CONSTRUCTING A FRAMEWORK THAT FACILITATES TECHNOLOGY TRANSFER TO SUB-SAHARAN AFRICA: A HEALTHCARE PERSPECTIVE

By

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Declaration

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Date: March 2020

Abstract

Healthcare technology transfer aims to alleviate healthcare burdens in developing nations through a combination of acquisitions and collaborative technology development. Although technology transfer may be viewed as a mature field and while various technology transfer models exist, few focus on health-related concepts in developing nations. This study sets out to develop a framework capable of facilitating health-related technology transfer to sub-Saharan Africa.

A systematic conceptual literature review is conducted to identify the major characteristics of technology transfer. The review outlines the evolution of technology transfer, critical technology transfer stakeholders and their roles, the available technology transfer methods, the requirement for knowledge transfer as well as known technology transfer barriers.

A systematic comparative literature review is conducted to refine the focus of the study towards healthcare technology transfer case studies completed in sub-Saharan Africa. Fifty-one case studies are compared to identify the required infrastructure components, technology transfer methods utilised as well as the stakeholders involved.

Based on the outcomes of the literature reviews, a conceptual framework is developed. This framework is divided into five phases and aims to guide a user through the phases of technology development, technology analysis, technology transfer method application, change management and commercialisation. Multiple guidelines and managerial best practices are provided at each phase.

The conceptual framework is evaluated using an evaluation procedure consisting of three levels. The first level utilises the outcomes of 16 semi-structured interviews conducted with healthcare and technology transfer industry experts. The second level utilises the outcomes of a survey instrument completed by 89 healthcare technology managers. The conceptual framework is retrospectively applied to three healthcare TT case studies for the third level of the evaluation procedure. Issues identified during this evaluation procedure are mitigated by conflating the outcomes into the existing framework. The final consolidated framework is presented along with individual phase expansions.

Uittreksel

Gesondheidsorgtegnologie-oordrag poog om gesondheidsprobleme in ontwikkelende lande te verlig deur die paralelle ontwikkeling van verkrygingskanale en die gebruik van tegnologie. Alhoewel verskeie tegnologie-oordragmodelle bestaan, fokus min op gesondheidsverwante konsepte in ontwikkelende Afrika-nasies. Hierdie studie streef daarna om 'n raamwerk te ontwikkel wat die gesondheidsverwante tegnologie-oordrag na Afrika, suid van die Sahara, kan fasiliteer.

'n Sistematiese konseptuele literatuuroorsig is gedoen om die belangrikste eienskappe van tegnologie-oordrag te identifiseer. Die oorsig beskryf die evolusie van tegnologie-oordrag, kritieke tegnologie-oordragbelanghebbendes en hul rolle, die beskikbare tegnologie-oordragmetodes, die vereistes vir kennisoordrag asook bekende tegnologie-oordragprobleme.

'n Sistematiese vergelykende literatuuroorsig is gedoen om die fokus van die studie na gesondheidsorgtegnologie-oordraggevallestudies in Afrika, suid van die Sahara, te verfyn. Een en vyftig gevallestudies word vergelyk om die vereiste infrastruktuurkomponente, tegnologie-oordragmetodes en belanghebbendes te identifiseer.

‘n Konseptuele raamwerk gegrond op die uitkomste van die literatuuroorsigte is ontwikkel. Hierdie raamwerk is in vyf fases verdeel en beoog om 'n gebruiker te lei deur die fases van tegnologie-ontwikkeling, tegnologie-analise, tegnologie-oordragmetodetoepassing, veranderingsbestuur en kommersialisering. Verskeie riglyne en bestuurspraktyke word in elke fase voorsien.

Die konseptuele raamwerk is geëvalueer deur gebruik te maak van 'n evalueringsprosedure wat uit drie vlakke bestaan. Die eerste vlak gebruik die uitkomste van 16 semi-gestruktureerde onderhoude wat met kundiges in gesondheidsorg en tegnologie-oordrag. Die tweede vlak maak gebruik van die uitkomste van 'n opname-instrument wat deur 89 gesondheidsorgtegnologiebestuurders voltooi is. Die konseptuele raamwerk word retrospektief toegepas op drie TT-gevallestudies vir gesondheidsorg vir die derde vlak van die evalueringsprosedure. Kwessies wat tydens hierdie evalueringsprosedure geïdentifiseer is, is in die bestaande raamwerk ingevleg. Die finale gekonsolideerde raamwerk word saam met individuele fase-uitbreidings verskaf.

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- The industry experts who participated in the semi-structured interview process. Their names have been omitted to maintain anonymity.
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Nomenclature

ANOM	Analysis of means
ANOVA	Analysis of variance
AUTM	Association of University Technology Managers
CHMI	Centre for Health Market Innovations
CSIR	Council for Scientific and Industrial Research
FDI	Foreign direct investment
GDHN	Global Digital Health Network
GT	Grounded Theory
HIS	Healthcare information systems
ICT	Information and communication technology
IP	Intellectual property
TT	Technology transfer
TTO	Technology transfer office
SME	Small-medium enterprises
SSA	Sub-Saharan Africa
SUREC	Stellenbosch University's Research Ethics Committee
WHO	World Healthcare Organisation

Chapter 1. Introduction

1.1 Healthcare and infrastructure chasms in sub-Saharan Africa and the requirement for technology transfer

Access to adequate healthcare is deemed a basic humanitarian right and international entities, such as the World Healthcare Organisation (WHO), have been established with the sole focus of promoting healthcare on a global scale (World Health Organization, 2006). Currently, there are several debates surrounding the concept of "adequate healthcare" with nations providing their citizens with different levels of healthcare access at varying cost (Ansari *et al.*, 2001; Mutula, 2008; Aranda-Jan *et al.*, 2014).

> *"The objective of the World Health Organisation shall be the attainment by all peoples of the highest possible level of health."*
>
> \- (World Health Organization, 2006)

Literature suggests a strong correlation exists between the economic and social development of a country and the level of healthcare provided within the country in terms of access, delivery, quantity and quality of healthcare professionals available (Salicrup *et al.*, 2006; Ssewanyana *et al.*, 2007). This directly results from a developed country's superior base of physical infrastructure, healthcare policies and medical training systems (Mutula, 2008; Bearman *et al.*, 2013). However, in developed countries the economic cost of healthcare, measured in Dollar, varies greatly from the statistical global average (Janssen *et al.*, 2004; Waldman *et al.*, 2004; Bastida *et al.*, 2008).

When compared to their developed counterparts, most developing nations lag in key areas measured through indicators such as percentage of the population with access to healthcare, proportion of the working population in healthcare professions and the number of medical facilities per capita (Nhampossa, 2005; Philip F. Musa *et al.*, 2005; Mengiste, 2010). It must be noted that although typically the case, there have been exceptions, with some developing nations not only providing comparatively excellent healthcare but also at a substantial discount when compared to first world countries such as Mexico and Sri-Lanka (Halstead *et al.*, 1985; Bastida *et al.*, 2008).

Despite these examples of exemplary healthcare systems in both developed and developing nations, extensive literature exists that document the inadequacies of healthcare systems across the globe (Fuchs *et al.*, 2008; Mutula, 2008). Numerous case studies surrounding disease outbreaks in sub-Saharan Africa (SSA) describe epidemics as “inevitable” due to the lack of freshwater, sanitation and basic immunisation products (Meso *et al.*, 2009; Luiz, 2010). This reiterates that the level of a country’s healthcare industry is directly dependent on its base infrastructure development. The implementation of healthcare devices and services have often been thwarted due to lacking power supply, information and communication technology (ICT) and telecommunications infrastructure (Akinsola, 2005; Luiz, 2010; Anyanwu, 2012).

Hard infrastructure is not the only obstacle to improving healthcare as inadequate training and education programs, management protocols, inoculation programs and national policies have been equally disruptive to the healthcare industry (Kimaro *et al.*, 2005; Piotti *et al.*, 2007; Smith *et al.*, 2008). In SSA countries universal access to healthcare has been proclaimed as the goal in various national healthcare mandates, yet when compared to world-leading healthcare nations, no African country can claim to have achieved this objective (Fuchs *et al.*, 2008; Wamala *et al.*, 2013)

It is in this context that e-Health technologies are being proposed as a method to aid in bridging the gap as e-Health technologies are designed primarily to strengthen, simplify and accelerate data capturing systems to add value to both the managerial and national-level decision-making process (Johnston *et al.*, 2004; Wamala *et al.*, 2013). Examples include healthcare information systems (HIS), online training and immediate access to external medical advice (Braa *et al.*, 2004; Piotti *et al.*, 2007; Mengiste, 2010).

The clear majority of frontline e-Health development occurs in developed nations as they possess the required resources (Piotti *et al.*, 2007; Mutula, 2008). These technologies are largely out of reach of SSA due to numerous barriers such as economic cost and technological readiness (Cleeve, 2012). Technology transfer (TT) could provide a potential solution to implementing e-Health technologies in SSA as it attempts to transfer knowledge and technology from one location to another (Sutter *et al.*, 2007).

However, TT is a process that, in order to occur, also requires base hard- and soft infrastructure (Kifle *et al.*, 2010). Depending on the complexity of the technology transferred, the success of the TT venture is firmly dependant on the available level of both hard- and soft infrastructure in the recipient’s domestic environment (Bozeman, 2000). Despite these inherent infrastructure requirements, TT could still be a vehicle capable of removing the barriers of e-Health development in SSA and subsequently improve domestic healthcare systems (Bozeman *et al.*, 2015).

1.2 Technology transfer as a vehicle for development

TT dates back to the 18th century, with one of the earliest documented cases resulting from eastern trade routes that provided western civilisations with the capability to fashion items out of silk (Brown, 1979). As technology has evolved, so has its transfer with a variety of TT methods currently available. From the outset, it is important to clarify that the transferor refers to the entity that will be transferring the technology and that the transferee will be the recipient of the transfer (Bozeman, 2000; Jesse *et al.*, 2010; Bozeman *et al.*, 2015). Technology, however, is not embodied solely in physical artefacts used to simplify processes but also entails knowledge, protocols and sub-systems (Sung *et al.*, 2000; Ann *et al.*, 2008; Handoko *et al.*, 2016). Transfer of these more tacit concepts has often been far more useful to the transferee than the acquisition of new hardware (Handoko *et al.*, 2016).

A TT case study that illustrates the economic and social development potential of technology dissemination for a transferee is the steel industry in Pasuruan, a coastal city in Indonesia. In the mid-1800s the trade of metalworking was introduced into the city through Dutch colonisation to produce sugar (Handoko *et al.*, 2016). The base technology along with the knowledge on how to operate, maintain and reconstruct it was presented to select individuals. Over time this knowledge disseminated into the local populace after the national government obtained ownership of the physical technologies in 1958 (Handoko *et al.*, 2016). Subsequently, over a period of 60 years more than 500 distinct small medium enterprises have been established in the region specialising in various forms of metalwork and steel fabrication. An estimated 6000 technicians have been trained to produce various steel products that are exported to neighbouring countries and large multi-nationals firms (Handoko *et al.*, 2016).

This example illustrates how base technology can be injected into a foreign environment and how resulting knowledge flows can penetrate an entire sector (Zhang *et al.*, 2016). Historically a fishing orientated village has today been transformed into a value-adding community able to trade and export specialised products as a result of TT (Handoko *et al.*, 2016). TT thus encompasses far more than a method for transferring artefacts and knowledge and has the potential to stimulate regional economic and social development (Martinez, 2003; Nhampossa, 2005; Handoko *et al.*, 2016).

1.3 Problem statement

Analysis of various case studies indicated that a variety of innovative human health technologies are being developed in highly developed environments (Johnston *et al.*, 2004; Bagayoko *et al.*, 2006; Fuchs *et al.*, 2008). These technologies exhibit the clear potential to strengthen SSA healthcare systems if the TT phases of adoption and integration become possible. The TT of such healthcare interventions holds great potential to improve the health and livelihoods of people living in developing, resource-scarce countries. However, the vast differences between the context and environments within which, and for which, these technologies are currently being developed calls for an investigation into the technology's specifications, policy development and implementation requirements.

This investigation must aim at identifying the various conditions that are required and that are conducive to successfully transferring these technologies to SSA countries. Thus, there is a requirement to identify technology-specific changes, drivers and barriers that must be addressed for the transfer of these human health engineering innovations to become a reality.

The fundamental issues that need to be elucidated are a methodology to holistically evaluate the systemic, technical and economic requirements to comprehensively evaluate the stakeholders, role-players and factors that influence the progression of TT. This shall, in turn, uncover a practical strategy for the expansion of the human health technologies from a highly-developed environment to developing countries by considering the unique environment and characteristics of the developing country.

1.4 Research aim and objectives

The aim of this research study is to contribute to the facilitation of health-related TT ventures both to and from the geographic region of SSA. The following research objectives are constructed to aid in the completion of the research study's overarching aim:

i. Conduct a systematic conceptual literature review [1] to identify key TT characteristics that can be subjected to further study from a SSA perspective.
ii. Conduct a systematic comparative literature review [2] to identify critical infrastructure components required specifically for healthcare TT in SSA.
iii. Construct a conceptual theoretical framework by completing the following sub-objectives:
    a. Deconstruct the infrastructure components that have been identified during the completion of the systematic comparative literature review;
    b. Synthesise concepts into a conceptual framework; and

[1] A systematic conceptual literature review refers to a structured literature review aiming to collect a wide collection of information regarding a knowledge area, such as TT, from multiple academic sources. A detail exposition of this type of review is shown later in Chapter 2.
[2] A systematic comparative literature review refers to a structured literature review aiming to identify relevant information in a specific setting by comparing data sources collected in a similar setting, such as SSA. A detailed exposition of this type of review is shown in Chapter 2.

c. Evaluate the conceptual framework by implementing a multi-level evaluation procedure consisting of semi-structured interviews, a survey and case study applications.

iv. Evolve the conceptual framework into a TT tool that can be utilised to facilitate healthcare TT ventures to SSA.

A framework has thus been proposed to facilitate the transfer of existing health-related technologies into SSA countries. The framework shall also aim to enable the co-creation of modern technologies between stakeholders as well as the modification of existing technologies.

Table 1-1 depicts how each research objective corresponds to the framework methodology utilised during this research inquiry. An illustration is also presented of how chapters relate to the completion of individual research objectives. An abridged version of Table 1-1 has been provided at the commencement of each new section undertaken in this document. It is noted that Chapter 2 is omitted from Table 1-1 as Chapter 2 outlines the research methodology of this research study and thus serves as a foundation for all subsequent chapters.

Table 1-1 - Research structure of this document

Document framework							
Research objectives	i.	i. & ii.	i. & ii.	ii. & iii.	ii. & iii.	iii.	iii.
	iv.						
Conceptual Framework Analysis phases	Map data sources	Categorise data	Identify concepts	Deconstruct concepts	Integrate concepts	Synthesis	Validate
Corresponding chapters	Problem statement **Chapter 1**		Comparative literature review **Chapter 4**			TT facilitation tool **Chapter 6** **Chapter 7**	
		Conceptual literature review **Chapter 3**			Conceptual framework **Chapter 5**		

1.5 Research strategy

This research study attempts to create a framework capable of facilitating healthcare TT into SSA countries. To construct this framework, relevant literature is collected and deconstructed to form a theoretical base for the framework. The first literature investigation comprises of a systematic conceptual literature review andaims to uncover the core facets of TT as well as existing TT models. The second literature investigation comprises of a systematic comparative literature review, aiming to identify the specific elements of TT prevalent in the region of SSA.

After the completion of the systematic literature reviews, the identified existing TT models and TT elements highlighted to be critical in the SSA context are categorised into five clusters. These clusters serve as the five major phases during the development of the conceptual framework. Each phase is subsequently expanded into multiple nodes and internal process flow, with each node being augmented with multiple managerial best practices.

After the completion of the conceptual framework, three evaluation procedures are applied to ensure the relevance, utility and validity of the framework's nodes, process flows and best practices. Semi-structured interviews, a survey, and three case study applications are all individually completed. Finally, the conceptual framework is consolidated with the outcomes of the evaluation procedures.

1.6 Scope and limitations of the research study

The research study revolves around healthcare and infrastructure concepts while holding TT at its core. The scope of the research is primarily the geographic region of SSA with the proposed framework specifically tailored to this region. Two systematic literature reviews are completed for this study. The first, a systematic conceptual literature review and the second a systematic comparative literature review. However, the nature of a systematic review leads to limitations as only a specific set of questions can be answered. Thus, while the framework presented in this dissertation has been constructed upon universal TT principles, the systematic literature reviews have been conducted out of a healthcare TT perspective. It is important to consider this limitation if the framework may be applied to other industries.

The systematic conceptual literature review, shown in Chapter 3, focuses on identifying TT as extensively as possible with only non-peer reviewed literature items excluded. The systematic comparative literature review, shown in Chapter 4, had stricter inclusion criteria to ensure that the scope of the review remained concretely on healthcare-related TT to the SSA region. Thus, the resulting selection has various geographic limitations and the systematic comparative literature review cannot be regarded as an all-encompassing study into the field of health-related TT. However, this is in line with the focus of this study being specifically on SSA.

A TT implementation tool is subsequently developed from the presented conceptual framework. However, the application of this final instrument and successive prospective TT trials, fall outside the scope of this dissertation.

1.7 Document outline

Figure 1-1 provides the layout of the document along with an overview of the contents of each chapter. The chapter order has been structured in accordance with the Concept Analysis

Methods (Nuopponen, 2010). It aims to provide knowledge surrounding the core topic areas to enable the reader to understand both the systematic external and internal analyses and the subsequent framework and conclusions derived from them.

1.8 Chapter 1: Conclusion

Chapter 1 presents an introduction to the research study by discussing its background and origin. Concepts of TT and the healthcare inadequacies of SSA are illustrated which provide the foundations for the research study. The problem to be addressed will be the identification of components of TT and the construction of a TT framework to facilitate the process. The aim and research objectives to address the problem have been listed along with a document outline to guide the reader through this research paper. In Chapter 2, the research design and methodologies that were followed during this study will be described.

Chapter 1: Introduction — **Research objectives: i. & ii.**

This chapter provides an abridged overview of the research area along with the problem statement and research objectives. Research characteristics such as the scope, limitations and outline of the document have also been stated.

Chapter 2: Research methodology

This chapter presents the research methodology implemented during the completion of this study. Overviews of the methodologies of a systematic literature review and conceptual framework development are provided here.

Chapter 3: Systematic conceptual literature review — **Research objectives: i. & ii.**

This chapter consists of a systematic conceptual literature review surrounding the concept of TT. This chapter provides a detailed elucidation of all these topics, extracted from the conceptual review.

Chapter 4: Systematic comparative literature review — **Research objectives: i. & iii.**

This chapter consists of a systematic comparative literature review of various case study analyses. The literature items correlate with the concepts identified in Chapter 3 and have been solely focussed on the SSA region.

Chapter 5: Conceptual framework — **Research objectives: ii. & iii.**

This chapter highlights the conceptual framework developed from the research compiled in Chapter 3 and Chapter 4.

Chapter 6: Interviews, survey and case studies — **Research objectives: iii.**

This chapter shows the conceptual framework's validation process by summarising the outcomes of the semi-structured interviews with industry experts, the survey results and the outcomes of the retrospective case studies.

Chapter 7: Technology transfer tool — **Research objectives: iv.**

This chapter displays the final validated TT tool aimed at facilitating health-related TT to SSA

Chapter 8: Conclusion

The final chapter provides a conclusion as well as recommendations regarding this document

Figure 1-1 - Chapter outline of this document

Chapter 2. Research methods

Chapter 2 aims to explain the research methodology required to undertake the systematic conceptual and comparative literature reviews that have been completed for this study along with the resultant TT framework development process. This chapter presents the groundwork theory for both a systematic conceptual- and comparative literature review and how they can be utilised in tandem to elucidate a topic area. Both literature reviews are based on the Grounded Theory (GT). Lastly, Chapter 2 describes the framework development protocol, derived from GT, which has been utilised for the development of the conceptual TT framework, outlined in Chapter 5. The key outcomes of Chapter 2 are summarised in Figure 2-1.

