only influences the efficiency of the platform operations, but also the company beliefs and values of which the platform and ecosystem dynamics are dependent on. The dynamics between the developers within the ecosystem is managed by the developer diversity management routine as good developers do not necessarily mean good services. The relations side of the management plan is dependent on the platform firm's company culture, business model and organizational requirements. The two adaptation routines are required to align the platform's technology with the developer and user communities' requirements to ensure ecosystem runs efficiently and attracts more people. Finally, platform adoption support ensures that developers transition smoothly into the ecosystem and fosters trust between the platform firm and the developers as they experience to be taken care of. This trust is strengthened by having a clear system and strategy in place for when platform operations are down and if incidents within the ecosystem needs to be dealt with.

Protection Primary Capability and Routines

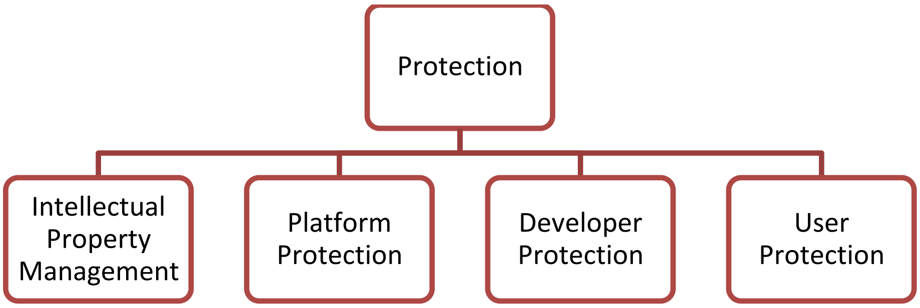


Figure 8.9: Protection Primary Capability and Routines Hierarchal Layout

The objective of the protection primary capability is to ensure the security of normal operations and the company's valuation. The protection considerations also need to extend beyond the platform firm and include all the ecosystem actors.

From the valuation perspective the platform firm's intellectual property (IP) and the end-user's data need to be protected to ensure value is not lost. Additional value can be derived from user protection as a differentiating factor where data protection is sold as a service.

To ensure the security of the platform and ecosystem's normal operations a continuous balancing act is required between all the protection services based on the risks involved to the platform firm, the time required to implement the protection applications and the cost thereof. This balancing act is translated into updates that deal with new threats posed by external factors, for example hackers, or bad developer practices within the ecosystem. Additionally, successful, and continuous protection of the platform operations also has a second-order reputational effect on how the actors within the market view the platform.

Learning Primary Capability and Routines

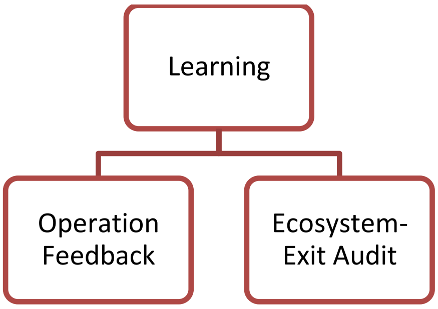


Figure 8.10: Learning Primary Capability and Routines Hierarchal Layout

The objective of the learning primary capability is to continuously gather feedback from the ecosystem during normal operations and when ecosystem actors decide to leave the ecosystem in order to improve the services provided by the platform. The communication channels always need to be open and implemented as a two-way system and the platform owner needs to ensure that the benefits derived from the feedback is shared within the ecosystem.

Strategy Management Primary Capability and Routines

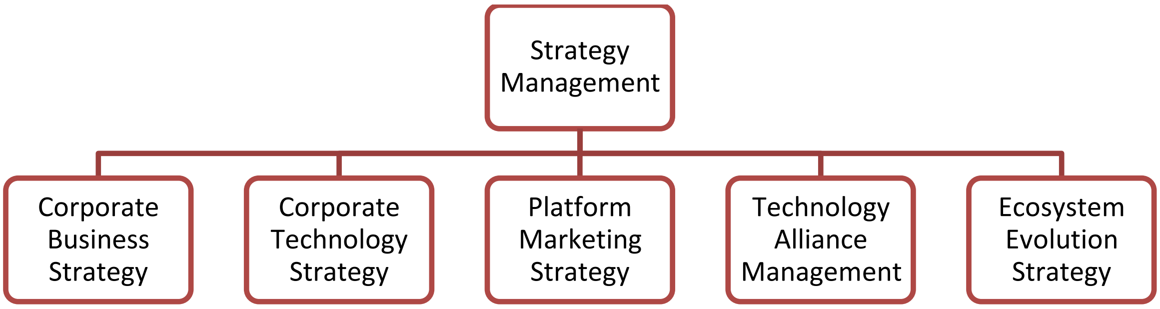


Figure 8.11: Strategy Management Primary Capability and Routines Hierarchal Layout

The strategy management routines underpin the considerations required to ensure a platform gains critical mass.

The five areas of strategy include the direction in which the company will move, the technology required to realize this vision, the marketing programs to attract ecosystem actors, the management of partners by aligning their capabilities with the platform technology, and managing the effects of platform owner's decisions within the ecosystem and ensure that the platform evolves along with its ecosystem.

These routines are required to define the key performance indicators (KPI) needed to reach the platform owner's envisioned goals and guide the planning and portfolio management routines. As data is gathered as part of continuous feedback during the platform implementation the relevant strategies are updated to ensure the KPIs are reached. Of the five strategy areas it is important to focus on the corporate business strategy, technology strategy and marketing strategy from the offset of the platform as the technology alliance management and ecosystem evolution strategy considerations are only required as the platform and ecosystem matures.

Innovation Management Primary Capability and Routines

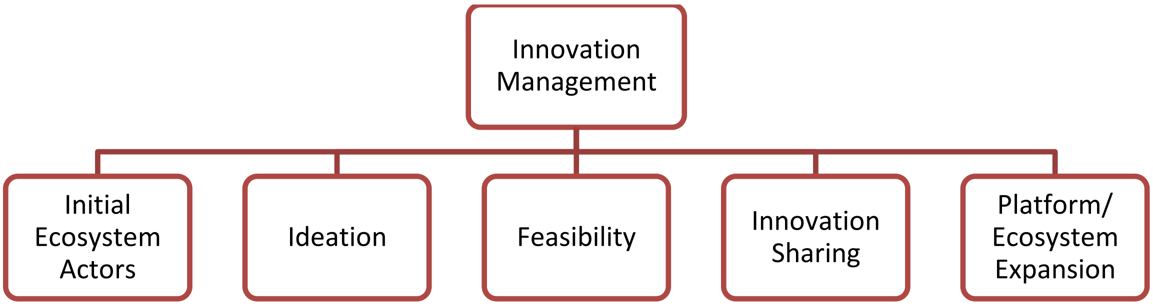


Figure 8.12: Innovation Management Primary Capability and Routines Hierarchal Layout

The goals of the innovation management routines are to ensure that an innovative culture is cultivated within the platform firm and ecosystem and that the value generated is shared between all the ecosystem actors. The culture within the ecosystem is dependent on the type of actors that are allowed onto the platform and effects how well the dynamic works between them. The two most important considerations are maintaining a balancing act between the ideation and feasibility and ensuring that the innovative ideas within the platform firm are aligned with the company vision and those within the ecosystem are bound by the platform's rules and regulations. It is also crucial to understand the relationship between innovation and ecosystem expansion, as they do not promote each other but rather provide new functionalities to developers.

Project Management Primary Capability and Routines

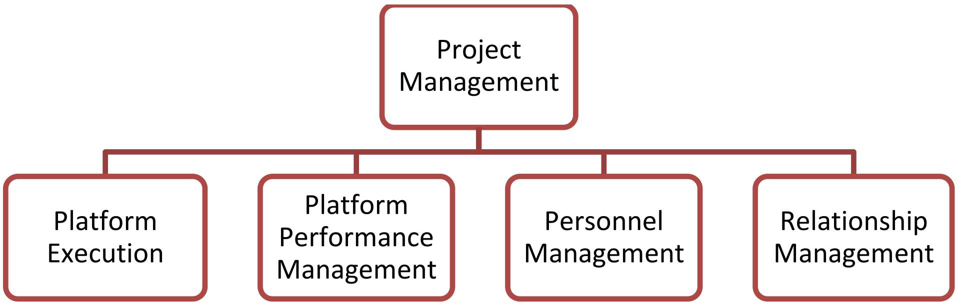


Figure 8.13: Project Management Primary Capability and Routines Hierarchal Layout

The project management routines are required to ensure that all the platform operations run smoothly and that the right resources are acquired timeously. The platform execution and performance management routines are concerned with the operation of the platform projects while the personnel and relationship management routines focus on the human resources required to execute the operations. These considerations maintain harmony between the ecosystem's actors and the platform firm employees and ensure the set-out plans are executed correctly in order to reach the defined KPIs.

The harmony within a platform and ecosystem affects how the outside world perceives the platform and builds on the theory that the ecosystem value is not coming from a special technology, but from the convening and aggregation of multiple sets of stakeholders in a business relationship that is based on trust. This trust can be established from the onset as platform owners can choose to foster personal relations with ecosystem actors during the early stages of the platform but should understand that this strategy is not scalable and should be replaced with automated systems as the platform matures.