Key outcomes

- Elucidation of Grounded Theory Methodology
- Outlining the research design utilised in this research study
- Elucidation of systematic conceptual literature review methodology
- Elucidation of systematic comparative literature review methodology
- Elucidation of the seven phases required for conceptual framework development
- Summarise the methodology employed at each phase of the conceptual framework development process
- Elucidation of the semi-structured interviews, survey and case studies' research methodology

Figure 2-1 - Key outcomes of Chapter 2

2.1 Research design

Preliminary literature analysis indicated that qualitative analysis can be utilised for framework development and to this extent, the conceptual framework developed in this study is founded upon the conclusions of two systematic literature reviews (Pope *et al.*, 2000; Jabareen, 2009).

GT was first introduced in 1994 by researchers Corbin and Strauss and has been considered as the foundation for all major conceptual framework development efforts (Pope *et al.*, 2000; Thorne *et al.*, 2002; Jabareen, 2009). As such, GT has been employed as the foundation for this study's methodology, refer to Figure 2-2, as it utilises coding[3] in order to promote conceptual development (Strauss *et al.*, 1994). It is preferable to methods such as content

[3] Coding refers to a structured process in which literature items are evaluated so that their core elements can be deconstructed in order to categorize the items into distinct clusters.

and thematic analysis as it provides researchers with structure while maintaining a strong theoretical basis (Jabareen, 2009).

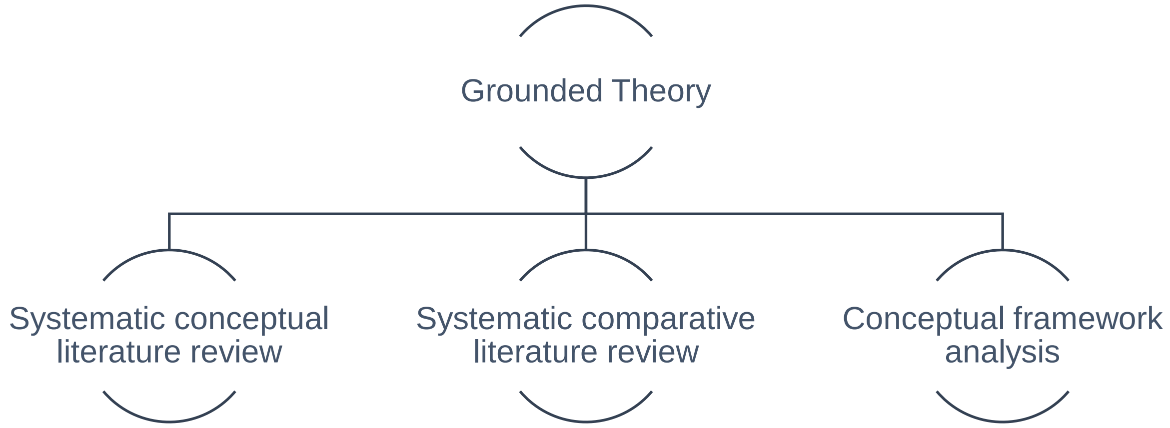

Figure 2-2 - Methodology foundations (adapted from Jabareen, 2009)

2.2 Overview of Grounded Theory

In its simplest form, GT is a generic methodology for developing a theory, a framework or a data set which has been founded upon systematically gathered data points (Strauss *et al.*, 1994). GT allows researchers space for free thinking with the possibility of both generating a new idea from collected data sets or expanding or modifying existing ideas through the exploration of supplementary data (Strauss *et al.*, 1994; Jabareen, 2009).

GT possesses similar features with other qualitative research methods such as the types of literature sources accessed and the ability to incorporate quantitative methods into the methodology as required (Strauss *et al.*, 1994). Critically, GT also promotes the creation of knowledge by including the interpretations and experience of researchers rather than merely rearranging existing viewpoints (Ryu *et al.*, 2010). The main factor that differentiates GT from other qualitative research methods is that GT places emphasis on theory development rather than the amalgamation of existing viewpoints (Strauss *et al.*, 1994).

As such, GT consists of certain general procedures to ensure functional theory development such as comparative reviews, concept-relating inquiries, theoretical sampling, systematic coding procedures and guidelines for attaining conceptual variation and integration (Strauss *et al.*, 1994). In turn, these guidelines serve as the research methodology for the systematic conceptual literature review, discussed in Section 2.3.

Another primary characteristic of GT is that this approach features comparative analysis between different data sets and has subsequently been utilised by researchers to qualitatively allow for systematic comparative analysis of available literature items (Strauss *et al.*, 1994).

Thus GT also forms part of the research methodology foundation of the systematic comparative literature review (Bearman *et al.*, 2013), discussed in Section 2.4.

2.3 Methodology of the systematic conceptual literature review

The motivation behind the use of a systematic conceptual literature review partly lies in the benefits that a systematic review provides in comparison with a traditional review. A systematic conceptual literature review aims to provide researchers with a structured research methodology which can produce repeatable data collection, data screening and comparison of data sources (Kitchenham, 2004). These features of a systematic conceptual literature review are illustrated in Figure 2-3.

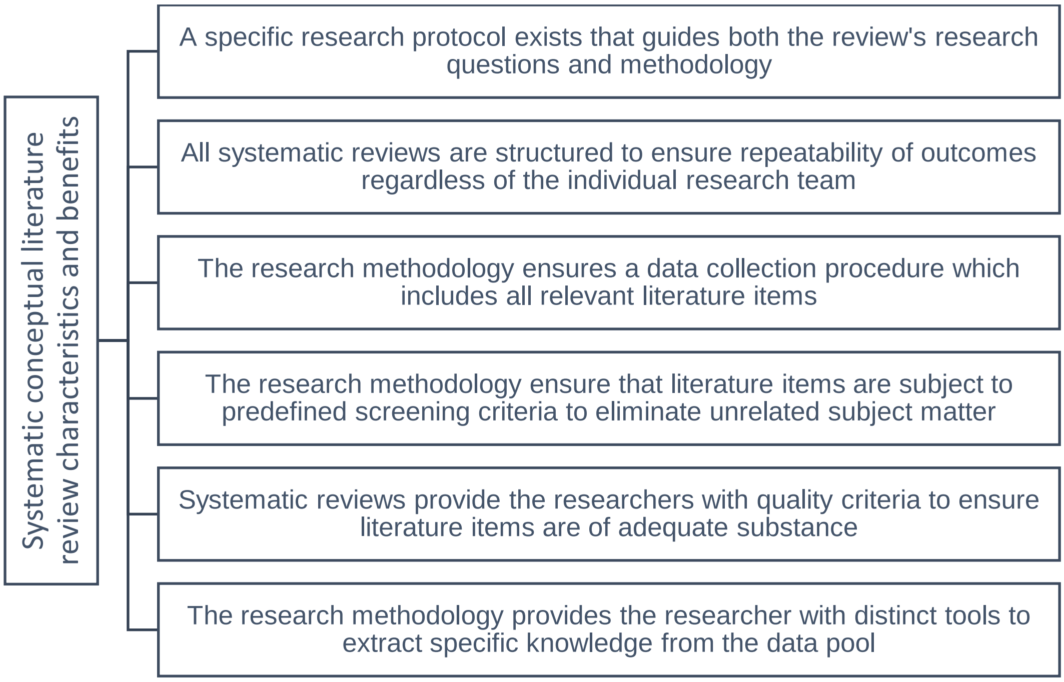

Figure 2-3 - Systematic conceptual literature review's characteristics (derived from Kitchenham, 2004)

Despite the benefits, systematic conceptual literature reviews do possess disadvantages. The main challenge being the amount of effort required to complete a systematic review in comparison to other literature review methodologies. Depending on the extensiveness of the research questions that guide the review, another potential disadvantage may be the limited scope of a systematic review as a narrow scope may lead to certain areas of a research topic remaining uninvestigated. The main benefits, aside from those highlighted in Figure 2-3, include reduced researchers bias, transparency and repeatability of results (Jackson, 2004; Petticrew *et al.*, 2008).

A key consideration behind the utilisation of a systematic conceptual literature review results from literature indicating that traditional content analysis often overlooks implicit concepts

(Jabareen, 2009). This, in turn, results in the overestimation of similarity between data sources as hidden information within the data sources will not be recognised (Carley, 1993; Jabareen, 2009). The systematic conceptual literature review, shown in Chapter 3, has thus been undertaken to thoroughly elucidate the wide-ranging topic area of TT.

The methodology followed during the completion of the systematic conceptual literature review has been founded upon the qualitative model described in dominant journal articles (Pope *et al.*, 2000; Ritchie *et al.*, 2002). A tool, comprising of three phases (Levy *et al.*, 2006), is utilised for the data approach and is summarised in Figure 2-4. Additionally, the third phase, data analysis, is augmented by incorporating a data handling framework developed for the healthcare industry. This expansion has been included as it specifically aims at effectively building knowledge from a large pool of data (Pope *et al.*, 2000). Originally derived from GT, this expanded model then applies a five-stage process for qualitative data analysis of the topic area (Pope *et al.*, 2000; Ritchie *et al.*, 2002). Figure 2-5 provides a summary of the five-stage process utilised in this research study for the data handling of the systematic conceptual literature review.

Data collection has been undertaken through the use of keyword searches in multiple academic literature databases after which titles and abstracts were screened to create a final pool of academic literature that could be analysed. The data analysis commences by immersing into the data pool after which the construction of various thematic framework and subsequent indexes had been undertaken. Lastly, a typology has been constructed to allow for explanation and mapping of the collected data.

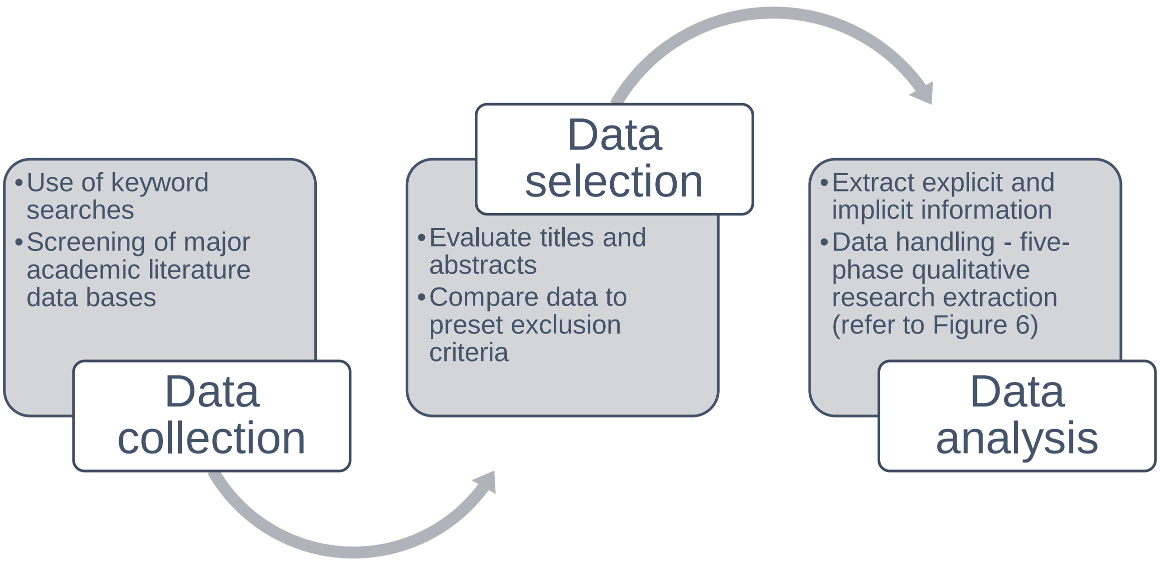

Figure 2-4 - Systematic conceptual literature review's data-handling process (adapted from Levy & Ellis, 2006)

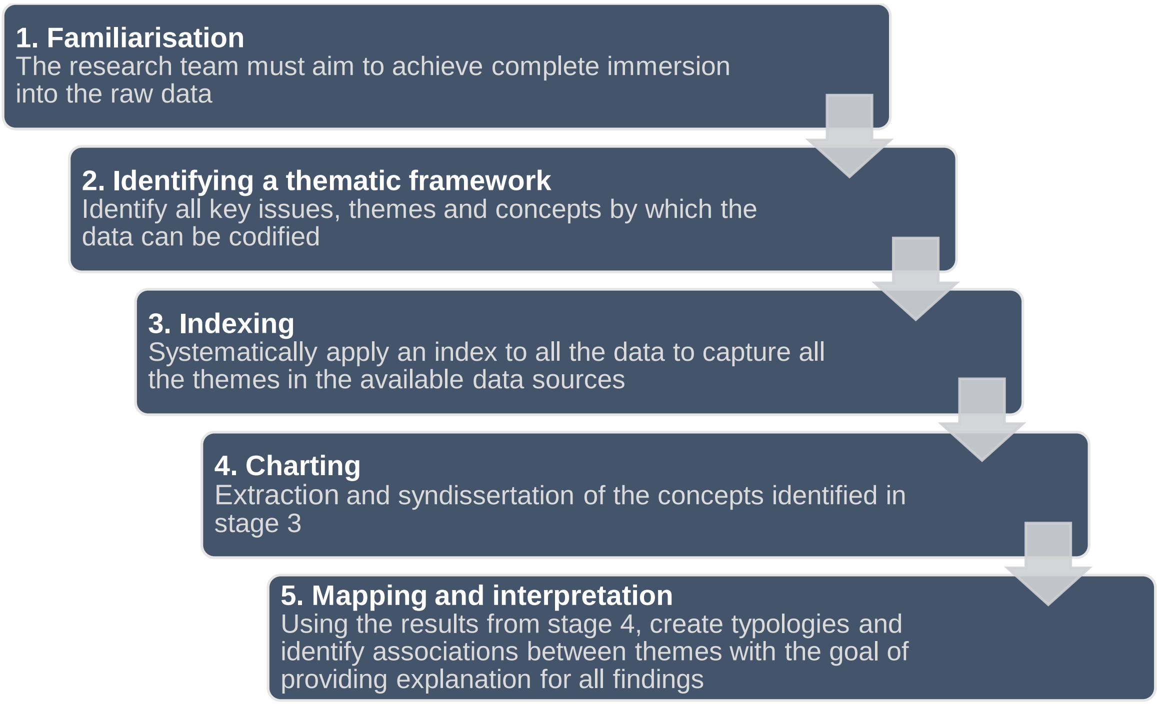

Figure 2-5 - Systematic conceptual literature review's data analysis methodology (Pope *et al.*, 2000)

The expanded data analysis methodology has been incorporated into the original three-phase methodology as it has been developed with the intent of subsequent use in the construction of conceptual frameworks (Pope *et al.*, 2000). This form of data analysis, in conjunction with the framework outline provided in Figure 2-7, ensures a concrete theoretic foundation for the conceptual framework developed in this research study (Strauss *et al.*, 1994; Pope *et al.*, 2000; Ritchie *et al.*, 2002; Jabareen, 2009).

2.4 Methodology of the systematic comparative literature review

While the systematic conceptual literature review is a useful tool for uncovering a variety of characteristics over a broad topic area, the systematic comparative literature review provides a narrower focus (Bearman *et al.*, 2013). As the scope of this research study surrounds a specific geographic area and field of study, refer to Section 1.5, the systematic comparative literature review has been undertaken to identify TT characteristics that are both unique and shared in the region of SSA.

A systematic comparative literature review addresses predefined research questions by collecting and summarising documented empirical evidence that corresponds to pre-specified eligibility criteria (Bearman *et al.*, 2013). The aim is to ensure an exhaustive summary of currently available literature while ensuring that bias is minimised (Popay *et al.*, 1998). The systematic comparative literature review utilises an objective and transparent approach for research synthesis (Aranda-Jan *et al.*, 2014). These reviews are initiated when a thorough search through a variety of literature sources has been undertaken (Strauss *et al.*, 1994). Titles, abstracts, geographical focus and timeframe may then be compared to a set of pre-existing criteria to determine if the literature items meet the inclusion criteria (Strauss *et al.*, 1994). Systematic comparative literature reviews may also entail the evaluation of the research methodologies followed within a literature item and if found unsatisfactory the item will be excluded from the study (Popay *et al.*, 1998).

The majority of systematic comparative literature reviews are based on an explicit quantitative meta-analysis of available data. However, there have also been cases of qualitative reviews which are more strongly related to the standards of gathering, analysing and reporting evidence (Kitchenham, 2004). A certain sequence of steps is typically performed during a systematic review to ensure that the results are both transparent and replicable (Bearman *et al.*, 2013). These steps are presented in Figure 2-6 and subsequently implemented, refer to Chapter 4, to ensure that the systematic comparative literature review adhered to the required research methodology to produce transparent and replicable results.

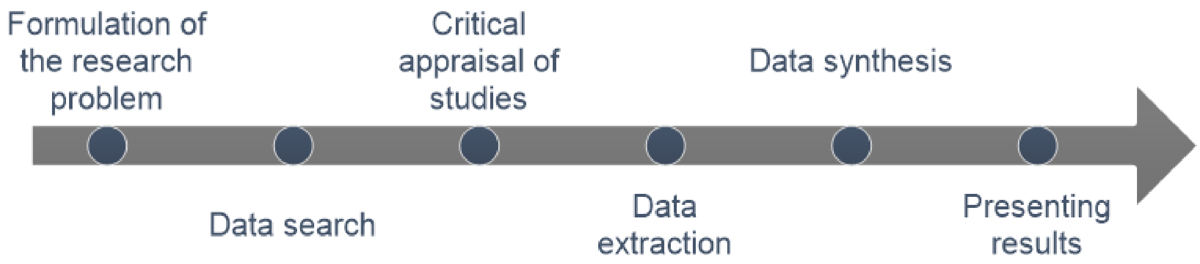

Figure 2-6 - Stages of a systematic comparative literature review (Kitchenham, 2004)

2.5 Methodology of the conceptual framework development

Conceptual Framework Analysis has been chosen for the framework development presented in this dissertation as it focuses on elucidating the attributes, characteristics, assumptions, limitations, perspectives and specific functions within the conceptual framework (Jabareen, 2009). It is important to stress that as Conceptual Framework Analysis, if founded upon GT, attempts to provide understanding and knowledge about data or a process rather than simply stating a theoretical explanation (Strauss *et al.*, 1994; Jabareen, 2009).

Figure 2-7 illustrates the eight phases aimed at producing a conceptual framework. The phases have been constructed in such a manner to ensure they are both iterative and transparent (Jabareen, 2009). The process focuses on the collection of multidisciplinary data relevant to a study and the subsequent processing of the collected data into a functional protocol (Jabareen, 2009). This eight-phase structure has been utilised as the overarching methodology to produce the TT framework presented in Chapter 5.

Phase 1 — **Mapping the select data sources:**
Identify data types of the multidisciplinary literature that surround the construct under review

Phase 2 — **Extensive reading and categorising of the selected data sources:**
Analyse and then categorise the data by discipline and importance

Phase 3 — **Identifying and naming concepts:**
Discovery of concepts through thorough examination of data sources

Phase 4 — **Deconstructing and categorising the concepts:**
Identify the main attributes, assumptions and roles and subsequent classification by role

Phase 5 — **Integrating concepts:**
Reduction of the number of concepts by grouping similarities together into a new concept

Phase 6 — **Synthesize and resynthesize:**
Synthesize concepts into a conceptual framework. Reprocess the framework until its utility is maximised

Phase 7 — **Evaluating the conceptual framework:**
Use peer reviews and feedback loops to validate the framework

Phase 8 — **Evaluation of the conceptual framework:**
As the framework is based on multidisciplinary fields it must be evolved in accordance with their growth

Figure 2-7 - Conceptual Framework Analysis guidelines (Jabareen, 2009)

2.6 Methodology of the evaluation procedure

Phase 7 of the Conceptual Framework Analysis, shown in Figure 2-7, calls for evaluation instruments to be applied in order to establish the validity of the conceptual framework constructed in Phase 6. To this extent, three ofthe evaluation instruments are utilised namely, semi-structured interviews with industry experts, a survey and three retrospective case studies. The individual research methodologies are implemented during the completion of each evaluation instrument and are shown in Section 2.6.1 to Section 2.6.3.

To ensure that the content and structure of the conceptual framework is reviewed in a progressive manner, a leveled evaluation procedure is implemented. As such, the three evaluation instruments will be applied consecutively to the conceptual framework developed in Chapter 5. For both the survey and the case studies, each evaluation instrument will, in part, be constructed from the outcomes of the previous instruments to ensure cross-examination of the conceptual framework's content and structure.

2.6.1 Methodology of the semi-structured interviews

The implementation of semi-structured interviews as the first level of evaluation allows for an iterative procedure in which the conceptual framework's content and overall structure can be efficiently evaluated (Longhurst, 2003; Rabionet, 2011). Semi-structured interviews can provide a mechanism through which it is possible to evaluate the normative value of a scientific research product (Rabionet, 2011). In terms of the conceptual framework, this mechanism is founded upon the reaction of industry experts when presented with the individual constituents of the framework. The first level of the evaluation process is thus achieved from expert analysis.

For each field of research study, the expert knowledge required to be considered as an “industry expert” will differ (Longhurst, 2003). To ensure that potential interview candidates are applicable to this research study, industry experts are required to adhere to predefined criteria aimed at ensuring the relevance of their knowledge and experience with regards to healthcare TT ventures implemented in SSA.

Figure 2-8 illustrates the four steps followed while conducting the semi-structured interviews and represents the overarching research methodology utilised to complete the first level of framework evaluation. The complete methodology of the semi-structured interviews is shown in Section 6.2.1 with the data results presented in Section 6.3. These steps are implemented as they provide a simple protocol with which the experiences of industry experts may be captured (Longhurst, 2003; Rabionet, 2011). In turn, this allows for deductive analysis of the interview results which can be subsequently conflated into a consolidated framework (Rabionet, 2011).

Steps for conducting semi-structured interviews	**1. Indentify and screen candidates**
	2. Provide context
	3. Engage in dialogue
	4. Administer predefined quetionaire

Figure 2-8 - Semi-structured interview procedure (Longhurst, 2003)

As summarised in Figure 2-8, a list of candidates is identified and screened to ensure the candidates’ individual expert knowledge and experience are applicable to this research study. After the final list, containing 16 interview candidates is confirmed, each candidate is electronically interviewed in sessions lasting approximately 60 minutes. During each interview session, candidates are first provided with an overview of the research and encouraged to engage in dialogue surrounding high-level overarching framework elements. A predefined questionnaire, shown in Appendix E, is then administered to extract industry experience directly relevant to individual components within the framework.

After the completion of the interviews, all findings are documented, summarised and deductively analysed to be incorporated into a consolidated framework. This consolidated framework is subsequently used in the construction of the second and third levels of the conceptual framework evaluation procedure.

2.6.2 Methodology of the survey

The survey instrument may either be adapted from existing elements or be newly constructed (Kitchenham *et al.*, 2002; Shields *et al.*, 2007). The completion of the systematic literature reviews in Chapter 3 and Chapter 4 highlighted that well-tested survey instruments are already available in the fields of TT and healthcare. The literature further highlighted that a questionnaire, supported by an extensive literature study, represents a well-tested survey instrument (Kitchenham *et al.*, 2002; Shields *et al.*, 2007; Schoen *et al.*, 2012; Free *et al.*, 2013; Whitty, 2013; Hailey, 2014). Thus, to improve the survey instrument's efficiency, validity and applicability an existing survey instrument was selected (Kitchenham *et al.*, 2002; Shields *et al.*, 2007).

Figure 2-9 illustrates the 12 steps in conducting a survey and this represents the overarching research methodology utilised to complete the survey used as part of the evaluation / validation strategy in this research study. The complete research methodology of the survey is shown in Section 6.2.2 with the data results presented in Section 6.3.3. These guidelines are constructed in a manner which allows for researchers, of all skills levels, to construct and administer a survey which will provide valid data outputs while also ensuring repeatability (Kitchenham *et al.*, 2002; Passmore *et al.*, 2002).

Steps for developing a survey	
	1.State the problem
	2. Plan the project
	3. State the research question
	4. Review literature
	5. Develop/adapt survey items
	6. Hypotheses creation
	7. Construct the survey
	8. Pilot test the draft survey
	9. Administer the survey
	10. Model creation
	11. Establishing model validity
	12. Model estimation

Figure 2-9 - Survey development guidelines (Passmore *et al.*, 2002)

An invitation link was sent to 563 potential respondents which, over the course of a 60-day period, produced 89 completed survey responses. The data results of the survey are modelled using a structural equation model and evaluated using mean analysis, variance analysis, regression analysis and correlation analysis.

2.6.3 Methodology of the case studies

After the completion of the survey instrument, the consolidated conceptual framework is applied to three case studies. This third level of evaluation is primarily implemented to highlight the applicability and versatility of the developed conceptual framework with respect to real-world healthcare TT ventures completed in SSA. Multiple literature items also strongly encourage the joint implementation of semi-structured interviews and case studies as these qualitative validation methods directly complement each other (Bassioni *et al.*, 2005; Meso *et al.*, 2005; Sekaran *et al.*, 2016). In turn, researchers develop a deeper and more concrete level of scientific validation for their research (Bassioni *et al.*, 2005; Barthel *et al.*, 2008).

Figure 2-10 illustrates the 6 steps in conducting a case study and represents the overarching research methodology utilised to complete the three case study applications. The complete research methodology of the case studies is shown in Section 6.2.3 with the results presented in Section 6.5.

Steps for case study application	1. Selection of case study type
	2. Selection of retrospective or prospective case study
	3. State the exclusion criteria
	4. Evaluate case study independence
	5. Conduct case study interviews
	6. Case study application

Figure 2-10 - Case study application guidelines (California State University, 2015)

Three illustrative and retrospective case studies are chosen (California State University, 2015). Seven exclusion criteria are enforced on all three case studies to ensure their relevance to the conceptual framework's fields of TT, geographic region, primary stakeholders, timeline, social impact and co-creation presence. The final exclusion criteria aim to ensure that the case studies are independent of one another by comparing the transfer objects, stakeholders and geographic application areas.

After completing Step 3 and Step 4, the project leaders of the case studies are interviewed to determine the managerial procedures implemented during the completion of the individual healthcare TT ventures. Two project leaders are interviewed for each case study in sessions of approximately 90 minutes.

As with the survey instrument, the case study outcomes are applied to both the five individual phases of the conceptual framework as well as the nine primary foundations of the conceptual framework. After the completion of the case study application, the outcomes of all three levels of validation are consolidated into a final conceptual healthcare TT framework shown in Chapter 7.

2.7 Chapter 2: Conclusion

Chapter 2 provides a detailed summary of GT and how it has been incorporated into the systematic conceptual and comparative literature reviews. Chapter 2 also describes the Conceptual Framework Analysis as well as the eight-phased process followed to develop the proposed TT framework. Section 2.3 and Section 2.4 highlights the methodological foundations of the two systematic reviews displayed in Chapter 3 and Chapter 4 respectively. Finally, a high-level summary of the conceptual framework's evaluation procedure is outlined in Section 2.6 along with the steps completed during the completion of the semi-structured interviews, a survey instrument and three case studies.

Chapter 3. Systematic conceptual literature review of technology transfer

In Chapter 3 the systematic conceptual literature review is documented. The motivation, utility and limitations behind this review process are outlined in accordance with the systematic conceptual literature review's methodology presented in Section 2.3. The complete research methodology behind the structure of this chapter is presented in Section 3.2. The key objectives of Chapter 3 are summarised in Figure 3-1 and the purpose of Chapter 3 within this research document is shown in Table 3-1 .

Table 3-1 - The role of Chapter 3 within the research structure

<table>
<tr><th colspan="8">Document framework</th></tr>
<tr><td rowspan="2">Research objectives</td><td>i.</td><td>i. & ii.</td><td>i. & ii.</td><td>ii. & iii.</td><td>ii. & iii.</td><td>iii.</td><td>iii.</td></tr>
<tr><td></td><td colspan="3">iv.</td><td colspan="3"></td></tr>
<tr><td>Conceptual Framework Analysis phases</td><td>Map data sources</td><td>Categorise data</td><td>Identify concepts</td><td>Deconstruct concepts</td><td>Integrate concepts</td><td>Synthesis</td><td>Validate</td></tr>
<tr><td rowspan="2">Corresponding chapters</td><td colspan="2">Problem statement
Chapter 1</td><td colspan="3">Comparative literature review
Chapter 4</td><td colspan="2">TT facilitation tool
Chapter 6
Chapter 7</td></tr>
<tr><td></td><td colspan="3">Conceptual literature review
Chapter 3</td><td colspan="2">Conceptual framework
Chapter 5</td><td></td></tr>
</table>

Key outcomes

- Identification of the evolution, barriers and motivation of technology transfer
- Identification of stakeholders involved in the technology transfer process
- Highlighting best practices for involved stakeholders
- Tabling the different methods currently available for technology transfer
- Identifying linkages between knowledge transfer and technology transfer

Figure 3-1 - Key objectives of Chapter 3

3.1 Conceptual literature review: the rationale

The systematic conceptual literature review serves as the preliminary research investigation into the constructs required to realise this research study's overarching aim as well as completing research objective i. This review has been conducted to ensure that all relevant concepts have been extracted from a compiled list of literature resources. As such, the systematic conceptual literature review has not limited available literature items by utilising geographic or industry exclusion criteria in contrast to systematic comparative literature review presented in Chapter 4. The research questions of this systematic conceptual literature review are presented in provided in Table 3-2, with the data handling process utilised to complete this review presented in Section 3.2.

These research questions have been constructed in such a manner as to ensure that the systematic conceptual literature review places emphasis on critical areas required for the subsequent framework development in Chapter 5. These questions also serve to aid in achieving the outcomes of this chapter.

Table 3-2 - Systematic conceptual literature review's research questions

Research question 1:	How has TT evolved?
Research question 2:	Who are the major stakeholders in a TT venture?
Research question 3:	What are the major TT methods?
Research question 4:	Which TT models are currently being utilised?
Research question 5:	Which key components are TT models comprised of?

3.2 Research methodology: Chapter 3

Phase 1 of the Conceptual Framework Analysis calls for an all-embracing review of all available literature and data sources regarding the identified topic area (Jabareen, 2009). This process must be as extensive as possible to ensure both inclusiveness and validity (Morse *et al.*, 2002). With these aims in mind, a preliminary literature search was undertaken from which a problem statement and subsequent research objectives were derived, refer to Table 3-2.

The preliminary literature search provided a high-level overview of the topic area but to map the problem in detail a complete systematic conceptual literature review has been undertaken. Referring to the methodology described in Section 2.3, individual research questions, as shown in Table 3-2, were outlined for the conceptual literature review. While knowledge transfer and TT barriers were not directly related to the systematic conceptual literature review's research questions, their prevalence in literature sources, as well as their impact on TT, led to their inclusion as search terms.

The three-stage process of data handling was then followed, refer to Figure 2-4, in a bid to answer the five primary research questions derived for the systematic conceptual literature review. Section 3.2.1 to Section 3.2.3 describes the process that has been undertaken during the completion of the systematic conceptual literature review.

3.2.1 Data collection

Literature sources were collected from online academic databases, media publications, informal interviews and academic libraries to ensure that the GT requirement for wide-ranging literature sources has been met. Barring the interviews, all literature searches have been undertaken by method of keyword search. A summary of these keywords has been provided in Table 3-3. It is noted that each keyword listed in Table 3-3 is preceded by the word "technology" during the data collection process. Table 3-4 summarises the various individual sources of the data collection process by category. The academic libraries of the universities of Stellenbosch and Singapore are screened due to their proximity to the primary researcher's personal accommodation. Grey literature sources primarily include medical research articles and news publications which have not been peer-reviewed.

Table 3-3 - Keyword search terms for the systematic conceptual literature review

Topic area	Keywords	Results presented in
Technology transfer	Transfer, stakeholders, conceptual framework, barriers, knowledge transfer	Section 3.3

Table 3-4 - Systematic conceptual literature review's sources of data collection

Online academic data bases	Media publications	Informal interviews	Academic libraries
Google Scholar **Scopus** **Emerald**	Various grey literature sources	University academic staff Private sector employees	Stellenbosch University National University of Singapore

3.2.2 Data selection

All literature items uncovered during the data collection phase were subject to basic exclusion criteria. If a literature item did not adhere to one or more of the criteria, it was removed from the data pool. The exclusion criteria have been summarised in Figure 3-2.

Exclusion criteria		
Language	**Availability**	**Foundation**
All items not published in English were excluded.	If a literature item was not freely available, it was not included. Thus paid for journal articles are not included.	Literature items uncovered during data collection with insubstantial foundations with respect to a topic area were excluded.

Figure 3-2 - Systematic conceptual literature review's data exclusion criteria

3.2.3 Data analysis

This section provides an overview of the five stages of data analysis performed during the completion of the systematic conceptual literature review. The literature sources remaining after the data collection and data selection stages were then deconstructed using the methodology outlined in Figure 2-5.

Stage 1 - Familiarisation

Stage 1 has been completed through a consistent analysis of the database produced by the data selection phase in Section 3.2.2. Each research item was appraised and a resulting list was constructed of each recurring theme per topic area. This list is presented in Table 3-5.

Table 3-5 - Recurring themes uncovered during the familiarisation stage of data analysis

Topic area	Recurring themes
Technology transfer	Stakeholders Variety of TT methods available TT barriers TT as knowledge transfer TT models

Stage 2 - Identifying a thematic framework

With Stage 2 of the data analysis methodology aiming to combine the results of Stage 1 with the primary research questions defined in Table 3-2, a detailed index of each key construct has been developed. The deconstruction of each concept, shown in Table 3-6, allows for manageable pools of information to be accessed and scrutinised during the latter stages of the data analysis process.

Table 3-6 - Thematic framework concepts identified during data analysis

Topic area	Recurring themes	Thematic framework concepts
Technology transfer	Stakeholders	- Domestic governments, universities, technology transfer offices - Foreign universities and multi-nationals
	TT methods	- Traditional transfer - Foreign direct investments - Joint ventures and free trade - Intellectual property and licensing
	TT barriers	- Infrastructure related barriers - Inherent technology barriers - Policy barriers - Cultural and social barriers
	Knowledge transfer	- Explicit knowledge - Implicit knowledge - Facilitation of knowledge transfer
	TT models	- Scientific discovery models - Commercialisation models - Knowledge transfer models

Stage 3 - Indexing

Each topic area, recurring theme and thematic framework concept, referred to in Table 3-6, has been assigned a numerical number in accordance with the methodology described in Section 2.3. The numerical values for the topic area of TT have been summarised in Table 3-7.

Table 3-7 - Numerical values assigned to technology transfer's topic area

Topic area	Recurring themes	Thematic framework concepts	Numerical values		
Technology transfer	Stakeholders	Domestic governments, universities, technology transfer offices	T1	T1.1	T1.1.1
		Foreign universities and multinationals			T1.1.2
	TT methods	Traditional transfer		T1.2	T1.2.1
		Foreign direct investments			T1.2.2
		Joint ventures and free trade			T1.2.3
		Intellectual property and licensing			T1.2.4
	TT barriers	Infrastructure related barriers		T1.3	T1.3.1
		Inherent technology barriers			T1.3.2
		Policy barriers			T1.3.3
	Knowledge transfer	Explicit knowledge		T1.4	T1.4.1
		Implicit knowledge			T1.4.2
		Facilitation of knowledge transfer			T1.4.3
	TT models	Scientific discovery models		T1.5	T1.5.1
		Commercialisation models			T1.5.2
		Knowledge transfer models			T1.5.3

Table 3-8 provides an abridged example of how five literature items have been assigned numerical values. This aims to provide an illustration of how the data has been codified for subsequent qualitative analysis. In total, 95 literature items are codified in this manner during the completion of the systematic conceptual literature review. This process was completed with the aid of Atlas.Ti, a software program design to facilitate the codification of large quantities of data into practical clusters (ATLAS.ti, 2018).

Table 3-8 - Abridged numerical coding example

Literature item	Numerical coding
Ann et al. 2008	T1.1; T1.2.1; T1.2.3; T1.2.4; T1.3.2; T1.4
Bozeman 2000	T1.1; T1.2; T1.3; T1.4; T1.5.2; T1.5.3
Golob 2006	T1.1; T1.2.3; T1.2.4;
Handoko et al. 2016	T1.1; T1.3.3; T1.4; T1.5.3
Hoekman & Javorcik 2006	T1.1; T1.2.2; T1.2.3; T1.3.1; T1.3.3; T1.4

Stage 4 - Charting

After the completion of the indexing stage, the data had been codified in such a manner that literature statements, both complimentary and contradictory, could be combined into summarised charts. These charts allow for subsequent conclusions to be drawn that had been substantiated by academic literature items collected during the systematic conceptual literature review. An example of a chart created from the codified literature items is Table 3-9 in Section 3.3.1, illustrating the evolution of TT paradigms.

Stage 5 - Mapping and interpretation

The results of the systematic conceptual literature review have been outlined in Section 3.3 and subsequently in the final synthesis of both literature reviews utilised to construct the conceptual TT framework. The mapping and interpretation of the systematic conceptual literature review has been presented alongside the synthesis of the systematic comparative literature review in the construction of the conceptual framework, presented in Chapter 5.

3.3 Technology transfer

This section presents the data results obtained from the systematic conceptual literature review and has been structured in accordance with the research questions that have been outlined for this literature review, refer to Table 3-2. As such, Section 3.3 outlines the process of TT, universal TT stakeholders, available TT methods and models, the influence of knowledge transfer and common TT barriers. As an introduction to TT, Section 3.3.1 attempts to outline the history and evolution of TT by illustrating the growth in available TT methods and their respective origins.

The fundamentals of the TT methods of traditional transfer, joint ventures, foreign direct investments (FDIs), licensing agreements, free trade and technology transfer offices (TTOs) have all been outlined in Section 3.3.4 with Section 3.3.1 merely focussing on how these respective methods influenced the various paradigm shifts within TT. A summary of the major TT paradigms and their respective characteristics are provided in Table 3-9.

3.3.1 Introduction and examples of TT throughout history

The first scientifically documented case of TT in history (Jeremy, 1991) regards the European textile industry's expansion in the 17th century, with silkworms and silk weavers transferred from Asia to various European countries. This could be argued to constitute the first known case of a country-to-country level traditional TT (Jeremy, 1991). Despite historical examples, the concept of *"technology transfer"* had only been explicitly defined in the middle of 19th century.

An initial TT case being reviewed in recognised academic literature pertains to TT's potential advantages in aiding sustainable economic development (Gerschenkron, 1962). This paper attempted to illustrate how modern technologies could be diffused on a national and international level, with a section dedicated to the analysis of governments' capability to adapt foreign technology to their domestic environment (Gerschenkron, 1962). Thus, it may be argued that this paper makes one of the first formal references to the method of traditional TT.

Before 1950, the Soviet Union, United States, Germany and Japan all relied on import substitution to push capital into their local economies (Shamsavari, 2006). Import substitution refers to substituting an imported product with one that has been locally produced and greatly limits all forms of TT bar traditional transfer (Brown, 1979; Shamsavari, 2006). Japan mandated this policy across all industry sectors to ensure independence from Western colonisation (Shamsavari, 2006). Historical examples exist of technologically independent, yet successful countries, such as the Soviet Union, Japan and Britain in the 19th century. However, none of these closed economic models allowed for long-term sustainable technological independence (Shamsavari, 2006).