Knowledge Management Primary Capability and Routines

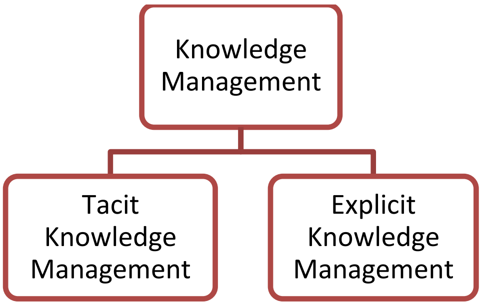
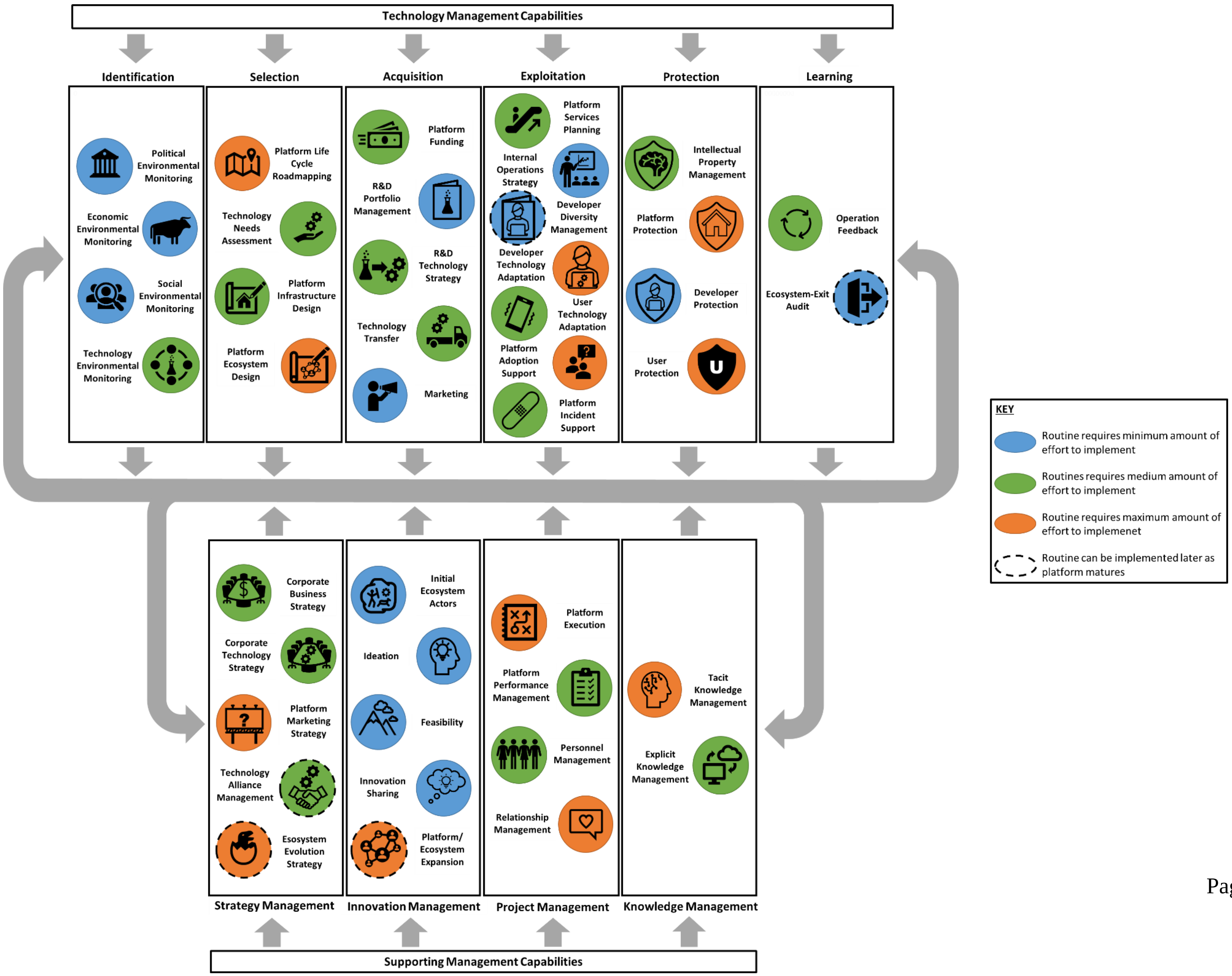


Figure 8.14: Knowledge management Primary Capability and Routines Hierarchal Layout

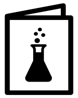
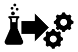
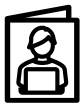
The objectives of the knowledge management routines are to ensure that all forms of information and data are captured, organised, and distributed within the firm. Platform owners should understand the different types of information that is beneficial to the platform firm and that conscious actions should be taken to capture and share the knowledge.

The capturing of tacit knowledge should become part of the company culture where employees must be encouraged to share their experience and knowledge with their colleagues through informal and formal methods. This will ensure the retention of the knowledge within the firm even if the employee leaves. The coding and analysis of the explicit knowledge leads to the prevention of future mistakes and improvement of current strategies and operations. It is important for a company to break down the information silos between different departments so that they can learn from each other and create better cohesion.

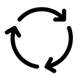
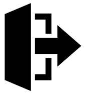
The final management tool as discussed in this section is presented below.

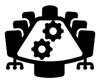

Technology Management Capabilities
Identification
Political Environmental Monitoring
Economic Environmental Monitoring
Social Environmental Monitoring
Technology Environmental Monitoring
Selection
Platform Life Cycle Roadmapping
Technology Needs Assessment
Platform Infrastructure Design
Platform Ecosystem Design
Acquisition
Platform Funding
R&D Portfolio Management
R&D Technology Strategy
Technology Transfer
Marketing
Exploitation
Platform Services Planning
Internal Operations Strategy
Developer Diversity Management
Developer Technology Adaptation
User Technology Adaptation
Platform Adoption Support
Platform Incident Support
Protection
Intellectual Property Management
Platform Protection
Developer Protection
User Protection
Learning
Operation Feedback
Ecosystem-Exit Audit
KEY
Routine requires minimum amount of effort to implement
Routines requires medium amount of effort to implement
Routine requires maximum amount of effort to implemenet
Routine can be implemented later as platform matures
Corporate Business Strategy
Corporate Technology Strategy
Platform Marketing Strategy
Technology Alliance Management
Esosystem Evolution Strategy
Initial Ecosystem Actors
Ideation
Feasibility
Innovation Sharing
Platform/ Ecosystem Expansion
Platform Execution
Platform Performance Management
Personnel Management
Relationship Management
Tacit Knowledge Management
Explicit Knowledge Management
Strategy Management
Innovation Management
Project Management
Knowledge Management
Supporting Management Capabilities

TECHNOLOGY MANAGEMENT CAPABILITIES		
Identification		
Political Environmental Monitoring	Scanning of the external governmental environment to identify existing laws and governing policies of the country or region in which the platform will operate, and to observe the political atmosphere towards the platform market to determine if new laws or regulations might be implemented that will impede the platform business or open new market opportunities.	*Owner*
Economic Environmental Monitoring	Scanning of the external economic environment to identify the upstream and downstream stakeholders or actors, the effect of economic growth on global, national, and local level on the adoption of the platform, and to determine the impact of economic activities carried out by competitors or the platform owner as the platform matures on market trends.	*Owner, Developer, & User*
Social Environmental Monitoring	Scanning the external social environment for key industry trends to identify the target market's characteristics, their needs, and the cultural and natural setting into which the platform is being introduced; and to identify competing platforms and ecosystems to determine if a gap in the market exists and what differentiates them from this platform and ecosystem.	*Owner, User*
Technology Environmental Monitoring	Scanning the external technological environment for wider technology and scientific advances to identify new technologies that are disrupting the industry or existing technologies that have been improved and can be implemented into the platform, such as security, distribution channels, and user devices.	*Owner*
Selection		
Platform Life Cycle Roadmapping	Setting out an agile and adaptable roadmap that shows when and how to develop identified technological capabilities that are required for future processes to maintain the constantly evolving ecosystem. Setting out includes defining the inputs and outputs of the different processes, the timeline to complete a process, and the technological requirements needed.	*Owner, Developer*
Technology Needs Assessment	Assessing what the platform and ecosystem need to evolve and the effect thereof on the user experience. This includes defining which technologies need to be implemented during the design routines due to upgrades or replacements, for example, to security firmware, the type of scalability of the platform, or platform hardware.	*Developer, User*
Platform Infrastructure Design	Designing and building the platform and supporting technology infrastructure. Considerations include the programming language adopted by the platform, what the interface will look like, the extent of access developers have to the platform functionality, the type of data transferred and stored during the use of the platform, and scalability of the platform.	*Owner, Developer*
Platform Ecosystem Design	Designing what the ecosystem will look like and how it will run. Considerations include who the key actors are, their roles in the ecosystem, how to implement the entry barriers, what the technological barriers are, the organisational structure in the ecosystem, how the ecosystem health will be monitored, and how the end products/services will be distributed.	*Owner, Developer, User*