In the early 1980s instances of traditional TT were frequently implemented and consisted of TT between domestic firms within a country (Shamsavari, 2006). These early models of traditional TT were extremely vaguely defined, merely following a linear transfer process to transfer an isolated physical artefact (Shamsavari *et al.*, 2002). These TTs often had a restricted scope, only focussing on the first TT paradigm's goals of economic and social gain (Connell *et al.*, 2007). When compared to modern-day TT, these early stages of traditional TT hardly obtain the basic features considered important for successful TT in modern times

(Shamsavari, 2006). Early examples of traditional TT were also restricted to the firm level, with country-level TT not readily occurring until the late 19th century (Shamsavari, 2006).

Despite Japan's various attempts to remain independent, the Japanese were one of the first countries to utilise licensing. This method of TT was incorporated within their engineering and consumer goods sectors and although licensing only occurred on a firm-to-firm level it constitutes one of the initial examples of the practice (Stewart, 1978).

Although licensing was starting to develop in Japan, Western civilisations had different demands. The influx of personal wealth in the post-war era resulted in an increase in expectations and consumerism. Thus, the demand for quality consumer products increased market competition and made licensing an unattractive method of TT (Auerbach, 1988). The promotion of free economies and international trade that resulted from Western consumerism instigated a shift in the TT paradigm from economic and social gain toward globalisation (Auerbach, 1988; Buse *et al.*, 2000).

Traditional transfer and licensing, restricted to within Japan, had been the dominating TT methods implemented until the 1980s as firm competitiveness and market share had been acquired from the ownership of strategic resources. However, during the 1970s firms began to realise that strategic knowledge resources started to become far more economically ubiquitous (Handoko *et al.*, 2016). This paradigm shift from globalisation to project management had been instigated from the realisation that the combination of knowledge and technology possessed the potential to generate tremendous monetary returns. Traditional factors of production such as the ownership of natural resources, human labour and land resulted in diminished marginal returns in comparison with technology creation, management and utilisation (Handoko *et al.*, 2016).

The increased implementation of FDIs, joint ventures, franchising and international trade projects during the 1970s all marked a shift from previous TT archetypes with even traditional TT rapidly evolving into a more complex method (Shamsavari, 2006). The project management paradigm shift expanded the complexity of the elements and factors considered for a successful TT venture and reiterated TT beyond the isolated transfer of physical equipment (Handoko *et al.*, 2016).

A case study regarding the Egyptian automotive industry provides an example of the TT paradigm shift, as initially, primitive traditional TT was exclusively utilised. However, at the start of the 21st century, this industry has been evolved into a market export and foreign investment-based sector. While traditional TT is currently still present in this industry, it has been largely overshadowed by newer TT methods (Taha, 2002).

The use of joint ventures, patent pooling, open sourcing and shared business modelling have had an ever expanding presence since the late 20th century (Ann *et al.*, 2008). Joint ventures and international trade ventures are still commonplace today but have only been readily utilised from 1980.

An example of an initial large scale joint venture resulted from the exposure to global trade, with various Chinese coastal cities, previously subjected to extreme communism, initiating TT joint ventures with Korea and Japan (Zhang *et al.*, 2016). These joint ventures predominately utilised the previously mentioned import substitution strategy. However, they provided a channel that would later be evolved into a method of attracting FDI (Marcotte *et al.*, 2000).

The Chinese public and private sectors have had major influences on the modern-day TT method of FDI (Zhang *et al.*, 2016). After 1990, the Chinese government restructured the country's joint venture policies to abolish import substitutions and expand free trade agreements with Europe and the United States. This policy change is regarded as the catalyst which reaffirmed global market confidence, resulting in the exponential growth of FDIs (Marcotte *et al.*, 2000). Thus, the evolvement of early-stage joint ventures promoted Chinese FDI to the current situation where the country is the most prominent global foreign investor (Zhang *et al.*, 2016). While modern FDI ventures are closely managed, the inherent nature of the TT method originates from the globalisation TT paradigm (Shamsavari, 2006; Barthel *et al.*, 2008).

Another policy implementation that has served as the foundation for both the globalisation and subsequent project management TT paradigms has been the availability of international free trade (Hoekman *et al.*, 2006; Renard, 2011). A study surrounding the prevalence of international trade and R&D concluded that for country-level TT, R&D has a negligible effect when compared to the availability of free trade in north to north transmissions (Schiff *et al.*, 2013).

Although free trade policies had not been required for early TT ventures, two 20th century academic studies found that there was insubstantial evidence to conclude that a beneficial relationship existed between agreements and knowledge transferred. Firms that did not engage in international trade experienced continual growth regardless and with respect to TT, no potential beneficial factors had been identified (Clerides *et al.*, 1998; Bernard *et al.*, 1999).

This has changed significantly with a more recent study undertaken by the World Bank provided contrasting results. The study clearly highlighted a positive correlation between the export orientation of the improvement of firm-level productivity through increased investments, workforce training, input resource selection and technology use (Hallward-Driemeier *et al.*, 2002). The study also concluded that learning effects from trade interaction have typically been compounded as the firm's trade experience increases (Hallward-Driemeier *et al.*, 2002). These examples highlight how modern TT evolution has been shaped through public sector interventions and policy implementations (Hoekman *et al.*, 2006).

Literature from the early 21st century started to highlight the importance of government and university intervention with respect to TT (Hoekman *et al.*, 2006; Bozeman *et al.*, 2015). While these stakeholders had typically been involved in the previous TT paradigms, the role of TTOs, consortiums and private research centres started to become far more prevalent in TT literature (Bozeman *et al.*, 2015). Currently, few large-scale TT ventures could be successful without the support of the public sector (Bozeman *et al.*, 2015).

This has partly resulted in the creation of the latest TT paradigm, which focusses on the improvement of human capital and knowledge transfer (Ryu *et al.*, 2010). The scope of this TT paradigm strongly correlates with a typical public sector agenda (Zhang *et al.*, 2016). The Chinese government's attempts to facilitate industrialisation by importing foreign knowledge and personnel serve as a recent example of this TT paradigm (Zhang *et al.*, 2016). This example also highlights how modern TT, in contrast to previous paradigms, prioritises knowledge transfer over hardware transfer (Zhang *et al.*, 2016).

The increased presence of university and government supervision in literature has been partly attributed to the inception of the Patent and Trademark Act Amendments in the United States. This act, also known as the Bayh-Dole Act, grants ownerships of technology that has been created by a university to the university rather than previous state ownership. Thus, universities were allowed to generate revenue from their patents through royalties and the licensing of intellectual property (IP) (Golob, 2006).

In the North American context, the inception of this act gradually allowed the growth of TT programs through increased university output, the inception of new TTOs and additional government policies focussed on reinforcing local and international TT ventures (Metcalfe, 1994; Golob, 2006). Public to private TT ventures became common as public universities and research facilities attempted to maximise their revenue by engaging in licensing agreements with multi-nationals (Metcalfe, 1994; Jaffe *et al.*, 2001; Berman, 2002).

Case in point, Columbia Innovation Enterprise, a TTO established specifically for Columbia University's TT activities, was founded two years after the inauguration of the Bayh-Dole Act. In 2010 this institution represented the largest TTO in the United States, annually producing 150 million dollars of revenue (Golob, 2006). This TTO also serves as an example of the potential benefits of promoting human knowledge capital in a TT venture (Pressman, 2002; Golob, 2006).

There has been a direct correlation between the evolution of TT and the resulting structure of the TTO (Golob, 2006). When TTOs had first been commissioned in 1980, these stakeholders were predominately focussed on the acquisition of licensing agreements between public universities and large private corporations (Berman, 2002). Early TTOs provided no assistance to start-up companies and the promotion of public and private research collaborations was rarely prioritised (Berman, 2002). The primary motivation for the commissioning of the initial TTOs had been obtaining a substantial return on investment with other activities deemed to be economically ineffective (Berman, 2002; Golob, 2006).

However, while licensing agreements are far less prevalent in current TT paradigms, they have served as a catalyst in the evolution of TTOs (Ryu *et al.*, 2010). The high licensing revenues obtained from the initial TTOs resulted in widespread exposure. Thus governments, university officials, public and non-profit sectors all better understood the correlation between a TTO and local economic development (Golob, 2006; Ryu *et al.*, 2010). The additional marketing exposure resulted in increased official support for TTOs, which enabled TTOs to widen their scope from licensing agreements towards comprehensive assistance for technology-based start-ups and spin-offs (Golob, 2006). Thus, by evolving a TTO from a purely economic tool into a comprehensive TT stakeholder, it reinforced the TT paradigm that prioritised the transfer of knowledge and the improvement of human capital (Ryu *et al.*, 2010).

To answer research question 1 of the systematic conceptual literature review, refer to Table 3-2, all the TT paradigms examined in Section 3.3.1, have been summarised in Table 3-9. The primary characteristics of each paradigm have also been provided. It is important to note that these paradigms do not directly relate to a particular historical time frame.

While the human knowledge capital paradigm is more prevalent in current day TT ventures, TT that adheres to economic and social gain characteristics are also still present (Meso *et al.*, 2009). Thus, all the TT paradigms presented in Table 3-9are presently still being utilised to varying degrees.

Table 3-9 - Technology transfer paradigms

TT paradigms	Core values of paradigm	References
Economic and social gain	- Linear transfer - TT process was elementary with a transferee acquiring and implementing a foreign technology - No concrete feedback between transferor and transferee - Traditional transfer has primarily been utilised to facilitate technology transfer	Connell et al., 2007 Ssewanyana & Busler, 2007 Meso et al., 2009
Globalisation	- Dominated by the transferor in terms of will, funding and decision making - Foreign markets provide new investment opportunities that result in monetary, knowledge and infrastructure flows across borders - Governments become primary stakeholders in the transfer process - FDIs, licensing and spill-overs are utilised to facilitate technology transfer	Buse & Walt, 2000 Boateng & Glaister, 2002 Alden & Davies, 2006
Project management and collaboration	- Partnerships and alignment of stakeholder's objectives are prioritised - Equal input from both transferor and transferee - Explicit supervisors have been assigned with feedback protocols in place between all levels of stakeholders - Joint ventures and, to a lesser extent, TTOs are utilised to facilitate technology transfer	El Ansari & Phillips, 2001 Heeks, 2002 Latourette et al., 2011
Human knowledge capital	- Main goal is not to facilitate physical artefacts but to instil knowledge of how to obtain, build, maintain, redesign and modify both existing and new technologies - Focus on human capability building and often results in new IP - TTOs and start-ups are utilised to facilitate technology transfer	Musa et al., 2005 Bagayoko et al., 2006 Fuchs & Horak, 2008

3.3.2 Defining and outlining of technology transfer

From the offset, it is important to clarify that the *transferor* refers to the entity that is transferring the technology, or *transfer object*, and that the *transferee* is the recipient of the transfer object (Bozeman, 2000; Jesse *et al.*, 2010; Bozeman *et al.*, 2015). TT can be construed as the movement or transmission of a technology from a transferor to a transferee or from one location to another (Smith, 1979). Alternatively, TT could refer to nothing more than the transferor explaining a relatively straightforward process to the transferee. TT has also been defined as the application of new technical ideas into existing products (Mazurowski, 2006).

The United Nations Centre for Transnational Corporation defines TT as the process of progressing through the three stages of introduction, adoption and integration (Teece, 1977), three stages which are still categorically prevalent today (Bozeman *et al.*, 2015). An exposition of the three phases through which each TT venture progresses has been provided in Table 3-10.

Table 3-10 - Three phases of technology transfer

Phases	Description
Introduction	Introduction refers to the process of the transferee being exposed to the new technology (Teece, 1977). This introduction is typically done by the transferor but exposure may come from a variety of sources (Bozeman *et al.*, 2015).
Adoption	Adoption is a process that requires the transferee to guarantee that the technology will be appropriate for its intended purpose. This process involves some form of modification or refinement in order to facilitate the technology into an existing system, as it would not be able to function had it been left unchanged (Handoko *et al.*, 2016). In some cases, these modifications are very subtle, whereas in others the final item bares only a few core similarities with the original technology. This is due to the environment in which the transferee operates in as it may be dissimilar from the corresponding environment of the transferor (Handoko *et al.*, 2016).
Integration	Integration, also sometimes referred to as absorption, is the final stage of any TT venture. There are many definitions of integration in literature but a common explanation argues that integration has only occurred when the transferee has been utilising the technology to a similar or greater extent than the transferor (Shamsavari *et al.*, 2002). "Utilising" must not be associated with scale but rather with the level of knowledge possessed regarding the technology (Becerra-Fernandez *et al.*, 2003). Another definition pronounces that a technology can only be regarded as integrated when it has been completely adopted and absorbed by the transferee without any outside assistance (Shamsavari, 2006). Integration, however, tends to be a complex process and necessitates some form of technological diffusion into the transferee's domestic environment (Chandra, 2006).

As TT is labour intensive, complex, dynamic, continually evolving and has a certain degree of associated risk there is an inherent need for experienced and knowledgeable individuals to drive the process (McAdam *et al.*, 2005; DeVol *et al.*, 2006). Due to the TT's intrinsic requirements of R&D and innovation, it occurs mostly in developed countries with sufficient financial backing and research facilities (Hoekman *et al.*, 2006).

Developing countries tend to be more reliant on imported TT to further their own technology development but this is not to say that no R&D occurs in developing countries (Hoekman *et al.*, 2006). Developing countries generally attempt to modify these imported technologies, resulting in local R&D, primarily through "reverse engineering". This modification process is conducted to promote successful adoption and ultimately integrate the technology into the local systems of the transferee country (Hoekman *et al.*, 2006). These modifications form the base of the adoption, also referred to as the adaptation stage of TT (Jesse *et al.*, 2010).

Thus, a key element of TT is the capability of the transferee to adopt and incorporate the given technology as ‘‘inventions rarely exist in isolation. No matter how clever the idea or great the implementation, an invention typically lives or dies depending on how well it can be integrated into a large social and technological context.’’ (Schwartz, 2004). If the transferee's organisational structure is not receptive to new technology imports, the likelihood of successful adoption greatly diminishes (Mazurowski, 2006). This becomes even more prevalent when some form of modification is required, which is generally the case (Handoko *et al.*, 2016).

The most critical interpretation that must be comprehended with regards to modern-day TT is that the word “technology” can be in many ways substituted with the term “knowledge” (Ann *et al.*, 2008). TT entails transferring an understanding, concept, instructions and knowledge on not only the physical artefact (Hoekman *et al.*, 2006)

There is thus an inherent difficulty in accurately defining TT due to the fact that physical hardware becomes less important when compared with the knowledge required to operate it (Shamsavari, 2006; Ann *et al.*, 2008). The concept of TT in terms of knowledge transfer has been expanded upon in Section 3.3.5.

Due to the complex nature of TT, a high number of yardsticks can be utilised to determine the relative success or failure of a TT enterprise. The Association of University Technology Managers (AUTM) has outlined the following key variables to be used in both their and other studies on the evaluation of TT ventures. These variables are updated each year in the AUTM annual survey and include (Ann *et al.*, 2008):

- Research expenditures per institution;
- New invention disclosures’
- Number of patent applications filed, and number of licenses granted per fiscal year; and
- Licenses ad options executed, and gross income earned on executed licenses.

In the early years of the AUTM, the variables and data utilised were only from public university sources. However, as TT has blossomed the surveys now incorporate company and private research centres’ data as well (Ann *et al.*, 2008). As TT has evolved a new metric has been created to measure how well knowledge access has been achieved (Ann *et al.*, 2008; Handoko *et al.*, 2016). Apart from the AUTM, a variety of TT models exist, with select models identified in Section 3.3.7.

Building on the concepts of *transferor* and *transferee,* it is important to note that these entities can take a variety of forms depending on the TT venture in question. If both entities are companies in a domestic market, then firm-to-firm level TT has taken place (Golob, 2006). Similarly, if both entities are governments, then country-to-country level TT has occurred (Bottazzi *et al.*, 2003). The third variant is firm-to-country level TT (Arnold *et al.*, 2005). There is also the distinction of private-to-private, which typically involves firm-to-firm level TT, and public-to-private TT. Public-to-private TT accounts for the bulk of all TT activities and involves technological diffusion from public research centres and universities into the private sector (Ryu *et al.*, 2010).

It is important to note that the word "transfer" immediately differentiates the process of TT from the purchasing and trade of goods and services. Thus, TT must be subject to different sets of laws and policies in order to accommodate "controlled" facilitation of TT over national borders (Shamsavari, 2006). Various literature items conclude that it primarily becomes the responsibility of the government to initiate the TT process and technology imports from abroad (Bozeman, 2000; Carlsson *et al.*, 2002; Chakroun, 2012). The stakeholders that are archetypally omnipresent in TT ventures have been expanded upon in Section 3.3.3.

There are a variety of different methods that have been consistently utilised to facilitate TT. Some examples include FDIs, joint ventures, licensing, IP and traditional transfer. Each of these methods have distinctive characteristics and has been expanded upon in Section 3.3.4.

3.3.3 Key universal stakeholders and their responsibilities

TT is typically only successful if all the relevant stakeholders are actively involved and thus there must be continual participation from both the transferor and the transferee (Mazurowski, 2006). This has been proven as the TT process can be observed in the rate of technological diffusion of the parent company, the process of manufacturing and in the technology itself (Mazurowski, 2006).

While governments, universities and other research facilities are viewed as key stakeholders in the TT process, until recently, their specific roles were largely vague and unorganized (Mazurowski, 2006; Ryu *et al.*, 2010). Literature stresses that as TT evolves so must the policies set forth which regulate TT stakeholders (Ryu *et al.*, 2010; Zhang *et al.*, 2016). These legal aspects of TT have been expanded upon in Section 3.3.6.

Figure 3-3 presents the major stakeholders and provides a concise explanation of their main responsibilities. Figure 3-3 presents a summary of the omnipresent TT stakeholders and serves to answer research question 2, shown in Table 3-2.

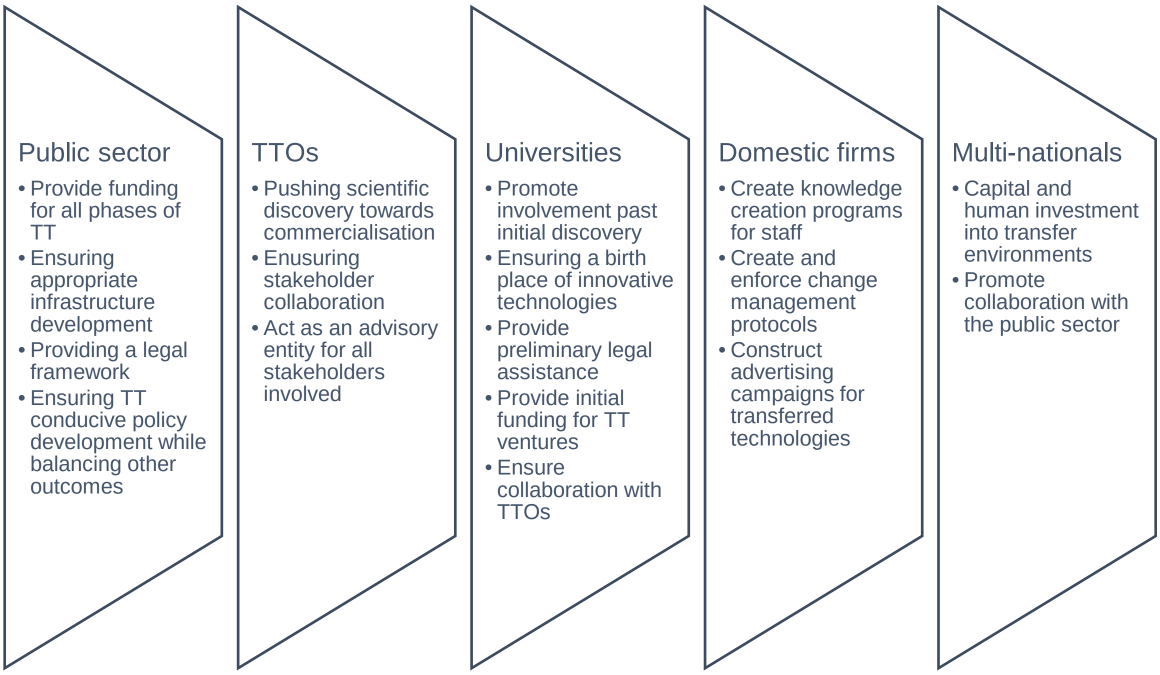

Figure 3-3 - Omnipresent technology transfer stakeholders and their roles

3.3.3.1 The public sector

Governments can regulate TT through both policy application and capital investment (Hoekman *et al.*, 2006; Link *et al.*, 2016). Investment refers to the provision and maintenance of both hard and soft infrastructure. Examples of policy regulation include subsidies for technological innovations and the protection of IP rights (Link *et al.*, 2016). The public sector's most commanding policy instrument has however been domestic and international trade regulations (Hoekman *et al.*, 2006). The effects of various public-sector policy implementations have been outlined in Section 3.3.6.4.

In terms of international trade policy, trade quotas, tariffs, taxes and general regulation form part of the tools utilised to manage the frequency and scale of TT occurrence (Hoekman *et al.*, 2006; Schiff *et al.*, 2013). An extreme regulatory example is North-Korea which possesses a restricted capacity for international technology diffusion as their economic market does not allow for free trade in global markets (Kihl *et al.*, 2014). Countries with free trade policies increase their capacity to absorb the maximum amount of international technology diffusion and integration (Koefoed *et al.*, 2008; Chakroun, 2012). This results from the capacity to attract FDIs and joint ventures, both of which are vital for stimulating economic growth (Hoekman *et al.*, 2006).

While a completely free trade platform may be favourable to FDIs and other TT projects, it is not necessarily exclusively advantageous to the welfare of domestic firms and local economies (Hoekman *et al.*, 2006). Literature does, however, argue that in some instances symbiotic relationships can occur. A widespread example being a FDI reinforced through domestic product and service sourcing as this limits economic pitfalls (Hoekman *et al.*, 2006; Piros *et al.*, 2013). Thus, policies interventions that facilitate free trade while inextricably enforcing stakeholders to utilise local resources are recommended (Hoekman *et al.*, 2006).

However, the mitigation of pitfalls in individual cases is overshadowed by the reality that international trade policy outcomes must encompass all economic activity (Piros *et al.*, 2013). A subset being the responsibility to ensure currency protection by controlling the influx of foreign currency, a direct result of multiple TT methods. Depending on various factors, foreign currency acquisition can have a detrimental effect on the protection of foreign exchange rates and a country's trade balance (Piros *et al.*, 2013).

Due to this intricate balance, literature sources argue the public sector should partly delegate decision making power to enable academic and research institutions to achieve further advancements (Ann *et al.*, 2008). This wave originated in the USA during the 1980s through the signing of the Bayh-Dole Act which transferred ownership of research inventions from government to the academic institutions from which they originated (Ann *et al.*, 2008; Swamidass *et al.*, 2009).

However, governments have been reluctant to cede power as the policy supervision of patents and IP for university TT has the potential for a large impact on stimulating domestic economic growth and increasing social welfare (Link *et al.*, 2016). Explicit statements from multiple literature sources thus conclude that, in terms of TT, the public sector faces an extensive balancing act between different policy outcomes to promote TT while adhering to other economic and social responsibilities (Hoekman *et al.*, 2006; Ann *et al.*, 2008; Piros *et al.*, 2013; Schut *et al.*, 2014; Link *et al.*, 2016; Zhang *et al.*, 2016)

3.3.3.2 Technology transfer offices

The TTO is a unique entity in this research document as it has been classified as both a TT stakeholder as well as an individual method for TT facilitation. As TTOs possess significant characteristics of both classifications, it has been investigated from both perspectives to adhere to the conceptual literature review's overarching aim of complete TT elucidation. It must be noted that TTOs are exclusively involved in university-based TT and rarely feature in other forms of TT ventures (Ryu *et al.*, 2010). This section aims to expose TTOs as a primary stakeholder to TT with Section 3.3.4 focussing on TTO as a method of TT.

TTO originated from the inherent infrastructure components required to create a conducive TT environment (Anderson *et al.*, 2007). Various literature sources, as identified in Section 3.3.3, argue that the required infrastructure can only be realised through direct government intervention (Shamsavari, 2006; Ryu *et al.*, 2010). To this extent, multiple governments have issued regulation that mandates any publicly funded research institution to establish a TTO (Anderson *et al.*, 2007). Select literature sources explicitly categorise TTOs as soft infrastructure (Siegel *et al.*, 2004; Anderson *et al.*, 2007) while others view TTOs as TT stakeholders (Ryu *et al.*, 2010).

Regardless of classification, a TTO's primary goal is the evolution of a scientific discovery into a commercially viable product or service with literature suggesting that TTOs hold as much stakeholder influence as the creators themselves (Ryu *et al.*, 2010).

Figure 3-4 presents an abridged version of university-based TT while clearly illustrating the barrier between a developed technology and its commercial success. It is thus the primary goal of any TTO to navigate a TT venture through this boundary (Rogers *et al.*, 2001; Ryu *et al.*, 2010).

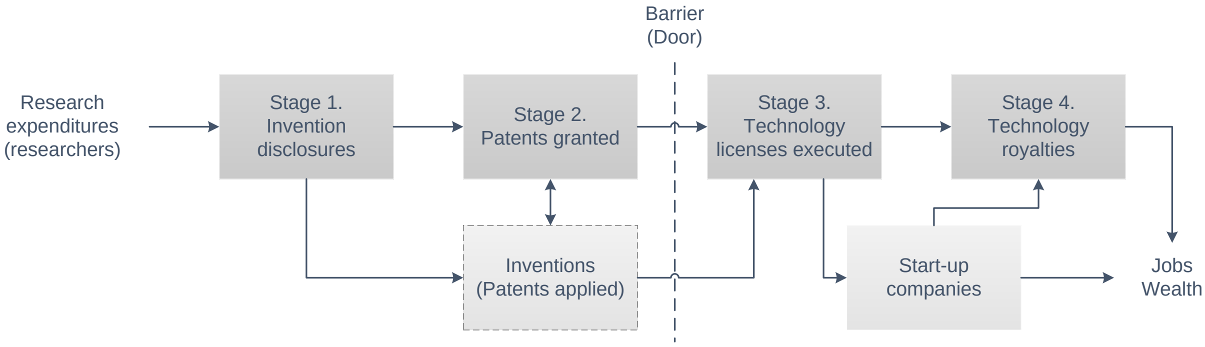

Figure 3-4 - Technology transfer process (redrawn from Ryu *et al.*, 2010)

The primary tasks of TTOs consist of patent management, technology appraisals, technology marketing, licensing and post contract activities emphasising profit maximisation (Ryu *et al.*, 2010). To aid with these tasks, different TTO's often collaborate among each other to combine personnel experience and enable increased exposure to commercial markets (Ryu *et al.*, 2010). A technology transfer consortium is an affiliation of two or more public research institutes that participate in cooperative technology transfer activities with the objective of facilitating technology transfer processes (Ryu *et al.*, 2010; Bozeman *et al.*, 2015).

The establishment of consortiums is often encouraged with a Korean case study concluding that fledgling TTOs which possess limited staff and knowledge will greatly benefit from a consortium as this enables access to existing experience (Rogers *et al.*, 2001; Ryu *et al.*, 2010). This consortia approach allows smaller research institutions to obtain leverage from the knowledge pooling effect which, referring to

Figure 3-4, increases the potential for progression through the commercialisation barrier. An additional benefit occurs as a segmented TTOs network with multiple incomplete technologies holds less appeal to technology buyers than an integrated consortium (Ryu *et al.*, 2010; Bozeman *et al.*, 2015).

Two independent empirical studies regarding TTOs and consortiums explicitly highlighted the beneficial influence of these organisations on a country's TT operations. Both studies determined that the inclusion of TTOs provided statistically significant growth in research staff, patent commercialisation and public and private benefactors (Rogers *et al.*, 2001; Carlsson *et al.*, 2002). Thus, the implementation of TTOs and consortia has resulted in a substantial increase of publicly developed technology commercialisation (Ryu *et al.*, 2010; Link *et al.*, 2016). A further conclusion highlighted the requirement for TTO staff to be incentivised as they strengthen the nurturing of entrepreneurial activities (Carlsson *et al.*, 2002; Ryu *et al.*, 2010).

Consortiums function with various scales with regards to total number of staff, geographic reach and funding. While a limited amount of consortiums are non-profit organisations, the majority are self-governed and sponsored either directly from government or through other public channels (Ryu *et al.*, 2010). A survey focussed on capturing the insights of TTO staff concluded that a positive correlation exists between a TTO's monetary return and the consortium's age, the size of universities' research budget and the amount of TTO staff in operation (Stevens, 2005).

Although TTOs and consortiums are influential stakeholders in the TT process, it must be noted that they are not always possible, refer to Section 3.3.6.5. TTOs require a minimum legal base such as the Bayh-Dole Act which is not universally present (Bozeman, 2000). Thus, factors such as the legal environment, ownership of inventions and the transfer thereof, government support, funding, trade policies and the age of TTOs all contribute to the feasibility of TTOs and subsequent consortiums (Maredia *et al.*, 2000).

3.3.3.3 Universities

With reference to stage 1 in

Figure 3-4 it is important to stress that, although private entities produce inventions and patents, the majority are produced by global public universities (Anderson *et al.*, 2007). Multiple literature sources also explicitly state the importance of universities with respect to a country's TT structure while simultaneously highlighting the universal barriers of university-based TT (Golob, 2006; Mazurowski, 2006; Swamidass *et al.*, 2009; Bozeman *et al.*, 2015).

Thus, it becomes extremely important that universities and TTOs collaborate in order for successful TT to occur (Swamidass *et al.*, 2009). Literature also strongly advocates for each university to establish its own TTO for commercialisation purposes (Mazurowski, 2006; Ryu *et al.*, 2010; Link *et al.*, 2016). As a result, it should be categorically stated that universities require TTO to enable successful TT and vice versa (Anderson *et al.*, 2007; Link *et al.*, 2016). In terms of TT stakeholders, universities should be evaluated in conjunction with their respective TTO to capture all implications.

An econometric study surrounding output-based incentives schemes concluded that the capability of a university to commercialise research discoveries through TT plays a critical part in market stimulation (Link *et al.*, 2016). As a result, literature advocates consistent university involvement during TT processes (Mazurowski, 2006; Link *et al.*, 2016). Subsequent monetary gains from TT involvement also provides an incentive for continual TT promotion among academic facilities (Golob, 2006; Mazurowski, 2006).

To this extent, multiple literature sources reference the Columbia University of Technology as the benchmark for TT promotion (Golob, 2006; Mazurowski, 2006; Anderson *et al.*, 2007). Case studies investigating the collaboration between the university and its TTO uncovered significantly higher staff levels than comparable institutes. The university's licensing income roughly equated $150 million per annum and subsequently represented 15% total income generated through university patents in the USA (AUTM, 2000; Mazurowski, 2006). The start-up companies originating from this university's patents created over 300 senior employment positions and raised $211 million in venture capital (Mazurowski, 2006). Due to the university's extensive network, it is also able to retain between 5% - 25% of the equity stakes of each start-up organisation (Golob, 2006). This example summarises the importance of collaboration between university and TTO stakeholders (Anderson *et al.*, 2007).

While Columbia University of Technology achieved success through standardised protocols, most universities have individual preferences with regards to licensing strategy and entrepreneurial assistance as a result of varying leadership styles and infrastructure availability (Link *et al.*, 2016). Despite erratic transfer environments, certain guidelines remain universally relevant. For instance, the rate at which TT spin-offs occur can be increased by promoting internal advocacy, faculty demand and venture capital ability (Mazurowski, 2006; Link *et al.*, 2016). This causal effect has been reinforced by the previous example as strong leadership parties resulted in proactive attempts to promote entrepreneurial events (Golob, 2006; Mazurowski, 2006).

Literature sources argue that future advancement of university-based TT requires shifting from traditional licensing techniques towards co-creation where start-ups and spin-off companies obtain equity shares (Mazurowski, 2006; Anderson *et al.*, 2007). Studies also indicate that faculty staff should become TT entrepreneurs as a direct correlation exists between incentivised staff and patent and licensing outputs (Mazurowski, 2006; Link *et al.*, 2016).

3.3.3.4 Domestic firms and multi-nationals

For this section, domestic firms largely correspond to the role played by the *transferee* of a TT venture. In contrast, multi-nationals largely correspond to the role played by the transferor. While both domestic firms and multi-national may potentially constitute a different form of stakeholder, literature suggests that these entities archetypally form part or the whole of the transferee and transferor respectively (Hoekman *et al.*, 2006; Shamsavari, 2006; Bartels *et al.*, 2009). Another study emphasises that the TT entrepreneurs are most likely to ensure commercial success, subsequently resulting in the creation of social and monetary wealth (Ann *et al.*, 2008). As such, the responsibilities of these entities may be viewed as the responsibilities faced by the transferee and transferor of a TT venture.

Responsibilities specifically linked with domestic firms and multi-nationals have been outlined in Figure 3-5. Domestic firms will typically be responsible for disseminating knowledge both internally and within their immediate market environment. Contrastingly, multi-nationals will often focus on larger impact areas and directly attempt to form collaborative partnerships with the public sector.

Figure 3-5 - Responsibilities of domestic firms and multi-nationals

3.3.4 Technology transfer methods

This section aims to elucidate all available methods of TT that are currently prevalent. These methods have been summarised in Figure 3-6 and an individual analysis of each method has been presented in the latter part of this section. Figure 3-6 also serves to answer research question 3, refer to Table 3-2 of the systematic conceptual literature review. The analysis of several empirical case studies revealed that specific TT methods may be used in conjunction while in other instances, a method may exhibit a detrimental effect on another (Anderson *et al.*, 2007; Link *et al.*, 2016).

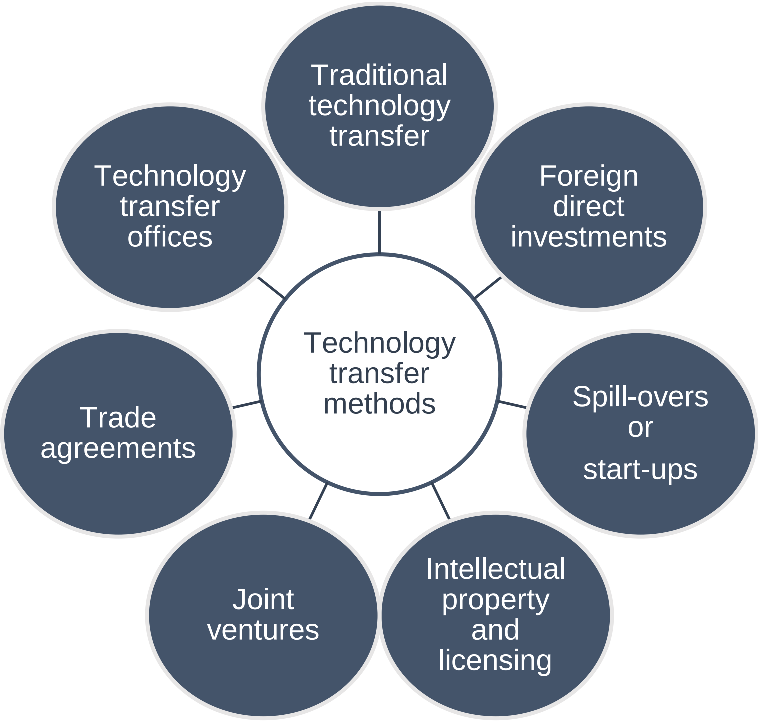

Figure 3-6 - Technology transfer methods (Hoekman *et al.*, 2006; Ryu *et al.*, 2010; Link *et al.*, 2016; Zhang *et al.*, 2016)

3.3.4.1 Traditional technology transfer

Traditional TT refers to the simplistic method where the technology is merely imported from the transferor and utilised by the transferee (Bozeman *et al.*, 2015). Simplified adoption and integration procedures, refer to Table 3-10, often occur in traditional TT (Bradley *et al.*, 2013). This method is mostly utilised for country-to-country and firm-to-firm level TT (Bozeman, 2000). Traditional transfer may provide an effective method for basic transfer objects in stable transfer environments that are resource-scarce (Bozeman, 2000).

However, as TT has evolved, this method has become largely inefficient. When compared with more modern techniques, traditional transfer lacks the required protocols to promote collaboration between involved stakeholders (Shamsavari, 2006). Literature argues that modern-day TT has shifted away from linear processes, refer to Section 3.3.1, into a more dynamic realm with active feedback and input from stakeholders (Shamsavari, 2006; Bozeman *et al.*, 2015).

3.3.4.2 Foreign direct investments

A FDI consists of foreign transferors, typically foreign governments or multi-nationals, investing human and economic resources into the transfer environment to gain access to its tangible and intangible resources (Anyanwu, 2012). FDIs require close regulation by the transferee's public regulatory body and intricate stakeholder collaboration is often mandatory (Bozeman *et al.*, 2015).

Multiple literature sources argue that FDIs are inherently conjoined with TT (Djankov *et al.*, 2000; Hoekman *et al.*, 2006; Zhang *et al.*, 2016) while others actively categorise it as a TT method (Renard, 2011; Anyanwu, 2012; Bozeman *et al.*, 2015). Regardless, a FDI enables economic growth for domestic firms through both foreign capital investment and access to a global pool of experience and information (Hoekman *et al.*, 2006; Renard, 2011). FDIs are also intertwined with the concept of knowledge transfer (Renard, 2011; Handoko *et al.*, 2016), a concept expanded upon in Section 3.3.5.

An empirical case study surrounding the Indonesian manufacturing sector highlighted the strategic advantages that were obtained by domestic firms involved in FDI's (Handoko *et al.*, 2016). Through acquisition of vital international experience, these firms enjoyed immediate improvement in strategic investments, productivity and output (Handoko *et al.*, 2016). In addition, firms engaged in a FDI are inherently restructured to ensure emphasis on imports and exports. This subsequently leads to the acquisition of supplementary knowledge and superior technology from both local and international trading partners (Arnold *et al.*, 2005).

3.3.4.3 Spill-overs

A positive spill-over, also known as a start-up, results from the process where technological information has been diffused into the local economy subsequently eliminating the technology's owner or producer's capability to monopolise the technology (Bottazzi *et al.*, 2003). Spill-overs regularly occur as a result of a FDI (Javorcik *et al.*, 2005). This causality results from imitations, trade and the movement of human capital from the transferor to the private market. This results in the technology being adopted by a variety of firms (Hoekman *et al.*, 2006).

While positive spill-overs have been praised by literature sources for their beneficial influence on a country, several argue that they may be undesirable on a firm-level as the technology's originator effectively loses control over their invention (Hoekman *et al.*, 2006; Barthel *et al.*, 2008; Bartels *et al.*, 2009). Technology originators combat this through licensing procedures which may thus be considered a deterrent to spill-overs (Maskus, 2000). Due to their association with FDIs, spill-overs are also applicable to both firm-to-country and country-to-country TT (Hoekman *et al.*, 2006).

3.3.4.4 Intellectual property and licensing

IP and licensing rights exist to provide legal protection for firms that create new technologies (Hoekman *et al.*, 2006). While limiting the complete dissemination of a technology, these legal entities allow for controlled technology diffusion especially for modern FDI ventures and international trade (Maskus, 2000; Arora *et al.*, 2004).