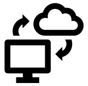
Acquisition			
	Platform Funding	Choosing the monetisation and pricing strategies to fund the platform and sustain its evolution. Considerations include the homing costs of developers, intermediary client investments, the profit distribution throughout the ecosystem, and if the revenue model should consist of a fixed amount, percentages, subscriptions, or licensing fees.	*Owner, Developer, & User*
	R&D Portfolio Management	Managing the portfolio of R&D projects to achieve a desired balance along the different organisational dimensions. Considerations include identifying who the stakeholders of the company are, how they will influence which R&D projects to follow and defining concrete project evaluation objectives.	*Owner*
	R&D Technology Strategy	Strategizing when to focus on which newly identified technological areas and determining the validity of the technology plans. Considerations include planning the progression of the technology being developed, defining the expected outcome of development projects, and how to transfer the information to the rest of the company.	*Developer & User*
	Technology Transfer	Defining the technological platform- and ecosystem entry barriers to attract and keep favoured developers and discourage others. Considerations include how developers will access the platform, what type of apps will the developers be able to develop, the toolkit of complementary products provided, and the level of difficulty for a developer to leave the platform.	*Developer*
	Marketing	Executing the platform and ecosystem marketing strategies to stand out in a crowded market and gathering feedback from the target market to determine if the strategies are effective or need to be updated. Considerations include testing the relevance of the marketing strategies for the target market and monitoring the marketing effects on business performance.	*Developer & User*
Exploitation			
	Platform Services Planning	Translating business drivers into service parameters and setting a clear plan of which direction the platform will evolve. Considerations include how and when new functionalities will be incorporated into the platform and the influence of these new functionalities on developer interest to stay with the platform or migrate from a competitor’s platform.	*Developer & User*
	Internal Operations Strategy	Strategizing how the platform firm’s internal organisation will operate. Considerations include defining the key resources (human and technology) to realise the platform, the internal processes for optimal platform performance, how the company culture, values and beliefs influence platform management, and the support given to the internal team.	*Owner*
	Developer Diversity Management	Managing the diversity of developers within the ecosystem to achieve cohesion and prevent unhealthy competition. Considerations include how innovation will be encouraged between developers, how to encourage information sharing, and defining a method to measure the satisfaction among developers regarding the platform services.	*Developer*

	Developer Technology Adaptation	Continuous development of the technological necessities developers require for platform adoption. Considerations include how compatible the platform/ecosystem is with other platforms, the influence of the developer hardware and software on the platform design, the developer's apps' marketplace requirements, and if a developer training tool is required.	*Developer*
	User Technology Adaptation	Developing the technological necessities users require from the platform to access the developers' apps. Considerations include the social, physical, and geographical context of the users, learnability of the platform app, how rapidly the platform app is updated, the navigation through the platform app, and the visual aspects of the app icon and interface.	*User*
	Platform Adoption Support	Providing ongoing support to developers during the platform adoption process. Considerations include providing documentation to describe platform use and functionality, easing the migration from competing platforms, forming a dedicated customer support team, providing debugging aids, and providing app testing support to developers.	*Owner, Developer*
	Platform Incident Support	Providing a support structure for developers and users when normal operations are interrupted by the platform being down or during a breach to platform security. Considerations include defining the processes to log incidents, systems to back-up and protect data, and the communication channels between the platform firm, developers, and users.	*Owner, Developer, & User*
Protection			
	Intellectual Property (IP) Management	Implementing procedures to protect the intellectual property of the platform company. Considerations include the ownership structure of the platform and its components, how the IP rights will be established, the licensing agreements with developers and the security measures taken to protect the transactional and user data generated by the platform.	*Owner*
	Platform Protection	Implementing procedures to protect the platform from bad developer practices Considerations include the level of architectural openness of the platform to developers and the security precautions taken to protect the platform against external factors, for example hackers.	*Owner, Developer*
	Developer Protection	Implementing procedures to protect the IP and data of the developers. Considerations include who will have access to developer data, defining who owns the data generated by the developers on the platform, making developers aware of governmental or organisational policies, and assuring developers of their data safety.	*Developer*
	User Protection	Implementing procedures to protect the personal data of the users. Considerations include following the country or region's laws and regulations related to the app industry, providing security methods that ensures the protection of the user's privacy, determining how user data will be stored and who will have access to it, and if privacy will be sold as a service.	*User*

Learning			
	Operation Feedback	Providing a channel for continuous feedback between developers, users and the platform owner as the platform/ecosystem evolves. Considerations include the method of gathering feedback, determining who is going to analyse the feedback gathered, if it is a one-way stream of information, or distributed as openly shared platform updates.	*Owner, Developer, & User*
	Ecosystem-Exit Audit	Conducting an audit to determine the reason why developers have left the platform and ecosystem. Considerations include determining how to track user loyalty, how to automate the audit process, analysing the developer successes or failures and the reasons for their success or failure, and recording the platform characteristics that led to their success/failure.	*Owner, Developer*

SUPPORTING MANAGEMENT CAPABILITIES			
Strategy Management			
	Corporate Business Strategy	Systematically breaking down a broad business idea into a realistic, achievable and simple business strategy. Considerations include determining the areas of platform operation, what the main goal of the platform is, what the envisioned future state of the platform is, and what the key performance indicators will be to measure if the platform is evolving as planned.	*Owner*
	Corporate Technology Strategy	Determining how the firm will pursue its technology acquisitions, technological areas of focus, and make/buy decisions. Considerations include determining if R&D will be done in correspondence with developers, defining the strategies that promote platform growth, risk management, reputation management and platform re-investment.	*Owner*
	Platform Marketing Strategy	Analysing the feedback gathered from the target market on the effectivity of the marketing programs, determining how the platform and ecosystem will be promoted above competitors and which marketing programs should be followed, and ensuring that what is being marketed is aligned with the platform capabilities.	*Owner, Developer, & User*
	Technology Alliance Management	Identifying, developing, and managing the strategic partnerships between partner platforms, various kinds of developers, external vendors, and existing technologies within the platform firm. Considerations include the managing operations taken to make the company's defined strategies routines come to fruition and translated into technological planning routines.	*Owner, Developer*
	Ecosystem Evolution Strategy	Managing the effects of the decisions being made by the platform owner to attract planned and potential groups of actors to the ecosystem. Considerations include identifying possible tensions between the owner and developers, the network effects on the ecosystem, and tracking the platform evolution to ensure that it matches with ecosystem evolution.	*Owner, Developer, & User*

Innovation Management		
Initial Ecosystem Actors	Defining what kind of developers will be allowed onto the platform initially and the type of users they will attract. Considerations include determining if the platform will become a skill sourcing area for competitors, and the geographical, cultural, and technological capabilities/restrictions of the platform, the developers, and the users.	*Owner, Developer, & User*
Ideation	Providing a platform and ecosystem that promotes innovative ideation between the developers, users, and employees of the platform firm. Considerations include determining how a culture of innovation within the firm and the ecosystem can be created and sustained, how to ensure ideation stays within the company scope and promotion methods for innovative ideas.	*Owner, Developer, & User*
Feasibility	Managing how new ideas and innovative endeavours are analysed and pursued. Considerations include a method to quickly gather data and measure the feasibility of new ideas, determining who the stakeholders are of new endeavours, and weighing the risks against the benefits.	*Owner, Developer, & User*
Innovation Sharing	Managing how innovation is shared within the ecosystem. Considerations include determining the level of restriction the platform rules provide, the standard application programming interfaces (API), their rules, who are responsible for them and how innovative knowledge will be shared within the ecosystem so that it benefits the developers and does not envelop them.	*Owner, Developer*
Platform/ Ecosystem Expansion	Translating the identification routines into platform/ecosystem adaptation actions taken to integrate new types of hardware and software, expand the ecosystem entry barriers and capabilities for new developer apps, and incorporate other identified ecosystems (for example competitors) into theirs.	*Owner, Developer*
Project Management		
Platform Execution	Executing the integrated activities of multiple projects' timelines by planning, staffing, designing, and managing them. Considerations include when specific milestones of each project need to be reached as defined in the roadmapping and the strategy routines and managing the resources required to realise them.	*Owner*
Platform Performance Management	Reconciling the different performance requirements between developers through measurement and management processes and implementing performance improvement schemes. Considerations include implementing control mechanisms among developers, defining the fundamental rules of platform use, and reviewing complementary services offered on the platform.	*Developer*
Personnel Management	Hiring, training, and retaining capable employees within the platform firm. Considerations include the influence of platform firm's reputation on attracting employees with favourable skills, when to hire new employees with certain skills, implementing development programs to further employee skills, and managing a positive culture within the firm.	*Owner*

	Relationship Management	Managing the relationship between the platform firm owner, developers, and users. Considerations include fostering trust within the ecosystem between all the actors, determining how external parties perceive the platform and the platform brand, maintaining loyalty of the developers, and ensuring that the monetary and proprietary dealings within the ecosystem are fair.	*Owner, Developer, & User*
Knowledge Management			
	Tacit Knowledge Management	Continuously managing the practices that gather and distribute tacit knowledge throughout the platform firm. Considerations include cultivating a culture where employees want to share knowledge amongst each other, implementing formal and informal knowledge sharing opportunities, and implementing procedures that can capture knowledge gained by employees.	*Owner*
	Explicit Knowledge Management	Continuously managing the practices that arrange and distribute explicit knowledge throughout the platform firm. Considerations include coding and filing the data gathered during the other routines and ensuring that it is readily available to all departments within the firm.	*Owner*

8.4. Chapter 8 Summary

The final management tool was presented during Chapter 8 of this study. This included giving background and motivation behind the tool's development and a summary of the design process followed. Each of the final management tool's structural elements were discussed in detail, followed by a conceptual overview of the primary capabilities and routines.