Literature argues that there has been a positive correlation between these protection methods and the number of FDIs initiated in a country (Hoekman *et al.*, 2006; Renard, 2011). Absence of IP rights discourages FDIs and international trade as trade secrets would not have legal protection. However, when sufficient patent protection has been present there has been a resulting increase in monetary incentives for international investors (Hoekman *et al.*, 2006). Literature sources disagree whether licensing constitutes an explicit method of TT or simply serves as a tool for other more prominent methods (Maskus, 2000; Hoekman *et al.*, 2006). Despite this, IP and licensing are prominent on an international level being applicable to firm-to-firm, firm-to-country and country-to-country TT (Ann *et al.*, 2008; Bozeman *et al.*, 2015).

3.3.4.5 Joint ventures

Joint ventures comprise of a transferor and transferee entering a collaboration aiming to either co-create or explicitly transfer a transfer object (Zhang *et al.*, 2016). These ventures may be contained within an individual country's geographic region, however, the most generic form, known as an international joint venture, unfolds over a global scale (Boateng *et al.*, 2002). Joint ventures are thus applicable to both country-to-country and firm-to-firm TT (Zhang *et al.*, 2016).

A joint venture typically originates from a transfer requirement shared between the transferor and transferee. Viewed from an economic standpoint, the transferor's requirement will be to expand products or services into a new market space or acquire new resources (Hertzfeld, 2002). A geographic example would be modern-day China where there are a potential 1.3 billion clients (Zhang *et al.*, 2016). Similarly, the transferee can utilise a joint venture as an economically efficient way to acquire advanced technology as well as substantial amounts of capital investment (Zhang *et al.*, 2016).

As identified during Section 3.3.3, various stakeholders may influence the TT process. However, when evaluating an international joint venture there are typically three primary stakeholders involved (Zhang *et al.*, 2016). These have been shown in Figure 3-7 and while case studies may contain additional third party stakeholders, their influence has always been statistically negligible when compared to the three primary stakeholders (Rebentisch *et al.*, 1995; Boateng *et al.*, 2002; Zhang *et al.*, 2016).

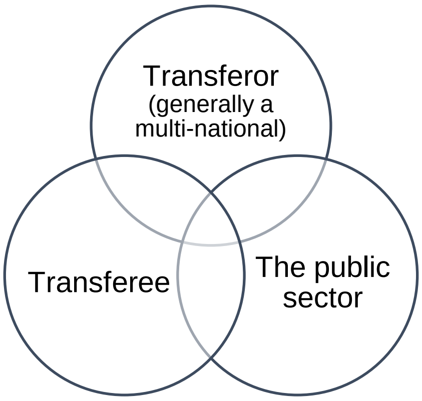

Figure 3-7 - Stakeholders of international joint ventures (author's conceptualisation)

3.3.4.6 Trade agreements

Trade agreements as a method of TT refer to the creation of "open door" trade policies, reduction of trade barriers and the trading of goods and services (Hoekman *et al.*, 2006). The public sector possesses the regulatory authority to manipulate policies to control the availability of international trade and subsequently realise both TT and other economic and social aims (Chanda, 2002).

International trade agreements possess the potential for technology diffusion, as trading of goods and services may lead to knowledge transfer (Hoekman *et al.*, 2006). Products bought will be subject to reverse engineering to gain experience, while knowledgeable buyers deliver input on product design (Alden *et al.*, 2006). This results in a symbiotic relationship where both transferee and transferor benefit (Hoekman *et al.*, 2006). This flow of knowledge has been directly related to the implicit knowledge construct elucidated in Section 3.3.5.2.

A Chinese case study regarding free trade serves as a predominate instance of the effects of free trade on TT. An "open door" policy, introduced in 1979, greatly increased the country's technology absorption which enabled the country to become a global technological superpower (Hoekman *et al.*, 2006). Literature argues that this is a direct result of free trade policies, with the vast import of capital goods and receipt of FDIs enabling rapid technological expansion (Marcotte *et al.*, 2000; Hoekman *et al.*, 2006; Renard, 2011). This case study indicates that trade agreements are applicable for country-to-country, firm-to-firm and firm-to-country TT and that they have routinely been utilised in conjunction with other methods of TT such as FDIs and joint ventures (Hoekman *et al.*, 2006).

3.3.4.7 Technology transfer offices

Section 3.3.3 investigates TTOs from a stakeholder perspective and provides an elucidation of all major TTO components. However, it has also been included as a method of TT as select literature articles indicate that universities may utilise a TTO as a TT complete package (Siegel *et al.*, 2004; Swamidass *et al.*, 2009). It must be noted that the difference in classification may be subtle and in most cases negligible (Bozeman *et al.*, 2015).

The most significant variation results from the lack of collaboration that occurs between TTO and university with the latter effectively using the TTO as a tool to evolve a scientific discovery into a commercialised entity. Thus, the university views the TTO as a value-adding machine rather than a stakeholder. TTOs are conducive to firm-to-firm and firm-to-country TT while being explicitly utilised for public to private TTs (Ryu *et al.*, 2010).

3.3.4.8 TT stakeholders and methods

Table 3-11 aims to provide a summary of Section 3.3.3 and Section 3.3.4 by highlighting the TT methods most frequently implemented by each TT stakeholder. However, it must be noted that Table 3-11 is in no means exhaustive or universally true as instances occur where different stakeholders implement different TT methods based on the unique settings of individual TT ventures, but it is however considered representative of the general findings of the literature items utilised during the completion of the systematic conceptual literature review.

Table 3-11 - Technology transfer methods favoured by stakeholders

		Stakeholders				
		Public sector	TTOs	Universities	Domestic firms	Multi-nationals
Methods	Traditional	x	x	x	x	x
	FDI	x				x
	Spill-overs	x	x	x	x	
	IP and licensing	x	x	x	x	x
	Joint ventures	x	x	x	x	x
	Trade agreements	x				x
	TTOs	x	x	x	x	x

3.3.5 Knowledge transfer and its influence on technology transfer

Knowledge has a significant impact on any form of TT, with most TT ventures largely dependent on some form of knowledge transfer (Handoko *et al.*, 2016). As stated in Section 3.3.2, TT may be defined as the exchange of data, experience and information between an entity that possesses it and one that does not (Hoekman *et al.*, 2006). This results from technology's inherent complexity as the knowledge transfer surrounding manufacturing, utilisation and product refinement then holds greater value than the transfer of the technology artefact itself (Hoekman *et al.*, 2006). Thus, successful TT cannot be insulated from knowledge transfer (Shamsavari, 2006).

Knowledge has been defined as a fluid mix of personal experiences, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences information (Davenport *et al.*, 1998). However, when referring to TT, knowledge has been classified into the two distinct categories of explicit and implicit knowledge (Gorman, 2002). The manner in which these categories have been conflated into TT ventures will have a critical impact on the outcome of a TT's success or failure (Gorman, 2002; Handoko *et al.*, 2016).

A study analysing the influence of knowledge in a TT venture concluded that although a combination of explicit and implicit knowledge may be present, one form will predominantly become the dominating form of knowledge transfer (Gorman, 2002). Explicit and implicit knowledge have been outlined in Section 3.3.5.1 and Section 3.3.5.2.

3.3.5.1 Explicit knowledge

Explicit knowledge, also known as codified knowledge, has been defined as instructions or information presented on a page, both digital and hardcopy, or via a recording allowing for a conducive learning set (Mohr *et al.*, 2002; Nygaard *et al.*, 2013). Examples of explicit knowledge include specifications, manuals, drawings, written instructions, procedures, statistical data and design standards (Marcotte *et al.*, 2000; Mohr *et al.*, 2002; Handoko *et al.*, 2016).

Thus, the process through which an experienced party transfers their knowledge and expertise onto a written document serves as an example of codification. These texts or illustrations may, in turn, be easily understood by an inexperienced party (Marcotte *et al.*, 2000). In TT ventures where the technology has been founded upon a factual and systematic process, explicit knowledge becomes the dominant form of knowledge transfer (Gorman, 2002).

While simpler than implicit knowledge transfer, explicit knowledge transfers have still been subject to failure. Often this results from poor transferor codification practices or misinterpretations from the transferee. (Olla *et al.*, 2006). In select instance, the transferee may have completely different methods of codification which makes successful explicit knowledge transfer improbable (Marcotte *et al.*, 2000). A basic example of different codification standards may be the utilisation of the metric system instead of the imperial system (Olla *et al.*, 2006).

Thus, when utilising explicit knowledge, the transferor and transferee must be forced into an agreement of a common language and standards (Nygaard *et al.*, 2013; Handoko *et al.*, 2016). Due to the resulting measurability that codified knowledge provides, firms and multi-nationals often promote the transfer of explicit knowledge in order to achieve effective knowledge-based

TT programs (Nonaka *et al.*, 2003). Thus, FDI TTs possessing strong elements of explicit knowledge transfer have been more likely to proceed past the introduction phase, shown in Table 3-10 (Hoekman *et al.*, 2006).

Consequently, literature portrays explicit knowledge as an efficient means of knowledge transfer as its simplicity mitigates the potential for communicational errors resulting from cultural or language barriers (Ryu *et al.*, 2010; Handoko *et al.*, 2016). An additional advantage of the simplicity of explicit knowledge is the limited amount of required contact periods between transferor and transferee. This, in turn, reduces the total transfer cost when compared to knowledge transfer facilitated through training sessions (Handoko *et al.*, 2016).

3.3.5.2 Implicit knowledge

Implicit knowledge, also known as tacit knowledge, consists of the experience, intuitions and insights of established entities (Becerra-Fernandez *et al.*, 2003). Alternatively, implicit knowledge has been defined as passive information deeply embedded in personal beliefs, attitudes, values and experiences (Popper, 1972; Nonaka *et al.*, 2003). While multiple literature sources provide similar definitions for explicit knowledge, the inherent nature of implicit knowledge results in literature providing vague and uncorrelated explanations (Bozeman, 2000; Handoko *et al.*, 2016). However, the most important difference between implicit knowledge and explicit knowledge are the increased challenges a TT venture will face when implicit knowledge has been utilised (Handoko *et al.*, 2016). In TT ventures where the embedded experience of the transferor is crucial to the operation of the technology, implicit knowledge transfer shall be the dominant form of knowledge transfer (Gorman, 2002).

Studies surrounding firm-to-firm level TT between Canada and China concluded that cultural differences had a crippling effect on the required implicit knowledge transfer (Marcotte *et al.*, 2000; Chandra, 2006). While cultural and language differences produce potential barriers to implicit knowledge transfer, literature argues that intrinsic barriers exist which are much more difficult to overcome or even define (Chandra, 2006; Handoko *et al.*, 2016). Literature has recommended that to aid implicit knowledge transfer, it must be codified before effective transfer is possible (Marcotte *et al.*, 2000; Chandra, 2006; Handoko *et al.*, 2016).

However, the problematic nature of implicit knowledge codification has been well established among literature sources, with certain tacit knowledge fragments impossible to codify or express (Bozeman *et al.*, 2015). Literature argues that these fragments can only be acquired through personal experience or involvement (Becerra-Fernandez *et al.*, 2003; Bozeman *et al.*, 2015). However, when an entity has been able to convey their personal experience through the spoken or written word, they have successfully converted implicit knowledge into explicit knowledge. This forms part of the codification process described in Section 3.3.5.1 and is a critical requirement of knowledge transfer (Handoko *et al.*, 2016). When codification becomes impossible, implicit knowledge transfer will constitute a substantial barrier towards effective TT (Handoko *et al.*, 2016).

3.3.5.3 The role of knowledge in technology transfer

This section attempts to identify how knowledge transfer has been incorporated into the three phases of TT, first outlined in Table 3-10. To highlight these relationships, Figure 3-8 has been constructed to provide a summary of the required level of knowledge transfer per TT phase. Additionally, a case study example surrounding a FDI TT venture has been deconstructed to practically illustrate the relationships shown in Figure 3-8. The section concludes by pressing various best practices aimed at facilitating the transfer of knowledge.

When juxtaposing the three stages of TT, the second stage of adoption has been explicitly outlined as the most complex. The complexity has been created from adoption's dependence on both explicit and implicit knowledge transfer (Amsden, 2001; Chandra, 2006). Literature states that the increased complexity may only be countered through implicit knowledge codification and actions emphasising the improvement of human knowledge capabilities and human capital related to TT (Bozeman, 2000; Golob, 2006; Bozeman *et al.*, 2015; Handoko *et al.*, 2016).

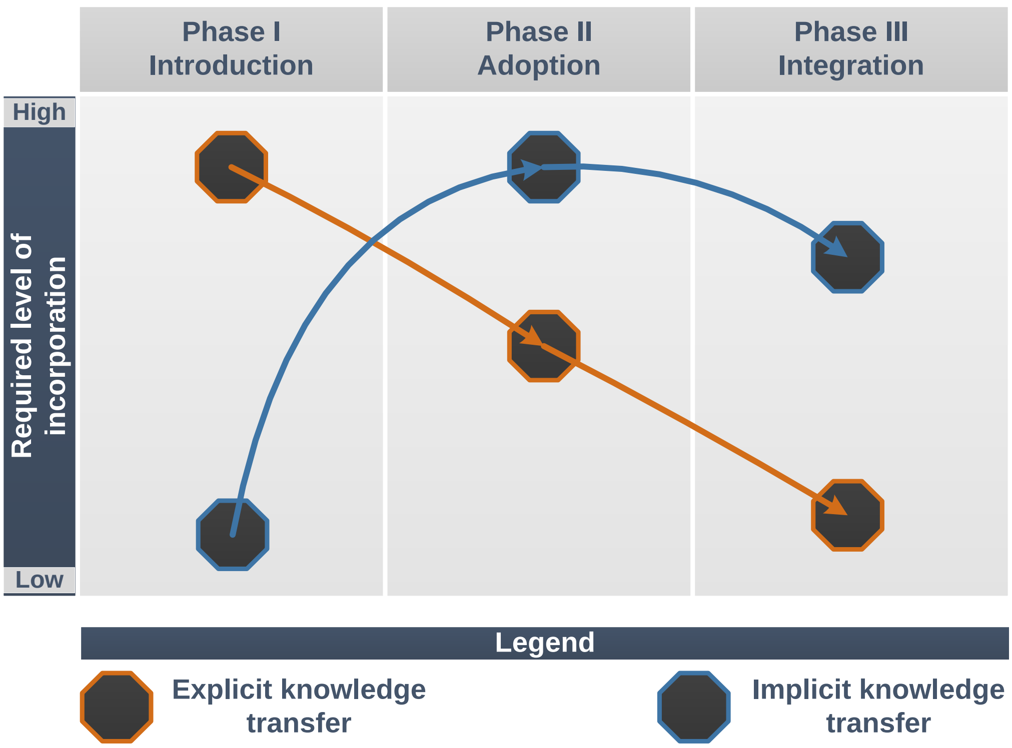

Figure 3-8 - Relationship between knowledge flows and the phases of technology transfer (author's conceptualisation)

Additionally, the technology modification or refinement that occurs in the adoption phase, often requires a managerial hierarchy structure containing various sets of expertise (Amsden, 2001). Higher level managers focus on the interpretation of implicit knowledge transfer elements, while lower level managers interpret and convey explicit knowledge transfer elements to the remaining TT team (Handoko *et al.*, 2016). Successful TT ventures become improbable when this managerial structure is absent (Amsden, 2001).

Thus, the inherent difficulty that implicit knowledge imposes upon TT ventures, coupled with the benefits of implementing a TT managerial team has greatly promoted the shift towards the human knowledge capital TT paradigm, shown in Table 3-9 (Bozeman, 2000; Handoko *et al.*, 2016).

As with adoption, integration, the final stage of TT, requires a high degree of understanding due to the requirement for the transferee to utilise the technology to a similar extent as the transferor. Thus, the transferred technology must be coaligned with the transfer of the technology's functions (Shamsavari *et al.*, 2002; Ann *et al.*, 2008; Handoko *et al.*, 2016).

While the introduction phase of TT precedes both adoption and integration, it has comparatively negligible knowledge transfer requirements (Handoko *et al.*, 2016). Explicit knowledge transfer is generally prominent during the initial phase and will be conducive towards diffusion amongst all levels of the transfer team (Becerra *et al.*, 2008). Explicit knowledge transfer does, however, produce diminishing marginal returns as the TT venture progresses through its maturity cycle (Wahab *et al.*, 2009; Handoko *et al.*, 2016).

A FDI TT surrounding the metal industry of Indonesia provides a practical illustration of the knowledge dissemination process that accompanies a TT venture and has been presented in Figure 3-9. The TT had been completed via a FDI method when a multi-national allocated capital toward the establishment of an industrial metal producing factory. Subsequently, domestic workers employed by the factory created over 200 different small-medium enterprises (SMEs). The various resulting SMEs facilitated the dissemination of metal production knowledge into local communities through employment opportunities, workshops and other spin-offs (Handoko *et al.*, 2016). This example also highlights the potential social and economic benefits of widespread knowledge dissemination (Handoko *et al.*, 2016)

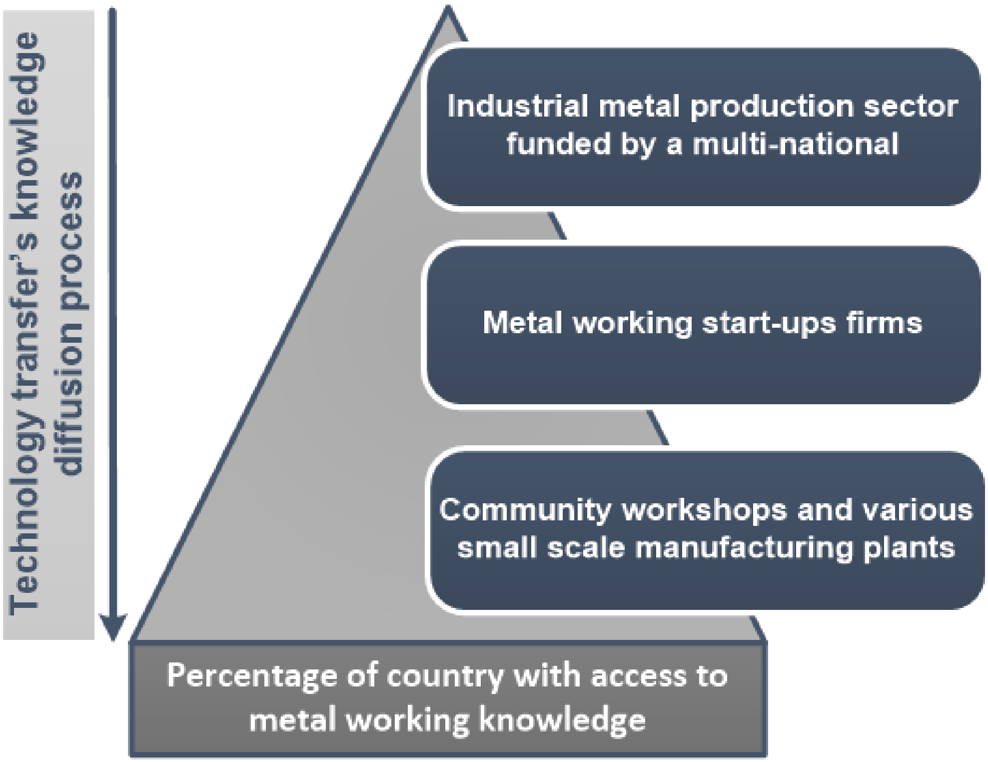

Figure 3-9 - Knowledge dissemination throughout the technology transfer process (author's conceptualisation)

While explicit knowledge transfer is readily attainable, Section 3.3.5 highlights the difficulty which TT ventures face when attempting to transfer implicit knowledge. Thus, an organisation who encourages or mandates their employees to continually learn by implementing various education protocols shall subsequently promote the transfer of knowledge within their corporation (Carlsson *et al.*, 2002). This culture of knowledge sharing and uptake will increase the likelihood of employees adapting foreign knowledge into tangible domestic outcomes (Handoko *et al.*, 2016).

Similarly, the creation of an open knowledge and information culture improves employees' technological foresight and adoption capability. Thus, the widespread propagation of knowledge increases the capability of all employees to successfully adopt and integrate TT ventures (Becerra-Fernandez *et al.*, 2003).

Finally, international trade and FDIs also indirectly promote local economic development, refer to Figure 3-9, by enabling local firms to tap into a global pool of knowledge (Nygaard *et al.*, 2013). Thus, government policies enabling TT and knowledge transfer will become highly desirable (Hoekman *et al.*, 2006).

3.3.6 Barriers to technology transfer

Section 3.3.6 attempts to identify the diversity of factors that may prohibit the TT methods discussed in Section 3.3.4, both individually and collectively. Literature sources have indicated that potential barriers may arise from unfavourable political, economic and social elements as well as inadequate infrastructure, public sector policies and obstacles faced by TTOs (Bozeman, 2000; Bozeman *et al.*, 2015). However, the most frequent obstacle encountered by TT ventures originates from the nature of the technology itself and its suitability in the transferee's environment (Jesse *et al.*, 2010; Bozeman *et al.*, 2015).

3.3.6.1 Barriers arising from the technology itself

Suitability may be evaluated by the three primary criteria, shown in Table 3-12. While a TT venture must adhere to all criteria to ensure suitability, examples have been uncovered which depict cases of total adherence, yet have still been unsustainable due to technology's incompatibility with the transfer environment (Shamsavari, 2006).

Table 3-12 - Technology transfer suitability criteria

Criteria	Description
Factor endowment	Appropriateness of the technology with regards to the factor endowment of the transferee firm or country (Shamsavari, 2006). For example, a capital-intensive technology may inherently not be suitable for a country that primarily relies on a low wage labour force.
Marketability	Nature, appeal and marketability in the transferee country (Zhang *et al.*, 2016). For example, luxury goods may not be suitable to be transferred to a low income developing country as they hold little appeal for the country's citizens and firms will struggle to successfully commercialise the technology.
Impact area	The technology's impact area refers to whether the TT focusses on urban or rural sectors (Clark, 1985; Zhang *et al.*, 2016). For example, a technology that requires resources to operate typically found in urban environments may be impracticable in countries with largely rural environments. Similarly, a technology that originated in a rural setting may be obsolete in an urban environment.

3.3.6.2 Barriers arising from the trade process

Firms that invented innovations generally have substantial economic influence over these innovations as their organisations have been specifically tailored to produce them. This inherently results in the price of the technology being above the natural market level and may thus not be socially optimal (Golob, 2006; Hoekman *et al.*, 2006; Piros *et al.*, 2013). The discrepancy between the innovation's demand and marginal cost enables the originator to obtain significant profits but in turn creates an international trade barrier towards the transfer of both complementary and substitute foreign innovations (Hoekman *et al.*, 2006; Piros *et al.*, 2013).

An academic study analysing factors which influence the absorptive capacity of a country concluded that increasing the quantity of imported technology will have a negligible effect in comparison with increasing the quality of imported technology. Thus the type of machinery and knowledge imported is far more important than the total volume of investment (Peluffo *et* *al.*, 2013; Handoko *et al.*, 2016). Resulting TT trade barriers arise when government policies merely aim to increase the quantity of imported technologies without considering the type of technologies that may be imported (Peluffo *et al.*, 2013).

3.3.6.3 Infrastructure related barriers

While Section 3.3.4.6 highlights the importance of free trade and a conducive environment to international technologies, literature argues that these requirements have been overshadowed by the transferee's ability to adopt the transferred technology (Hoekman *et al.*, 2006; Jesse *et al.*, 2010; Handoko *et al.*, 2016). Successful adoption occurs more readily when transferee countries have R&D networks in place which have been complemented with the knowledge and output of domestic research institutions and universities.

Thus, there is a requirement for a base level of human capital and knowledge in order for TT to occur (Tybout, 2000; Hoekman *et al.*, 2006). This conclusion has been reinforced by an academic study that determined poor countries could only increase their absorptive capacity by implementing programs aimed at improving human capital (McCalman, 2001). Without soft education and training infrastructure, a country will be severely restricted in TT participation (Tybout, 2000; McCalman, 2001; Hoekman *et al.*, 2006).

Poor economic and social infrastructure will also greatly increase the difficulty for any potential transferee countries to attract FDIs and the subsequent TT that follows (Javorcik *et al.*, 2005). If a country possesses a small or inadequate supplier network, multi-nationals tend to prefer neighbouring countries with improved supply chain infrastructure (Hoekman *et al.*, 2006). This barrier will be compounded if the public sector does not intervene, as local suppliers have no incentive to develop, thus reducing the country's future TT marketability (Piros *et al.*, 2013). The critical interdependence between the transferee's economic development and foreign investment can initially only be improved through capital investment from both domestic public and private sectors aimed at infrastructure development (Djankov *et al.*, 2000; Smarzynska Javorcik, 2004; Hoekman *et al.*, 2006).

Another characteristic of technology which prohibits complete TT has been the unrelenting pace at which technological innovation occurs. This results in integration, the final phase of TT, being unobtainable for many technologically undeveloped countries as new innovations make current TTs redundant (Hoekman *et al.*, 2006). When this occurs, countries are characterised as being technologically dependent. The United Nations Conference on Trade and Development defines countries as technologically dependent when they exhibit the characteristics shown within Table 3-13.

Table 3-13 - Characteristics of technological dependence (White, 1978)

Characteristics of technological dependence
Countries illustrate low levels of innovative activity typically measured by the number of patents owned within the country as well as new patents registered per annum.
Countries which lack high-level skills and knowledge required to make sound technological choices.
Countries which lack low-level skills and knowledge required to operate basic and intermediate levels of machinery.

If any of these characteristics have been displayed by a firm or country, it will automatically result in TT obstacles (Shamsavari, 2006). Technological dependence has been directly linked with both hard and soft infrastructure inadequacies and may only be reversed through mass capital investment aimed at the improvement of both human and asset capital (Gorman, 2002; Shamsavari, 2006).

3.3.6.4 Barriers arising from policy outcomes

Section 3.3.4 outlined the TT methods of IP, licensing, trade agreements and FDIs as well as highlighting their prominence in global TT ventures. While these methods have been directly linked with TT, they also influence other economic and social factors resulting in strict government supervision (Hoekman *et al.*, 2006; Piros *et al.*, 2013).

Currently, there are numerous IP regulations that directly influence the prevalence of TT (Bozeman, 2000). For example, the absence of a legal basis for the protection of proprietary information and trade secrets greatly decreases a country's FDI and international trade appeal (Bozeman, 2000; Erdem *et al.*, 2003; Hoekman *et al.*, 2006). Contrastingly, the increased cost of importing IP protected technology into less developed countries may overshadow the potential benefits (McCalman, 2001).

With respect to TT adoption and integration, refer to Table 3-10, historical examples, such as the telegraph, often illustrate the negative influence that IP and trade secrets hold over TT. When technology originators attempt to maintain the proprietary nature of their technology, the rate of technological diffusion will be greatly reduced as the knowledge required to construct, maintain and operate the technology remains concealed (Jeremy, 1991). Thus, the potential monetary gain that proprietary technologies may provide should be balanced with the technology's integration into its environment (Schwartz, 2004). This balance has been reaffirmed by a study which identified that universities produce more start-up companies when incorporating economic and societal development factors in comparison with exclusively emphasising income generation (Golob, 2006).

When evaluating the policies which affect FDIs and trade agreements, the decisions of the public sector and the available market structure becomes paramount (Javorcik *et al.*, 2005; Hoekman *et al.*, 2006). It has been argued that an open trade market model shall produce an optimal economy (Piros *et al.*, 2013). A primary motivator for an open trade market has been the unrestricted influx of foreign investments and trade agreements. Consequently, this results in increased domestic competition and subsequent product and service price stability (Arora *et al.*, 2004; Hoekman *et al.*, 2006; Piros *et al.*, 2013).

However, the increased domestic competition may also promote an increase in the average cost faced by domestic firms. Higher average cost may result in lower productivity and over long-term economic cycles, various domestic firms will be forced to exit the market. Historically, developing countries with lacking industrialisation and technological innovation will exacerbate these market casualties (Auerbach, 1988; Hoekman *et al.*, 2006; Piros *et al.*, 2013).

An academic study evaluating the economic effects of the introduction of foreign competition into Eastern European markets presented similar casualties. This study included data collection from domestic firms owners, with 29% of the respondents claiming a market share decline after the introduction of foreign competitors (Javorcik *et al.*, 2005). A parallel study completed in the Czech Republic produced near-identical results (Javorcik *et al.*, 2005).

Another study lamented the promotion of free trade after uncovering a negative correlation between international trade and TT. This correlation has been attributed to the domestic firm casualties outweighing the positive effects of knowledge transfer (Aitken *et al.*, 1999). Even though these studies portray the results of trade agreements and FDIs as harmful, a fundamental law of free-market economics reinforces the validity of this process by stating that when a firm cannot compete in its environment, it must either improve productivity or exit the market (Piros *et al.*, 2013).

While the long-term economic importance of this law has been well established, the short term loss of domestic firms, from a political party's viewpoint, has often been undesirable. (Hoekman *et al.*, 2006; Piros *et al.*, 2013). Thus, while the TT methods of FDIs and trade agreements have been widely regarded as economically beneficial, public sectors still face a balancing act between the promotion of these TT methods and the mitigation of their short term social disadvantages (Hoekman *et al.*, 2006). When public sector policies attempt to limit trade or foreign investment to any extent, an automatic TT barrier will be created as governments sacrifice consumer benefits for producer security (Djankov *et al.*, 2000; Javorcik *et al.*, 2005; Piros *et al.*, 2013).

As the methods of TT have evolved, so have the corresponding laws that govern them, been refined. Several recent public-sector policy implementations have specifically emphasised the promotion of FDIs while simultaneously enforcing domestic firm longevity. Examples include offering greater incentives for national firms than for multi-national subsidiaries (Hoekman *et al.*, 2006). This reinforces domestic firms and commerce while not categorically excluding all potential FDIs (Zhang *et al.*, 2016). However, this policy implementation may inadvertently create a future TT barrier as government-endorsed domestic firms often become inferior to the corresponding foreign counterpart which in turn reduces a country's long-term FDI marketability (Hoekman *et al.*, 2006; Nygaard *et al.*, 2013).

An example of a more promising widespread policy intervention has been the regulations governing multi-nationals and their foreign supply chains. Currently, many developing countries require multi-nationals to diffuse their technologies and knowledge into sectors which form part of their supply chain. However, as these regulations often force the diffusion upon entire sectors, made up of firms which supply the multi-nationals as well as those who do not, diffusion attempts have typically been lacklustre and elementary as the diffusion may result in aiding supply chain competitors (Djankov *et al.*, 2000; Hoekman *et al.*, 2006). This, in turn, creates knowledge transfer barriers (Djankov *et al.*, 2000). Policies that guide technology diffusion between multi-nationals and their direct suppliers have been known to be far more successful and effective (Djankov *et al.*, 2000).

The double-sided nature of public sector TT regulation stems from ignorance regarding various policy implementations, with literature arguing that their effects have not been explicitly documented or accurately interpreted (Javorcik *et al.*, 2005; Hoekman *et al.*, 2006; Ryu *et al.*, 2010). Many academic studies evaluating TT policies rely on empirical evidence, based upon aggregated data or cross-sectional surveys. The nature of these foundations results in inconclusive outcomes, subject to many different interpretations (Javorcik *et al.*, 2005; Hoekman *et al.*, 2006). Contrastingly, when academic studies utilise case studies, they provide clear TT policy insights into specific sectors, firms or countries. However, the outcomes of these studies have typically been difficult to standardise and apply to other regions (Hoekman *et al.*, 2006; Ryu *et al.*, 2010).

Thus, the appropriateness of policy interventions and their subsequent channels of focus have often been misaligned (Hoekman *et al.*, 2006). When policymakers attempt to improve a country's TT capability or marketability, seemingly comparable foreign initiatives have often been copied and implemented in the domestic environment. However, subtle differences in transfer environments may result in these policy interventions becoming prohibitive or redundant (Javorcik *et al.*, 2005; Hoekman *et al.*, 2006). Consequently, multiple literature sources argue that the most prominent TT related policy barrier stems from the requirement to utilise implicit, rather than explicit knowledge, in policy creation, as this has historically been a difficult and messy process (Nonaka *et al.*, 2003; Hoekman *et al.*, 2006; Handoko *et al.*, 2016).

3.3.6.5 Barriers faced by TTOs

Due to the restricted amount of academic research that evaluates TTOs, TTOs face similar difficulties to public sector policymakers. Literature has noted that no clear guidelines have been created for TTO employees to utilise with the effect of this omission compounded as TTOs must continually incorporate implicit knowledge transfer to achieve success (Nonaka *et al.*, 2003; Ann *et al.*, 2008; Link *et al.*, 2016).

This barrier proves difficult to circumnavigate, as the scope of most young TTOs' has been vaguely defined. The unstructured nature of new TTOs results in difficulty attracting and retaining staff capable of navigating the marketing, legal, technological and competitive uncertainties of radical and incremental innovation (Ryu *et al.*, 2010). Literature sources conclude that obtaining experienced personnel capable of administering implicit knowledge transfer acts as a primary TTO barrier (McAdam *et al.*, 2005; DeVol *et al.*, 2006; Ryu *et al.*, 2010).

An academic study evaluating the lifecycles of Korean TTOs highlighted another knowledge related barrier, after identifying the financial susceptibilities of young TTOs employing less than ten personnel. The study attributed the TTOs' financial difficulties to the small knowledge base being insufficient to achieve sustainability (Ryu *et al.*, 2010). Employees of small TTOs also often suffer from fatigue, resulting in service shortcomings and displeased TT stakeholders across all levels (Ann *et al.*, 2008).

An intuitive solution has been the establishment of consortiums, consisting of multiple TTOs that have banded together. However, a different Korean study highlighted the reluctance of mature TTOs to join consortiums due to potential leadership conflicts and differing agendas. The study found that only half of established TTOs had been willing to join while concluding that consortiums created by inexperienced parties do not solve the TTO competency barrier (Friedman *et al.*, 2003). The study has also argued that even consortiums made up of experienced TTOs are not guaranteed success citing that consortiums in Korea produced only a third of the licensing revenue and a twentieth of the royalties when compared with individual United States TTOs of the same time period (Friedman *et al.*, 2003).

However, despite these varying revenue outputs, all TTOs have been particularly conducive towards licensing agreements. Literature suggests that TTOs which do not engage in licensing agreements with large firms or multi-national corporations have not been completing their inherent objective as the market structure of the global economy strongly endorses commercialisation activities (Golob, 2006; Caldera *et al.*, 2010; Piros *et al.*, 2013). When TTOs do not facilitate licensing agreements, a barrier towards TT commercialisation will be created. (Golob, 2006; Bozeman *et al.*, 2015).

While most TTOs emphasise licensing activities, a study highlighted that TTOs ineffectively utilise the volume patents and research development provided by public universities when only this TT method has been undertaken (Berman, 2002). Large companies often require some level of evidence proving a technology's feasibility and have shown reluctance to invest in green technologies (Taha, 2002; Golob, 2006). Thus even though, licensing agreements should be the primary method utilised for TT, it cannot be the only one as this will result in the decline of start-ups and spin-offs (Berman, 2002; Golob, 2006; Ryu *et al.*, 2010).

3.3.7 Technology transfer models

This section provides a summary of the TT models that have been identified, thus it aims to answer research question 4, refer to Table 3-2, of the systematic conceptual literature review as to which TT models are currently being utilised. The models that have been identified and subsequently investigated have been presented in Table 3-14, with the complete elucidation of each individual model available for review in Appendix A. The data presented within Appendix A serves to answer research question 5 of the systematic conceptual literature review as to what the primary components of TT models are.

Table 3-14 - Summary of all identified technology transfer models

Technology transfer model	Developing Author(s)	Publishing date	Description
The Chantramonklasri model	Chantramonklasri, N	1990	Linear TT model highlighting knowledge assimilation during a five-phase process.
Levels of involvement model	Gibson, David V; Smilor, Raymond W	1991	A tiered model providing managerial best practices for the technology transfer's development, acceptance and application.
Organisational capabilities-based model	Rebentisch, Eric S; Ferretti, Marco	1995	Developed for international joint ventures, this model focusses on the transfer scope, transfer methods, knowledge architectures and the adaptive abilities of the stakeholders involved.
Contingent effectiveness model	Bozeman, Barry	2000	This model focuses on the transfer agent, transfer media, transfer object, demand environment and transfer recipient while also providing evaluation criterion for a TT venture.
Traditional TT model	AUTM	2000	Specifically designed to facilitate TT from a public research institution into the private sector.
Revised Levels of Involvement model	Sung, Tae Kyung; Gibson, David V	2000	Add an additional tier on top focusing on the commercialisation of the transfer object.
Interactive broadcasting model	Malik, K	2002	Designed to aid intra-firm TTs by viewing the transfer object as a "message broadcast" to be distributed throughout a company.
Traditional model of university TT	Siegel, Donald S; Waldman, David A; Atwater, Leanne E; Link, Albert N	2004	A more expansive model of the traditional TT model. Still primarily focussed with research to private space TT ventures.
Stage-gate model	Jagoda, Kalinga; Maheshwari, Bharat; Lonseth, Robert	2005	A three-phase model focussing on the initiation, planning and execution of a TT venture. Also incorporates a stage-gate feature through the TT.
Policy integration model	Smith, Brian	2007	Primarily designed for FDI TT ventures. It attempts to facilitate the acquisition and development of infrastructure required for FDI TT.
Alternative model of university TT	Bradley, Samantha R; Hayter, Christopher S; Link, Albert N	2013	Further refinement on the traditional model of university TT by investigating multiple relationships between framework nodes.
Revised Contingent Effectiveness model	Bozeman, Barry; Rimes, Heather; Youtie, Jan	2014	Added the additional evaluation criteria measuring public value.
Knowledge in technology adoption model	Handoko, F; Nursanti, E; Harmanto, D Sutriyono	2016	This model primarily focusses on ensuring implicit and explicit knowledge transfer in conjunction with the transfer of the transfer object.

TT models typically are classified into either scientific discovery, commercialisation or knowledge transfer models. Scientific discovery models emphasise the transfer of technologies developed by public research institutes to a private stakeholder (Siegel *et al.*, 2004; Bradley *et al.*, 2013). Commercialisation models focus on creating market value from the technology that has been transferred, while knowledge transfer models typically focus on transferring additional training and educational programs in conjunction with the primary transfer object (Sung *et al.*, 2000; Bozeman *et al.*, 2015; Handoko *et al.*, 2016). Knowledge transfer models often focus on creating public value rather than market value (Bozeman *et al.*, 2015; Handoko *et al.*, 2016).

Some TT models may serve as a combination of the categories above and will attempt to commercialise a public research institute's scientific discovery. It must be noted that the TT model categories are not exhaustive. While these categories have been uncovered, no attempt has been made to assign the individual TT models outlined in Appendix A to a specific TT model category. Instead, the individual characteristics, shortfall, advantages and unique features of all TT models identified have been discussed in Appendix A.

3.4 Chapter 3: Conclusion

The systematic conceptual literature review presented in this chapter has identified the most prominent TT characteristics. The public sector, TTOs, universities, domestic firms and multi-nationals are all identified as universal stakeholders involved in most TT ventures. The responsibilities of each of these stakeholders have also been provided. The TT methods of traditional transfer, FDIs, joint ventures, spill-overs, trade agreements, licensing and TTOs have all been elucidated. Additionally, 13 prevalent TT models have been identified and have been utilised in the construction of the framework presented in Chapter 5.