The design science research progression checklist items defined by Hevner and Chatterjee [14] as set out in Section 2.5, Table 2.4 that were addressed during Chapter 8 are listed below

Table 8.1: Design Science Research Progression Checklist [14] **– Items 2, 7, & 8**

NUM	QUESTION	RESPONSE
2	- What is the artifact?	- The final artifact is a management tool that can be used by a platform owner to launch and manage a technology platform and platform ecosystem.
	- How is the artifact represented?	- The final management tool consists of two canvases. The first canvas gives an overview of the activities required and their interrelationships while the second gives concise definitions and considerations for each activity. There are 42 proposed routines distributed between 10 primary capabilities that form part of technology management and supporting management capabilities.
7	- What new knowledge is added to the knowledge base and in what form (e.g., peer-reviewed literature, meta-artifacts, new theory, new method)?	- A new management tool is added to the knowledge base. The management tool shows a new representation of existing TMC theories, additionally new theory is added through the proposed routines.
8	- Has the research question been satisfactorily addressed?	- The research question has been sufficiently addressed. The management tool developed during this study addresses the different considerations required to launch and manage a technology platform and presents these considerations in a user friendly and practical manner.

The final chapter of this study follows where a summary of the research is given, the contributions and limitations of the work is discussed and where future work is proposed.

Chapter 9

Conclusions and Recommendations

Chapter 9 key objectives:

- Give a summary of the study and used methodology
- Discuss how the research objectives were satisfied
- Present the research contributions
- Elaborate on the study limitations
- Provide recommendations for future work

Chapter 9 covers the concluding discussions of this study. First, a summary of the study and research methodology used is given and discussed to show how the research objectives were met. The research contributions are then elaborated on, and the limitations given. The chapter concludes with recommendations for future work. The context of Chapter 9 relating to the DSRM process, and within this document, is shown in Figure 9.1 below

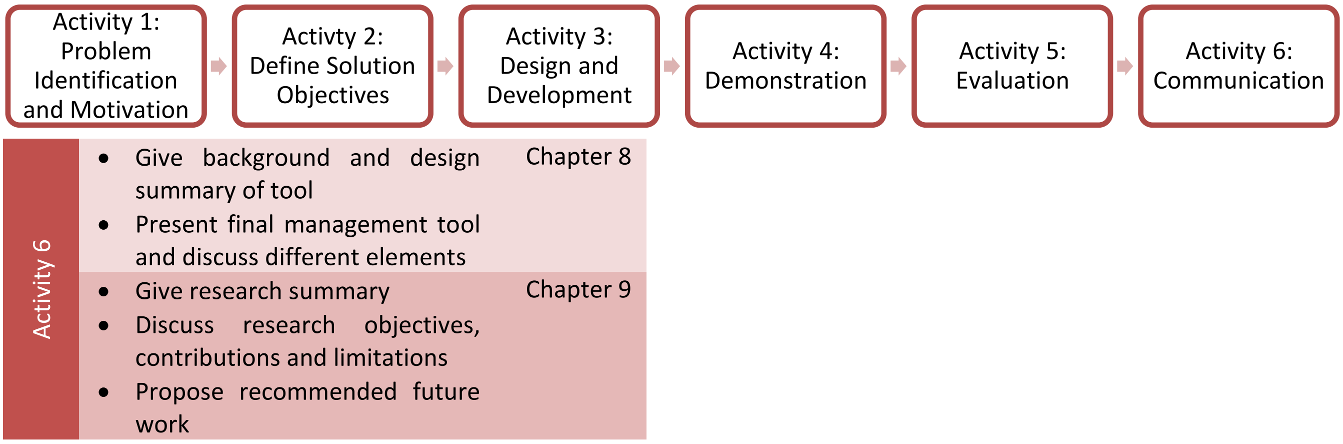


Figure 9.1: Research Context Diagram - Chapter 9

9.1. Research Summary

The research conducted in this study was of qualitative nature and the methodology adopted was the design science research methodology proposed by Peffers et al. [1]. The DSRM consists of six activities that were subdivided into key objectives derived from the activity definitions and based on the study's research objectives.

Figure 9.2 below shows the six activities and their key objectives, followed by a discussion of each.

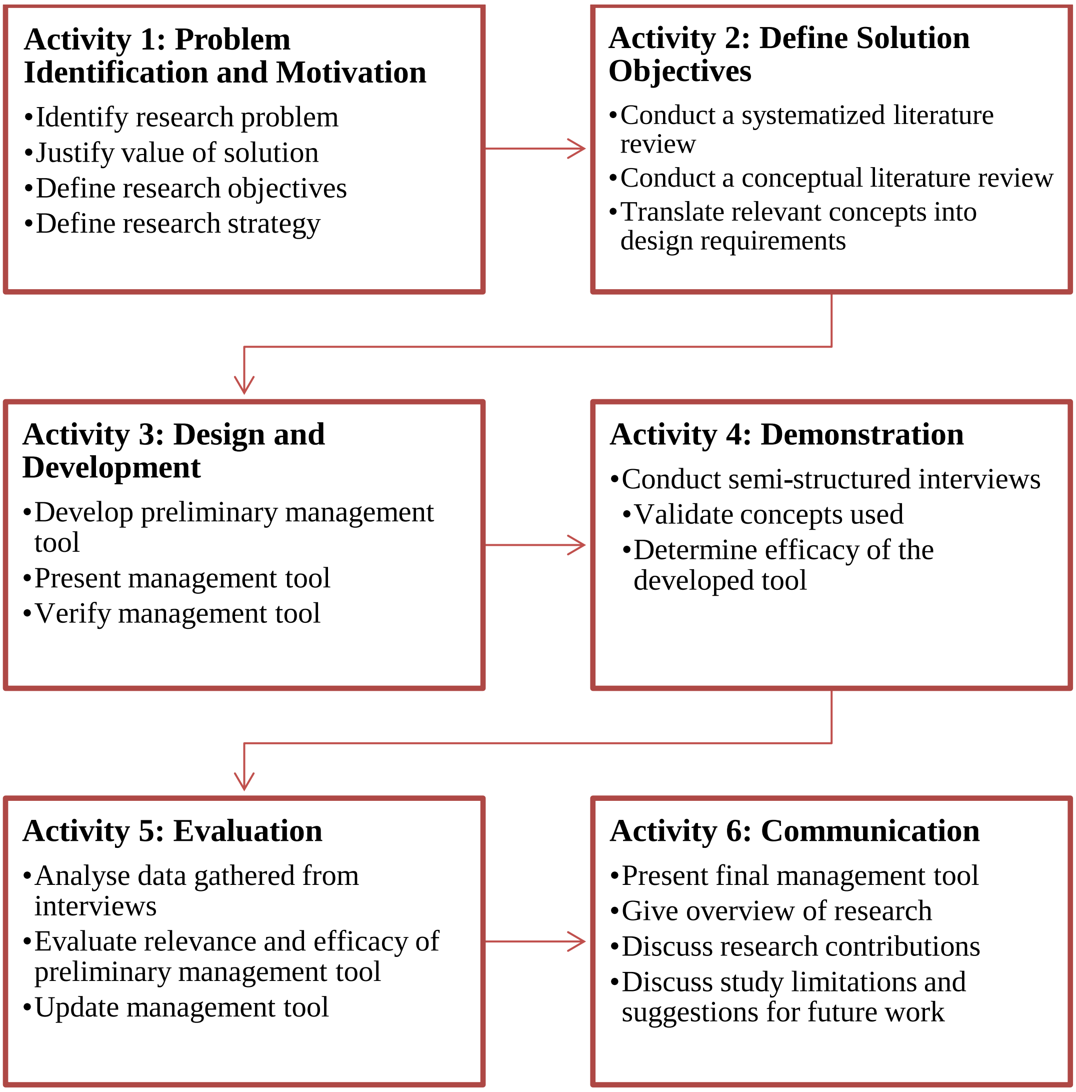


Figure 9.2: Research Design Overview

9.1.1. Activity 1: Problem Identification and Motivation

The first activity was covered by Chapters 1 and 2. Chapter 1 consisted of defining the research problem by giving background information about technology platforms, platform ecosystems, management considerations of technology platforms, and how technology management capabilities can be utilized for platform management. This background information was used to define the research problem to justify the need for a management tool. Subsequent research questions and objectives were developed to ensure that a suitable solution was developed to address the research problem.

The various research objectives were divided into two phases with phase one focusing on the theoretical components and phase two on the practical components. The first phase consisted of building the knowledge base necessary to address the research problem and resulted in defining the design requirements for the management tool. The objectives included in the practical phase consisted of the development, evaluation and presentation of the management tool.

Chapter 2 covered the research methodology and design of this study. To choose an appropriate research methodology the researcher conducted a detailed investigation into what research entails and different research approaches. From this investigation it was concluded that this study was of qualitative nature. Due to the final outcome of this study being a practical management tool the researcher chose to adopt Design Science Research (DSR) as suitable methodology as it is driven by the desire to better the environment through introducing new and innovative artifacts [24]. Furthermore, the design science research methodology proposed by Peffers et al. [1] is a commonly accepted framework implemented to carry out the production and presentation of design science research and provides researchers a mental model of how to conduct research successfully [14],[1].

9.1.2. Activity 2: Define Solution Objectives

Chapter 3,4 and 5 covered the objectives for the second DSRM activity. Each of the chapters represented a step required to first build a competent knowledge base for the researcher to accurately define the solution objectives.

Chapter 3 included a systematized literature review to determine the state of the problem. Here the researcher aimed to gain knowledge about the relationship between TMC literature and the management of technology platforms, establish the literature gap between the two research fields, and identify the key concepts for technology management capabilities required to effectively apply the theory to a practical management tool. Eight conclusions were drawn from review, including

(1) The key concepts identified for TMC literature,
(2) The most frequently reoccurring concepts within the review's primary studies,
(3) The hierarchal structure of dynamic capabilities,
(4) The need for practical management tools to be implemented during TM routines,
(5) The gap in existing literature within developing countries,
(6) The identified existing TM routines,
(7) How technology platforms are viewed as a capability in existing literature, and
(8) The importance of functionality, integration, and flexibility of technology platforms.

These eight conclusions formed the building blocks for further research conducted in the chapters to follow, starting with Chapter 4 which included a conceptual literature review. During this review in depth knowledge was gathered regarding technology platforms, platform ecosystems, existing management tools, and the key TMC concepts identified during the systematized literature review.

Finally, the knowledge gathered during the two literature reviews was supplemented with research regarding conceptual framework features in Chapter 5 which completed the required knowledge base. Nineteen design requirements for the preliminary management tool were then defined based on the conducted research.

9.1.3. Activity 3: Design and Development

The development process consisted out of three steps which were distributed between Chapters 5 and 6. Chapter 5 included the first step which sought to apply the existing TM routine literature to technology platforms and platform ecosystems.

Each of the existing routines were analysed against an existing platform management tool to determine its relevance within a platform business. During this process the existing routines were either kept and redefined, discarded, or a new routine was proposed.

Of the twenty-seven existing routines, sixteen were kept, seven were re-named and four were discarded. Additionally, fourteen new routines were proposed. All of the preliminary routines were giving a new definition that was aligned with technology platform and platform ecosystem management.

Chapter 6 covered the last two steps of the development process which included the development of the overarching framework to contain the proposed preliminary routines. The rational used by the researcher was supplemented by the knowledge base populated during the two literature reviews and methodically presented during the development process. The preliminary management tool consisted of two canvases. The first canvas was the flow diagram canvas which showed an overarching view of the entire management process. This included a diagrammatic presentation of the proposed routines and capabilities, the hierarchy structure between the various capabilities and routines, and the dynamic interrelationships between all of them.

Finally, the researcher concluded the development process by verifying that all the design requirements were adhered to as the first evaluation method.

9.1.4. Activity 4: Demonstration

Activity 4 and 5 were discussed in Chapter 7. The demonstration phase consisted of the researcher conducting semi-structured interviews with experts in the field of technology management and technology platforms.

Semi-structured interviews were conducted with a total of ten interviewees. The participants included a diverse group of experts in the field of technology management and technology platforms to validate the different aspects of the proposed management tool. The profiles of each interviewee are given in Table 9.1 below.

Table 9.1: Interviewee Profiles Reflection

INTER-VIEWEE	NATIONALITY	VOCATION	CONTRIBUTING AREA OF EXPERTISE
A	South Africa	Scholar	Technology management, Developer perspective
B	England	Technology Manager	Platform owner perspective, platform start-up
C	USA	Scholar	Technology management
D	USA	Scholar	Technology platforms
E	South Africa	Platform Owner	Platform owner perspective
F	USA	Scholar	Technology platforms, Platform ecosystems
G	South Africa	Technology Consultant	Technology management, Technology platforms
H	South Africa	Management Consultant	Technology platforms, Platform ecosystems, Technology management
I	Germany	Scholar	Platform ecosystems
J	South Africa	Scholar	Technology management

A standardised process for the interviews was defined to ensure that the data gathered during each interview was as comparable as possible. The interviews conducted had three main goals. The first was to validate the concepts used throughout the preliminary management tool. Nineteen questions were formulated based on the ten primary capabilities to determine the goals of each and the validity of the routines that formed their groupsets. Two final questions were added to determine the validity of the primary capabilities themselves.

The second goal of the interviews was to gather quantitative data regarding preliminary management tool's efficacy by conducting an impact-effort analysis. The analysis consisted of the interviewees rating the proposed routines based on the effort required to implement the routine and level of positive impact the routine contributed to the platform company. Both these metrics were rated on a scale of 1 to 5 and mapped during the evaluation process.

The third goal was to gain insight from the various experts by asking following up questions to identify concepts that might have been overlooked and determine where the management tool can be improved.

9.1.5. Activity 5: Evaluation

The second half of Chapter 7 discussed the evaluation of the data gathered during the semi-structured interviews. During the interviews both quantitative and qualitative data was gathered. Microsoft Excel was used to transcribe both data sets.

The quantitative data analysis included mapping the average routine ratings on an impact-effort matrix to determine the relevance and efficacy of each routine. The matrix included four quadrants, namely Quick wins (High impact, Low effort), Major Projects (High impact, High effort), Fill-ins (Low impact, Low effort) and Thankless Tasks (Low impact, High Effort). Of the thirty-seven preliminary routines, eleven were plotted in the Quick Wins quadrant and twenty-six in the Major Project quadrants. None of the proposed routines were plotted in the Fill-ins and Thankless Tasks quadrants meaning that all of the preliminary routines proposed were seen to have an above average positive impact on the platform company. The result was that all the preliminary routines being kept in the final management tool.

The qualitative data collected included the interviewee's rational behind their impact-effort ratings, their answers to the formulated questions and the insights gained during the discussions thereof. To ensure that the qualitative data was analysed and presented in a structured manner, the researcher followed the six-step process for qualitative data analysis as proposed by Creswell [20], namely organise and prepare, read data, coding process, description, data presentation, and data interpretation. Two coding cycles were implemented to transcribe the data gathered during the interviews. The first cycle coded the primary capability group concepts into three categories, namely validated concepts, disagreed statements, and additional insights gained. By coding the primary capabilities first, the researcher could determine the goals of each and adopt them as lenses during the second coding cycle. The second cycle included establishing the validity of the concepts, identifying disagreements, and gaining additional insights of the proposed routines by analysing the rational given by the interviewees for their ratings during the effort-impact analysis.

The evaluation process concluded with the researcher proposing eleven structural and conceptual changes to the preliminary management tool. The structural changes comprised of updates to the physical appearance of the management tool and the conceptual changes included redefining and renaming the proposed routines based on the insights gained during the interviews.

Finally, two of the preliminary routines were divided and three additional routines were proposed for the final management tool.

9.1.6. Activity 6: Communication

The objectives of the final activity are to present the developed artefact and communicate its novel and thoroughness of design [1], [14]. These objectives were met during Chapter 8 and Chapter 9.

After the updates were applied to the preliminary management tool the final management tool is presented in Chapter 8. Each of the management tool's structural and conceptual elements were discussed in detail to highlight the novelty and efficacy of the tool. The structural elements included the two canvases and how they presented the technology management capability literature, dynamic nature of the capabilities, the hierarchy structure between the different capabilities, and the effort required to implement the different routines. The conceptual elements included the ten primary capabilities and the forty-two routines.

Chapter 9 formed the final chapter in this study and gave a summary of the research conducted, discussed the various contributions to the existing body of knowledge and practical world, elaborated on what the limitations of the research was and gave recommendations for further work to improve the management tool.

9.1.7. DSRM Checklist

The DSRM checklist proposed by Hevner and Chatterjee [14] aids researchers to ensure that their work qualifies as design research projects and to help assess their progress. It consists of questions, which if answered successfully shows that the project addresses the key aspects of design science research.

At the end of each of this study's chapters the addressed checklist items were listed and the questions answered. Table 9.2 below includes the full checklist with corresponding answers and the chapter that addresses the DSR aspect.

Table 9.2: Reflection on Complete Design Science Research Progression Checklist [14]

NUM	QUESTION	RESPONSE	CH.
1	- What is the research question (design requirements)?	- The main research question is: What constitutes a management tool that utilizes technology management capabilities to aid platform owners to help administer their platforms? This question is broken down into sub-questions regarding platform management tools, and the literature reviews and evaluation methods required. - Nineteen design requirements were proposed and distinguished as either Functional requirements, User requirements, Design requirements, Boundary conditions, Attention points	- Ch.1 - Ch.5

2	- What is the artifact? - How is the artifact represented?	- The artifact is a management tool that can be used by a platform owner to launch and manage a technology platform and platform ecosystem. - The final management tool consists of two canvases. The first canvas gives an overview of the activities required and their interrelationships while the second gives concise definitions and considerations for each activity. There are 42 proposed routines distributed between 10 primary capabilities that form part of technology management and supporting management capabilities.	- Ch.6 - Ch.8
3	- What design processes (search heuristics) will be used to build the artifact?	- The research methodology adopted for this study is the design science research methodology proposed by Peffers et al. [1]. Systematized and conceptual literature reviews were conducted to build the knowledge base. The gathered information was translated into the design requirements based on the recommendations made by Van Aken and Berends [39]. - A three-step development process was followed that looked at the definition, relation, and distribution of the proposed management routines.	- Ch.2 - Ch.3 - Ch.4 - Ch.5

4	- How are the artifact and the design processes grounded by the knowledge base?
	
	- What, if any, theories support the artifact design and the design process?
		- The design processes look at the technology management routines which are the activities required to develop and manage technology platforms. The processes are grounded by the knowledge base as they look at routines in the existing literature, their application within a platform business, the dynamic relations between them, and their distribution between primary capabilities.
		- The theories that support the artifact design are:
		  - Technology management and supporting management capability literature
		  - Dynamic capability theory
		  - Hierarchy theory of capabilities
		- Existing management tools and literature for technology platforms and platform ecosystems
			- Ch.5
			
			- Ch.3
			- Ch.4
			- Ch.6

5	- What evaluations are performed during the internal design cycles? - What design improvements are identified during each design cycle?	- The design requirements were used as an initial evaluation method to verify that the critical aspects detailed in existing literature were addressed during the development process. - Semi-structured interviews and impact-effort analyses were conducted. - Ten structural and conceptual modifications were applied to the preliminary framework as a result of the evaluation process.	- Ch.6 - Ch.7 - Ch.7
6	- How is the artifact introduced into the application environment and how is it field tested? - What metrics are used to demonstrate artifact utility and improvement over previous artifacts?	- Impact and effort ratings were given for each routine by local and international experts during the semi-structured interviews. - Qualitative and quantitative data gathered during the semi-structured interviews based on the validity of the proposed routines and preliminary management tool.	- Ch.7 - Ch.7
7	- What new knowledge is added to the knowledge base and in what form (e.g., peer-reviewed literature, meta-artifacts, new theory, new method)?	- A new management tool is added to the knowledge base. The management tool shows a new representation of existing TMC theories, additionally new theory is added through the proposed routines.	- Ch.8
8	- Has the research question been satisfactorily addressed?	- The research question has been sufficiently addressed. The management tool developed during this study addresses the different considerations required to launch and manage a technology platform and presents these considerations in a user friendly and practical manner.	- Ch.8

9.2. Research Objectives

The main objective of this study was to develop a general management tool that can aid platform owners launch and manage their technology platforms and platform ecosystems. To achieve this goal the main objective was subdivided into ten subobjectives that were systematically completed throughout the study. Table 9.3 below lists the ten subobjectives and the chapter number which addressed them.

Table 9.3: Research Objectives and Addressing Chapters

#	RESEARCH OBJECTIVE	REF
RO1	Identify the key concepts of technology management capabilities and dynamic management capabilities by conducting a systemized literature review.	Ch.3
RO2	Establish the literature gap between technology management capabilities and management of technology platforms and platform ecosystems.	Ch.3

#	RESEARCH OBJECTIVE	REF
RO3	Elaborate further on the key concepts identified during the systematized literature review through conducting a conceptual literature review.	Ch.4
RO4	Establish the contexts and requirements of management tools for technology platforms through conducting a conceptual literature review.	Ch.4
RO5	Translate the existing literature gathered during the systematized and conceptual literature reviews into design requirements for a management tool.	Ch.5
RO6	Develop a preliminary management tool for technology platforms based on the existing literature gathered during the systematized and conceptual reviews.	Ch.6
RO7	Validate the preliminary management tool with the design requirements defined during Phase 1.	Ch.6
RO8	Evaluate the validity of the design requirements and concepts used within the management tool through semi-structured interviews.	Ch.7
RO9	Update the preliminary management tool based on the feedback from the semi-structured interviews.	Ch.7
RO10	Present final management tool for technology platforms based on technology management capabilities.	Ch.8

9.3. Research Contributions

The final management tool contributes practically to platform owners and to existing technology management and technology platform literature. The contributions that fall under these two categories are listed in Table 9.4 and Table 9.5 respectively. For the practical contributions the researcher looked at the various elements of the management tool to determine the benefits.

Table 9.4: Practical Research Contributions to Platform Owners

TOOL ELEMENT	CONTRIBUTION
Platform and ecosystem perspective	- The management tool presents the considerations to develop and manage both the technology platform and platform ecosystem. - The tool shows the importance of platform governance and links the ecosystem expansion with platform expansion.
Routines	- The tool shows the platform owner all the processes and considerations required to develop and manage a technology platform and platform ecosystem with the practical routines. - The routines are not just technology focused but also take into consideration the skills required within the platform firm to create and operate the platform.
Routine distribution	- The routine distribution helps the owner to understand which actions are required to achieve the goals of the various primary capabilities.

TOOL ELEMENT	CONTRIBUTION
Routine definitions	- The concise definitions of the routines make it clear what the objective of each routine is. - The considerations given with every routine are practical and shows what it requires to implement each action.
Relevant ecosystem actors	- The tool shows the platform owner which ecosystem actors they need to take into consideration when implementing a routine.
Effort colour scheme	- The colour scheme used for the routines shows how much effort each routine requires to implement.
Mature routine identification	- The tool shows which routines are not immediately necessary to develop and launch a platform but are required as the platform and ecosystem mature.

Further contributions addressed the gaps identified in the literature and additions to existing literature. As stated in the introductory chapter of this study, the management considerations for businesses that utilize technology platforms differ from traditional linear businesses [5]. This was further indicated by the data showing platform owners struggling to grow critical mass at the right time within the platform and ecosystem life cycle [6], showing the need for a practical management tool to aid platform owners to develop and manage their platforms. Therefore, the management tool was designed to be used from a platform owner's perspective and to be practically useable in the industry.

Secondly, the management tool bridges the gap between the engineering perspective and business perspective. The research indicated that many studies in existing literature adopt one or the other perspectives.

The third contribution addresses the lack of practical research for technology management capabilities and their routines. Most TMC models are ambiguous and are not practically applicable to the industry. The routines given in the final management tool give concise considerations for a platform owner to implement each activity. Next, many literature sources only address technology platforms as supporting capability and miss the considerations and activities they create and require that influence the business decisions within a firm. This is a clear gap that this research aimed to address and contributes to the academic literature by proposing routines for technology platforms that are business related.

The final contribution is to the lack of TMC research conducted in developing countries. Five out of the ten interviewees that participated during the evaluation phase were local experts in the field of technology management and local industry leaders.

Table 9.5 summarises the research contributions to existing literature and the gaps addressed during this study. The motivations for each contribution are also given and include supporting references gathered during the study.

Table 9.5: Research Contributions to Existing Literature

CONTRIBUTION	MOTIVATION	REF
Practical platform management tool	The existing tools from literature often lack practicality in the real world.	[87], [88]
Adopts both an engineering and business perspective	Many of the existing studies do not address both perspectives and miss how their influences overlap.	[63], [67]
Practical TMC model	Existing TMC models and routines are often ambiguous or not practically presented.	[23], [132], [138]
Platforms not just as supporting capability	Platforms are often presented as a supporting capability and do not take into consideration their business decisions.	[47]–[49]
Gap in TMC literature in developing countries	The interviews determined the practicality of TMC concepts in South Africa as existing literature is mostly from developed countries	[13], [128], [129]

9.4. Study Limitations

After critical reflection of the systematized and conceptual literature reviews, the evaluation methods, and final management tool, the researcher acknowledges that this study and its findings include limitations. Further reflection also resulted in aspects identified that could have been approached differently. The identified limitations are listed below.

1. A systematized literature review was conducted and not a full systematic literature review.
2. The systematized review was only conducted by one researcher and creates room for bias.
3. Only one database (Scopus) was used to conduct the systematized review.
4. Only 14 primary studies were identified during the systematized review. More studies would have resulted in more comprehensive search results.
5. The systematized literature review was not peer reviewed although it has been submitted to a journal for peer review (IEEE Transaction on Engineering Management).
6. Although the design requirements were based on comprehensive research, they were defined by one researcher which creates room for bias.
7. Only semi-structured interviews were used for the evaluation of the management tool. Further evaluation would have led to the final management tool being more refined and validated.
8. A case study was not utilized as an evaluation method during the study and may have delivered richer results regarding the efficacy of the tool.
9. The same follow-up questions were not asked during the interviews, making it difficult for the researcher to compare all the data gathered.
10. The impact-effort ratings gathered during the routines were based on personal views of the interviewees, which creates room for bias.
11. The analysis and interpretation of the data gathered during the evaluation phase was dependent on the researcher's knowledge of the various topics.
12. The routines that were added in the final management tool were not evaluated and the effort to conduct them were based on the researcher's understanding of the activity, thus creating room for bias.

13. Only the platform owner, developers and end-users were chosen as ecosystem actors regarded in the tool. There are other ecosystem actors that can be added, for example technology vendors and consultants.
14. Although the management tool was designed to be generalised and not industry specific, it only focuses on integrated platforms and there would still be platforms that won't relate to the tool due to their diverse and complex nature.
15. The management tool needs to continuously evolve to keep up with platforms' and ecosystems' dynamic nature and remain applicable within the industry.

9.5. Recommendations for Future Work

Based on the study limitations and the final management tool the researcher identified multiple avenues for future work.

The first concerns the systematized literature review conducted during this study. A full systematic literature review could be conducted to determine a more comprehensive scope of how technology management capability literature is applied to technology platforms. A full systematic review with more than one researcher will also lessen the chance for biases to arise.

It is recommended that the management tool be further evaluated using varying methods. Multiple case studies could be conducted to determine the tool's efficacy in different industries. Evaluation methods that include gathering quantitative data regarding the effect of the tool' use within a company could be another area for further investigation. Further evaluation is also required to exactly determine which routines could be implemented at a later stage of the platform's lifecycle as the current method within the tool is based on the researcher's analysis of the interviewee's feedback.

The aim of this study was to deliver a generalised tool, thus the quantitative data gathered during the impact-effort analysis was specifically evaluated to test the general efficacy of the tool. A larger scale impact-effort analysis of all the proposed routines could deliver new insights by approaching more participants from varying backgrounds. The information gathered could include if participants' ratings differ due to their regions, specifically split between developing and developed countries, or if companies in different industries find it more difficult to implement certain routines.

Further avenues of prospective research include possible additions to the management tool. For example, the tool could be expanded by adding a canvas that tests the maturity of the routines within the tool as the platform and ecosystem evolve.

9.6. Chapter 9 Summary

Chapter 9 included the final chapter of this study and was comprised of the concluding discussions. A summary of the research conducted was presented followed by the research objectives. Both the practical contributions of the tool for platform owners and theoretical contributions to existing literature were then discussed. Finally, the study limitations were listed and recommendations for future work were given.

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Appendix A: Interview Consent Form

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STELLENBOSCH UNIVERSITY

ELECTRONIC CONSENT TO PARTICIPATE IN RESEARCH

TITLE OF RESEARCH PROJECT:	Towards a management tool for technology platforms based on technology management capabilities in South Africa
REFERENCE NUMBER:	ING-2021-21857
PRINCIPAL INVESTIGATOR:	Stian Venter
ADDRESS:	Industrial Engineering Building Faculty of Engineering Banghoek Rd University of Stellenbosch 7600 Stellenbosch
CONTACT NUMBER:	+353 83 414 1501
E-MAIL:	stianventer20@gmail.com

Dear prospective participant

Kindly note that I am a MEng student at the Department of Industrial Engineering at Stellenbosch University, and I would like to invite you to participate in a research project entitled "Towards a management tool for technology platforms based on technology management capabilities in South Africa".

Please take some time to read the information presented here, which will explain the details of this project and contact me if you require further explanation or clarification of any aspect of the study. This study has been approved by the Research Ethics Committee (REC) at Stellenbosch University and will be conducted according to accepted and applicable national and international ethical guidelines and principles.

1. **INTRODUCTION:**

The use of technology platforms has rapidly grown as industry leaders have identified them as giving an edge on their competitors. This said, sound management procedures and techniques are essential for the effective and continuous growth of the company and should be addressed in such a way that it captures the dynamic nature of technological advancement. Technology management as a research field may provide the answer as it is defined as the process of managing the development and implementation of technological capabilities to achieve the strategic objectives of a company.

2. **PURPOSE:**

The main aim of this study is to develop a management tool for technology platforms based on technology management capabilities. The researcher envisages that the study will aid new and existing platform business owners by providing a management tool that brings a new perspective to platform management, which is not industry specific, and that is easy to use. This study also adds to the literature on technology platforms, their corresponding platform ecosystems and how to practically implement technology management capabilities.

The management tool to be developed requires validation by experts in the field and therefore requires a practical component through interviews.

3. **PROCEDURES**

As this study is qualitative of nature, participants will be asked to partake in an interview discussion concerning technology management capabilities and technology platforms. For the safety of the participant and the interviewee regarding the transmission of the coronavirus, the interviews will be conducted via Microsoft Teams or Zoom, depending on the interviewee's preference.

4. **TIME:**

Each interview will be kept within an hour and a half timeframe. If more time is required, the principal investigator will contact the participant and request a follow-up interview. The study is to conclude on the 31st of August 2021.

5. **RISKS:**

All possible risks and discomforts have been taken into consideration by the researcher who has implemented safeguards to completely mitigate these risks while creating an atmosphere that is safe and conducive to learning. The participant will not be threatened by any physical or psychological risks during the interview.

6. **BENEFITS:**

Participants will not benefit directly from the study through payments as participation is done on a voluntary basis, but their participation will add to the literature on technology management capabilities and technology platforms which can be used in providing innovative solutions to future technology companies.

7. **PARTICIPATION & WITHDRAWAL**

The participation in this study is completely voluntary and the participant is free to withdraw from the study at any time without any negative consequences. The participants are also free to refuse to answer questions they do not feel comfortable with.

If you choose to withdraw mid-way through the interview, then the interviewer will disregard any responses that you have provided, terminate, and delete the voice recording and discard any notes that may have been made. If you decide to the withdraw at any time after the interview has been completed, then the researcher will not incorporate any of your responses into their research and they will also destroy any written notes or electronic copies related to your responses.

8. **CONFIDENTIALITY:**

The confidentiality and terms of engagement will be discussed prior to the interviews between all parties. The information gathered during this interview/questionnaire will only be used for research purposes, specifically related to my thesis.

As prospective participant you will not be requested to provide any personal information during the interview/ questionnaire, which can identify you as an individual. Furthermore, participants will be anonymised throughout the study documentation and no personal information of any participant will be disclosed.

Interviewee direct quotes will only be used in the thesis document with the complete permission of the interviewee.

Any form of correspondence between prospective participants and investigators will be kept confidential, and only the principal investigator will have access to this information. If future use of data obtained from the questionnaires is requested, then it will only be disclosed with the permission of the relevant participants.

9. **RECORDINGS:**

The interviews will be voice-recorded, and the researcher will take notes, if necessary, to allow them to refer to the interviews.

10. **DATA STORAGE:**

The recordings of the interviews will be stored on a secure Google Drive account that is password protected, which will only be available to the interviewer. The interview dates will be used as a naming convention for the recordings to ensure anonymity of the interviewee.

If you have any questions or concerns about this research project, please feel free to contact Stian Venter at +353 83 414 1501 or stianventer20@gmail.com, and/or the supervisor Prof Sara Grobbelaar at ssgrobbelaar@sun.ac.za.

RIGHTS OF RESEARCH PARTICPANTS: You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché (mfouche@sun.ac.za / 021 808 4622) at the Division for Research Development. You have the right to receive a copy of this Consent form.

If you are willing to participate in this research project, please select the relevant box in the Declaration of Consent below and email it back to Stian Venter at stianventer20@gmail.com.

DECLARATION BY THE PARTICIPANT

As the **participant** I hereby declare that:

- I have read the above information and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions and all my questions have been adequately answered.
- I understand that taking part in this study is voluntary and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- If the principal investigator feels that it is in my best interest, or if I do not follow the study plan as agreed to, then I may be asked to leave the study before it has finished.
- All issues related to privacy, and the confidentiality and use of the information I provide, have been explained to my satisfaction.

As the **participant** I hereby select the following option:

	I accept the invitation to participate in your research project, and if I decide to be interviewed it would automatically mean that I have given consent for my responses to be used confidentially and anonymously.
	I accept the invitation to participate in your research project, and if I decide to complete the questionnaire it would automatically mean that I have given consent for my responses to be used confidentially and anonymously.
	I decline the invitation to participate in your research project.

DECLARATION BY THE PRINCIPAL INVESTIGATOR

As the **principal investigator** I hereby declare that the information contained in this document has been thoroughly explained to the participant. I also declare that the participant has been encouraged (and has been given ample time) to ask any questions. In addition I would like to select the following option:

	The conversation with the participant was conducted in a language in which the participant is fluent.
	The conversation with the participant was conducted with the assistance of a translator, and this "Consent Form" is available to the participant in a language in which the participant is fluent.

Signed at *(place)* **Date**

Signature of Principal Investigator

TM and Supporting Capabilities	**Questions**
Identification	• Which environments would you say are important to scan for new technology/skills? • Which actors/trends would you say are important to keep in mind when scanning these environments to determine the relevance of a new technology/skill?
Selection	• How important is it to have a plan to know when to implement newly identified technology/skills? • Should future platform owners continuously prepare a platform/ecosystem for newly identified technology/skills?
Acquisition	• Does R&D still play a role in platform/ecosystem management? • Would you say that the level of platform and ecosystem entry barriers are influenced by the method of funding?
Exploitation	• Should developer services and developer relations be considered under one portfolio to manage? Or be made separate? • Would you say it is better to have varying support structures for different business processes?
Protection	• Do you think different levels of protection are needed for technology platforms? • How frequently would you say should new protection applications be considered for technology platforms/ecosystems?
Learning	• When would be the appropriate time for a platform owner to be open to learning? • Which communication channels would you say is incremental to learning within a platform ecosystem?
Strategy Management	• Which areas of strategy would you say are important for the management of technology (platform/ecosystem)? • Do you think that these different strategy routines should use a specific routine to communicate between them?
Innovation Management	• What are important considerations for innovation management within a platform ecosystem? • How important a role would you say is innovation between developers within a platform ecosystem?
Project Management	• Do you think that maintaining a good environment between employees and developers is important for project execution? • Should different performance improvement schemes be implemented for specific indicators?
Knowledge Management	• Should knowledge management be kept as one routine or split into multiple routines?
Technology Management Capabilities	• Do the six technology management capabilities reflect a realistic roadmap for managing technology from start to close-out?
Supporting Management Capabilities	• Beyond Strategy-, Innovation-, Project- and Knowledge management what other divisions would be important to support technology through its lifecycle?

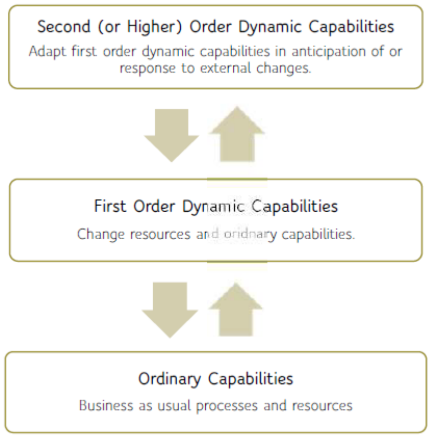
Appendix B: Systematized Review Primary Studies

NUM	AUTHOR(S)	TITLE	REF
1	Y. Liu, W. Wu, P. Gao, K. Liu	Exploring the Different Combinations of Technological Capability and Technology Management Capability in Different Stages of New Product Development	[10]
2	D. Cetindamar, R. Phaal, D. Probert	Understanding technology management as a dynamic capability: A framework for technology management activities	[13]
3	E. Unsal, D. Cetindamar	Technology management capability: Definition and its measurement	[23]
4	Z. Asim, S. Sorooshian	Exploring the Role of Knowledge, Innovation and Technology Management (KNIT) Capabilities that Influence Research and Development	[47]
5	T. Li, Y. Chan	Dynamic information technology capability: Concept definition and framework development	[48]
6	H. Li, W. Han	Knowledge Management Processes, IT Platform and the Performance of Diversified Enterprises	[49]
7	G. DeGregorio	Technology management via a set of Dynamically linked roadmaps	[50]
8	J.J.N Sanchez	The effect of information technology management capability on firm competitiveness	[51]
9	W. Wu, B. Yu	Strategic Planning for Management of Technology of China's High-tech Enterprises	[52]
10	W. Wu, Z. Liang, Q. Zhang, H. Zhang	Coupling relationships and synergistic mechanisms between technology management capability and technological capability in product innovation: a simulation study	[53]
11	W. Wu, Y. Yang, Q. Deng, B. Yu	Technology Management Capability and New Product Development Performance: The Mediating Role of Absorptive Capacity	[54]
12	J. Rose	Improving software management: the industry model, the knowledge model, the network model	[55]
13	E. Lefebvre, L. Lefebvre, L. Prefontaine	Relating technology management capabilities to the use of information technology	[56]
14	W. Wu, B. Yu, J. Wang	Dynamic models of technology management capability development based on knowledge diffusion	[57]

Appendix C: Semi-Structured Interview Slideshow

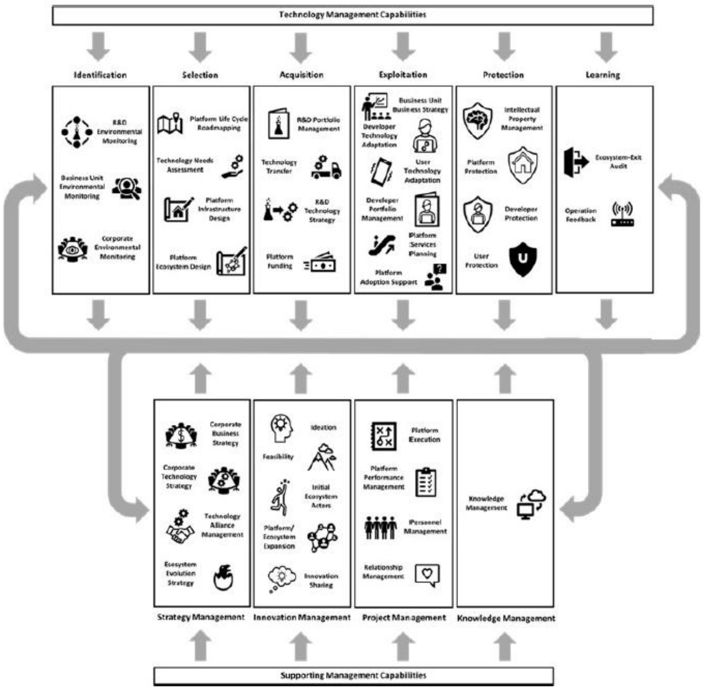
Technology Management Capabilities

- Dynamic process
- Implementation of technological capabilities
- Accomplish the objectives of an organization
- Hierarchal structure between capabilities



TMC view on Technology Platforms

- Existing literature only sees technology platforms as a type of capability
- This study argues differently, due to…
  - Technology platforms variation from traditional business strategy
  - The central role the platform plays within the company
  - The importance of platform and ecosystem evolution



Proposed Management Tool

Proposed Management Tool

TECHNOLOGY MANAGEMENT CAPABILITIES			
Identification			
	R&D Environmental Monitoring	Scanning the external technological environment for wider technology and scientific advances to identify new technologies that are disrupting the industry and can be implemented into the platform, such as security, distribution channels, and user devices.	*Owner*
	Business Unit Environmental Monitoring	Scanning the external cultural environment for key industry trends to identify the target market's characteristics, their needs, and the cultural and natural setting into which the platform is being introduced; and to identify competing platforms and ecosystems to determine what differentiates them from this platform and ecosystem.	*Owner, User*
	Corporate Environmental Monitoring	Scanning of the external economic environment to identify the upstream and downstream stakeholders or actors, the effect of economic growth on global, national and local level on the adoption of the platform, and to determine the impact of economic activities carried out by the platform owner and their competitors on the market trends.	*Owner, Developer, & User*
Selection			
	Platform Life Cycle Roadmapping	Setting out the roadmap that shows when and how to develop identified technological capabilities that are required for future processes to maintain the constantly evolving ecosystem. Setting out includes defining the inputs and outputs of the different processes, the timeline to complete a process, and the technological requirements needed.	*Owner, Developer*
	Technology Needs Assessment	Analysing how the platform and ecosystem evolves, and identifying technologies that need to be upgraded, replaced or discarded, for example security firmware, the type of scalability of platform, or hardware requirements. The output of this routine flows into the 'Platform infrastructure design' routine and 'Platform ecosystem design' routine.	*Developer, User*
	Platform Infrastructure Design	Designing the platform and supporting technology infrastructure. Considerations include the programming language adopted by the platform, what the interfaces will comprise of, the extent of access developers have to the platform functionality, the type of data transferred and stored during the use of the platform, scalability of the platform, etc.	*Owner, Developer*
	Platform Ecosystem Design	Designing what the ecosystem will look like and how it will run. Considerations include who the key actors are, their roles in the ecosystem, what entry barriers will be implemented, what the technological barriers are, the organisational structure in the ecosystem, how the ecosystem health will be monitored, and how the end products/services will be distributed.	*Owner, Developer, User*
Acquisition			
	R&D Technology Strategy	Strategizing when to focus on which newly identified scientific and technological areas and determining the validity of the technology plans. Considerations include planning the progression of the technology being develop, defining the expected outcome of R&D projects, and how to transfer the information to the rest of the company.	*Developer & User*

Interview Outline

- Thank you for participating in this interview as part of the research towards my Master's degree in Engineering Management.
- The aim of this interview is to gain practical insight and feedback on the developed management tool regarding the usability and completeness of the tool from an expert in the field.
- With your permission, a recording of this interview will be made to document the interview for further reference. As participant you will receive a copy of the recording. All names and personal details will not be disclosed in the study and will be kept anonymous.
  - Please ensure that you have filled out the consent form.
  - You can answer Yes/No, elaborate further, or choose not to answer at all.
  - As mush information as possible would be appreciated.