While not explicitly relating to the systematic conceptual literature review's research questions, the prominent TT barriers, as well as the influence of knowledge of TT, have also been summarised to create a comprehensive TT conceptual literature review. Table 3-15 provides a summary of the systematic conceptual literature review's research questions along with the corresponding figures, tables and appendices that complete them.

Table 3-15 - Systematic conceptual literature review's research question summary

Research question 1:	How has TT evolved?	Refer to: Table 3-9
Research question 2:	Who are the major stakeholders in a TT venture?	Refer to: Figure 3-3
Research question 3:	What are the major TT methods?	Refer to: Figure 3-6
Research question 4:	Which TT models are currently being utilised?	Refer to: Table 3-14
Research question 5:	Which key components are TT models comprised of?	Refer to: Appendix A

Chapter 4. Systematic comparative literature review of sub-Saharan Africa's health-related technology transfer case studies

Chapter 4 documents the systematic comparative literature review that has been undertaken. The motivation, utility and limitations behind this review process have also been outlined in accordance with the systematic comparative literature review's methodology presented in Section 2.4. The key objectives of Chapter 4 are summarised in Figure 4-1 and the purpose of Chapter 4 within this research document is shown in Table 4-1.

Table 4-1 - The role of Chapter 4 within the research structure

Document framework							
Research objectives	i.	i. & ii.	i. & ii.	ii. & iii.	ii. & iii.	iii.	iii.
			iv.				
Conceptual Framework Analysis phases	Map data sources	Categorise data	Identify concepts	Deconstruct concepts	Integrate concepts	Synthesis	Validate
Corresponding chapters	Problem statement **Chapter 1**		Comparative literature review **Chapter 4**			TT facilitation tool **Chapter 6** **Chapter 7**	
		Conceptual literature review **Chapter 3**			Conceptual framework **Chapter 5**		

Key outcomes

- Elucidation of the descriptive statistics derived from the comparative review
- Identification of the main stakeholders involved in SSA TT
- Identification of the hard infrastructure requirements for SSA TT
- Identification the soft infrastructure requirements for SSA TT

Figure 4-1 - Key objectives of Chapter 4

4.1 Systematic comparative literature review: the rationale

The systematic comparative literature review has been undertaken to ensure a more complete elucidation of the major TT topic areas identified in Chapter 3. This review has been specifically tailored to the healthcare field in the region of SSA and serves to complete research objective ii, shown in Section 1.4. The data handling process, methodology and research questions utilised to complete this review have been presented in Section 2.4 and Section 4.2. The research questions for the systematic comparative literature review, refer to Table 4-2, have been constructed in such a manner as to ensure that emphasis will be placed upon critical areas required for the subsequent framework development in Chapter 5.

Table 4-2 - Systematic comparative literature review's research questions

Research question 1:	What are the major TT methods being utilised in SSA?
Research question 2:	Who are the major stakeholders and what are their motivations in a SSA based TT venture?
Research question 3:	Which physical infrastructure will be required in SSA for health-related TT to occur?
Research question 4:	Which intangible infrastructure will be required in SSA for health-related TT to occur?

4.2 Research methodology: Chapter 4

This section aims to outline the research methodology utilised during the completion of the systematic comparative literature review. As illustrated in Figure 2-6 in Section 2.4, the systematic comparative literature review utilised a six-step process to create a theoretical foundation for the combined topic areas of TT, infrastructure and e-Health within the SSA region.

4.2.1 Formulation of the research problem

While the conceptual literature review uncovered all the primary characteristics of the TT topic area, its wide focus area resulted in knowledge that was not universally applicable to the research document's scope, outlined in Section 1.5. Consequently, this systematic comparative literature review has been undertaken to refine concepts uncovered during the systematic conceptual literature review to the required geographical and application areas. To accomplish this, the systematic comparative literature review focusses explicitly on health-related TT case studies in the region of SSA.

4.2.2 Data collection

The data search protocol of the systematic comparative literature review reflected a modified version of the systematic conceptual literature review's data collection methodology. The keywords and search areas of the systematic comparative literature review have been presented in Table 4-3 and Table 4-4 respectively. The search produced 84 literature sources, which included peer reviewed journal articles, grey literature, working papers, conference papers and a master's level dissertation.

Table 4-3 - Systematic comparative literature review's sources of data collection

Topic area	Keywords	Results presented in
Health-related technology transfer's infrastructure requirements in SSA	Technology transfer, sub-Saharan Africa, ICT, Healthcare, Infrastructure.	Appendix B

Table 4-4 - Keyword search terms for the systematic comparative literature review

Online academic data bases	Media publications	Academic libraries
Google Scholar Scopus Emerald	Various grey literature sources	Stellenbosch University

4.2.3 Critical appraisal of the studies

As the systematic comparative literature review had a narrow area of focus, literature items collected during the data search phase were subject to a stricter degree of exclusion criteria when compared with the systematic conceptual literature review. The exclusion criteria for the systematic comparative literature review has been presented in Figure 4-2. Table 4-5 presents the appraisal process and how each literature item, obtained during the search process, has been subjected to a review process. This ensured that all literature items uncovered during the primary search phase would be refined into a final applicable data pool.

Exclusion criteria		
	Language	All items not published in English have been excluded
	Availability	If a literature item was not freely available it was not included
	Geographic restrictions	Literature items must contain case studies depicting TT to or from a SSA country
	Period	Research studies must be completed after 2000 to ensure current technological relevance
	Empirical foundation	Evidence that research study followed a basic methodology must be present
	Repetition	Instances where both journal and conference papers were available for a particular study, only the journal article has been included

Figure 4-2 - Systematic comparative literature review's data exclusion criteria

Table 4-5 - Data selection process for the systematic comparative literature review

Systematic comparative literature review's search data appraisal process		
Grey literature 6	Exclusion criteria	**Academic articles** 78
(1)	Language	(2)
-	Availability	(11)
-	Geographic restrictions	(4)
-	Period	(3)
(3)	Empirical foundation	(1)
(2)	Repetition	(6)
0	Final database 51	**51**

After the data selection process had been completed, the final data pool was reduced to 51 academic papers. The reduction was primarily because of the elimination of grey literature sources and lack of freely available journal articles. Figure 4-3 illustrates the composition of literature items that have been included in the final systematic comparative literature review. The complete list of literature items has been made available for review in Appendix B.

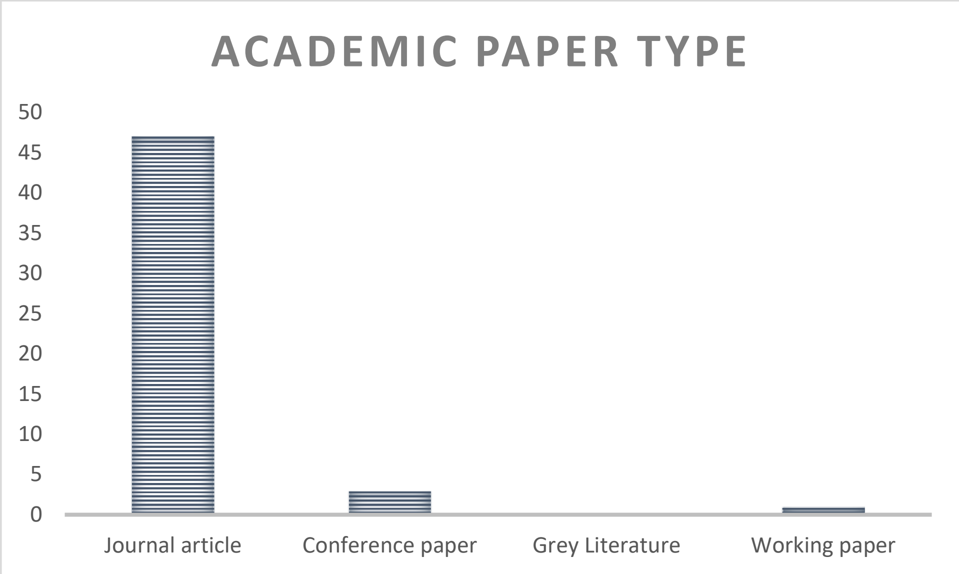

Figure 4-3 - Composition of academic papers

4.2.4 Data extraction

Information from the final pool of data had been extracted and subsequently tabulated into five main categories, namely: (i) paper characteristics; (ii) empirical elements; (iii) technology transfer foundation: (iv) infrastructure requirements; and (v) observations. The full expansion of the data extraction process has been presented in Figure 4-4.

i. Paper characteristics

- Title of document
- Author's name
- Author's country of affiliation
- Publishing date of document
- Document type
- Document publisher
- Analysis timeframe of document
- Citations
- Geographic focus of document
- Unit of analysis (Technology transfer method)
- Application area

ii. Empirical elements

- Data collection methods
- Validation techniques
- Methodology employed in document
- Gap in literature document addresses

iii. Technology transfer foundation

- Transferor
- Transferee
- Level of transfer
- Push and pull elements of technology transfer
- Implicit and explicit knowledge transfer
- Public sector involvement
- Technology transfer office's involvement
- Technology transfer paradigm
- Hard and soft technology transferred
- Technology transfer motivations and barriers

iv. Infrastructure requirements

- Hard and soft infrastructure requirements
- Sub-Saharan Africa's physical infrastructure barriers
- Structural barriers
- Knowledge barriers
- Political interference

v. Observations

- Conclusion drawn by authors of the document
- Oversights by authors
- Restrictions and pathways identified in the document

Figure 4-4 - Results of systematic comparative literature review's data extraction

4.2.5 Data synthesis

After the completion of the data extraction process, conclusions could be drawn from the systematic comparative literature review. To support this process, various charts, tables and flow diagrams have been constructed. These illustrations allow for subsequent conclusions to be drawn that have been substantiated by the literature items collected during the systematic comparative literature review. For an example of a chart created from the data extraction process refer to Figure 4-14 depicting the hard infrastructure requirements of TT in SSA.

4.2.6 Presenting results

The final stage of the systematic comparative literature review has been outlined in Section 4.3 and in the combined synthesis of both literature reviews utilised to construct the conceptual TT framework. The mapping and interpretation of the systematic comparative review literature review have been presented alongside the synthesis of the systematic conceptual literature review in Chapter 5.

4.3 Data results

After the process outlined in Section 4.2.3 had been completed, the extraction of the required information out of the final data pool commenced. The following sections provide a summary of the information uncovered in the systematic comparative literature review.

Section 4.3.3 provides an overview of the stakeholders involved in the TT process as well as their individual motivations. Section 4.3.4 focuses on the primary infrastructure requirements of TT to SSA, with Figure 4-14 highlighting the physical infrastructure that literature concluded as being essential to the TT process. Section 4.3.5 reviews more implicit infrastructure requirements, which may not necessarily contain physical artefacts. Both Section 4.3.4 and Section 4.3.5 must be analysed in conjunction as both sets of requirements are vital for successful TT.

4.3.1 Descriptive statistics

This section illustrates the descriptive statistics of the systematic comparative literature review and the academic papers within it. Several key bibliometric indicators have been highlighted to display the practicalities of the analysis. Figure 4-5 shows the timeline per composition of the academic papers included in the review. Of the 51 academic papers analysed in the study 85% had been published between the year 2003 and 2012.

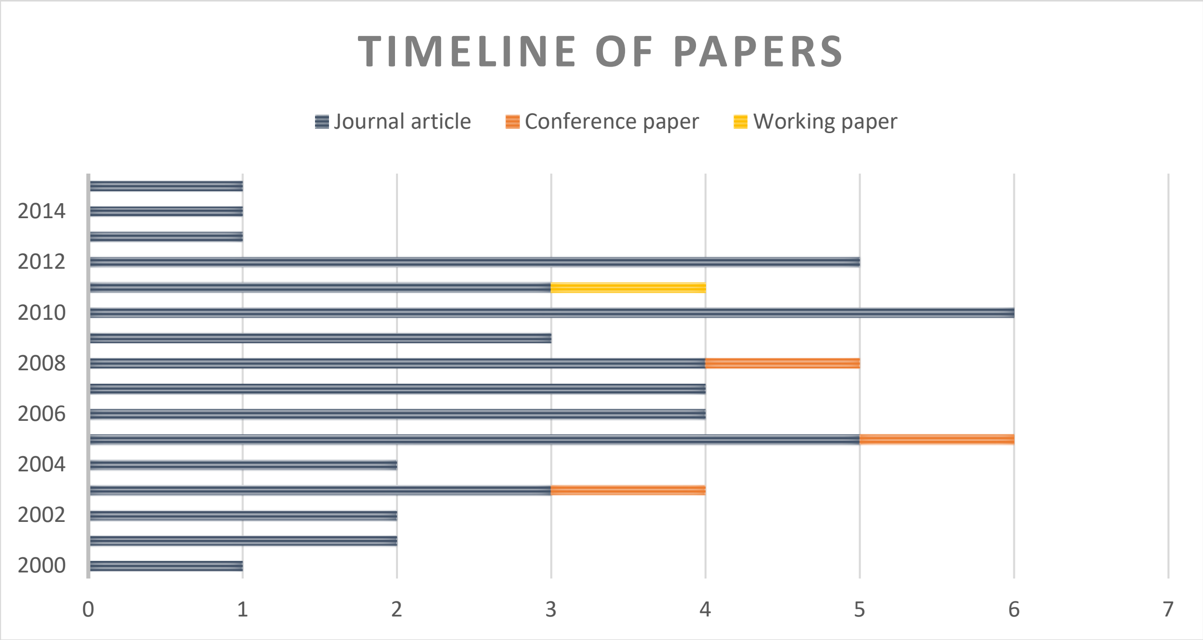

Figure 4-5 - Publishing date literature items included in the final systematic comparative literature review

When inspecting citation statistics, Figure 4-6 illustrates that 80% of the total citations[4] have results from published journal articles that, bar one exception, did not directly focus on healthcare. Instead, high impact journals focussed on the subject matter surrounding economics, ICT and infrastructure. Thirteen journals with journal articles of less than 30 citations have been excluded in a bid to improve the readability of Figure 4-6

[4] All citation data has been derived from Google Scholar on 11/12/2018

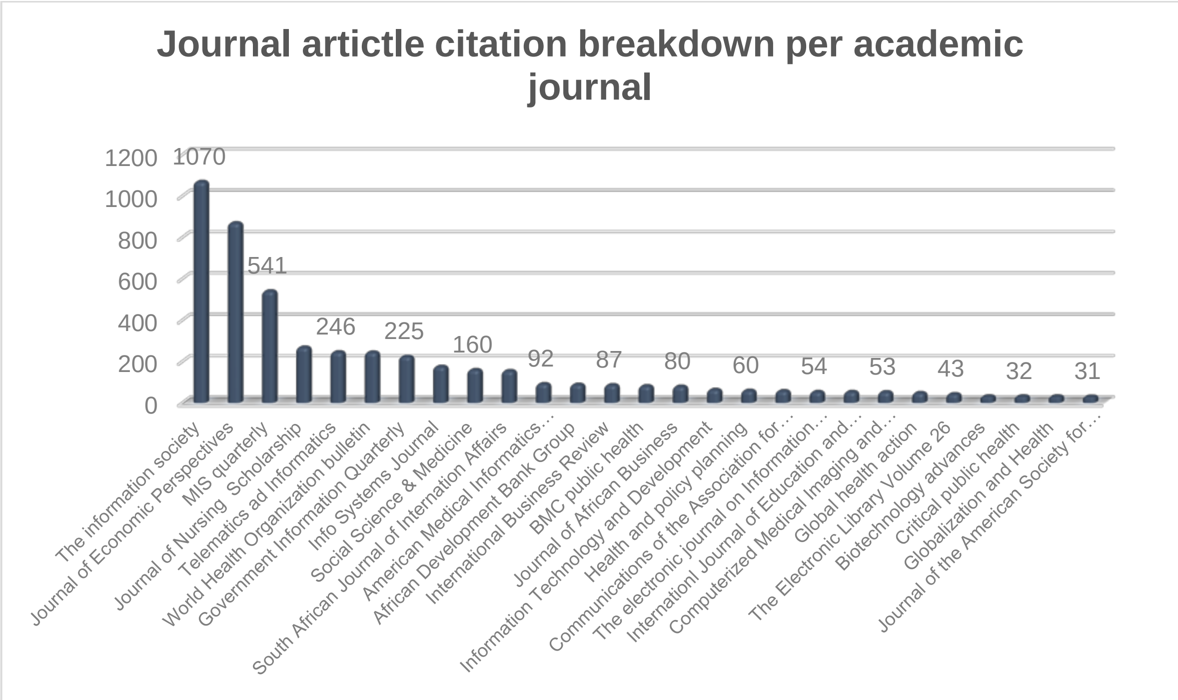

Figure 4-6 - Citation count per academic journal included in the systematic comparative literature review

4.3.2 Introduction to the comparative study

The focus of the comparative study has been the elucidation of the nuances of TT in an e-Health environment. ICT transfers have also been included after literature and Figure 4-6 highlighted a strong correlation between healthcare and ICT TTs (Meso *et al.*, 2009; Wamala *et al.*, 2013). Figure 4-7 provides a summary of the various transfer divisions that have been identified in the systematic comparative literature review.

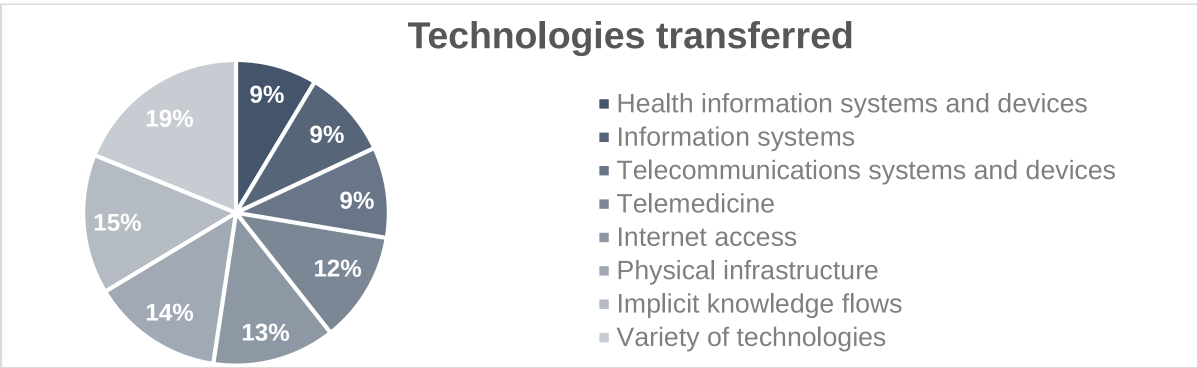

Figure 4-7 - Divisions of technologies transferred

While 19% of the literature items comprised of multiple technologies being transferred, each of these included at least one example of a HIS or telecommunications transfer. An important conclusion derived has been that HIS transfer must often be abandoned due to lacking base infrastructure (Kariuki, 2009; Wamala *et al.*, 2013; Aranda-Jan *et al.*, 2014). Multiple case studies that had initially been commissioned for HIS related transfers has been forced to shift focus towards mitigating lacking underlying foundations such as internet access, telecommunication devices and stable power supplies (Bagayoko *et al.*, 2006; Fuchs *et al.*, 2008).

Figure 4-8 provides a summary of the geographic TT areas included in the study. It is important to note that several academic papers focussed on more than one country. If a paper focussed on more than three SSA countries, it has been included in the additional category of SSA as an entire region, as indicated in the bottom left corner of Figure 4-8. This SSA region accounted for 39% of the documents reviewed, while South Africa, Kenya and Ghana represented 43% of the geographic focus areas. Figure 4-8 also highlights the prominence of the health-related TT hard infrastructure requirement for internet access as easily accessible underwater fibre optic cables service the east coast of Africa.

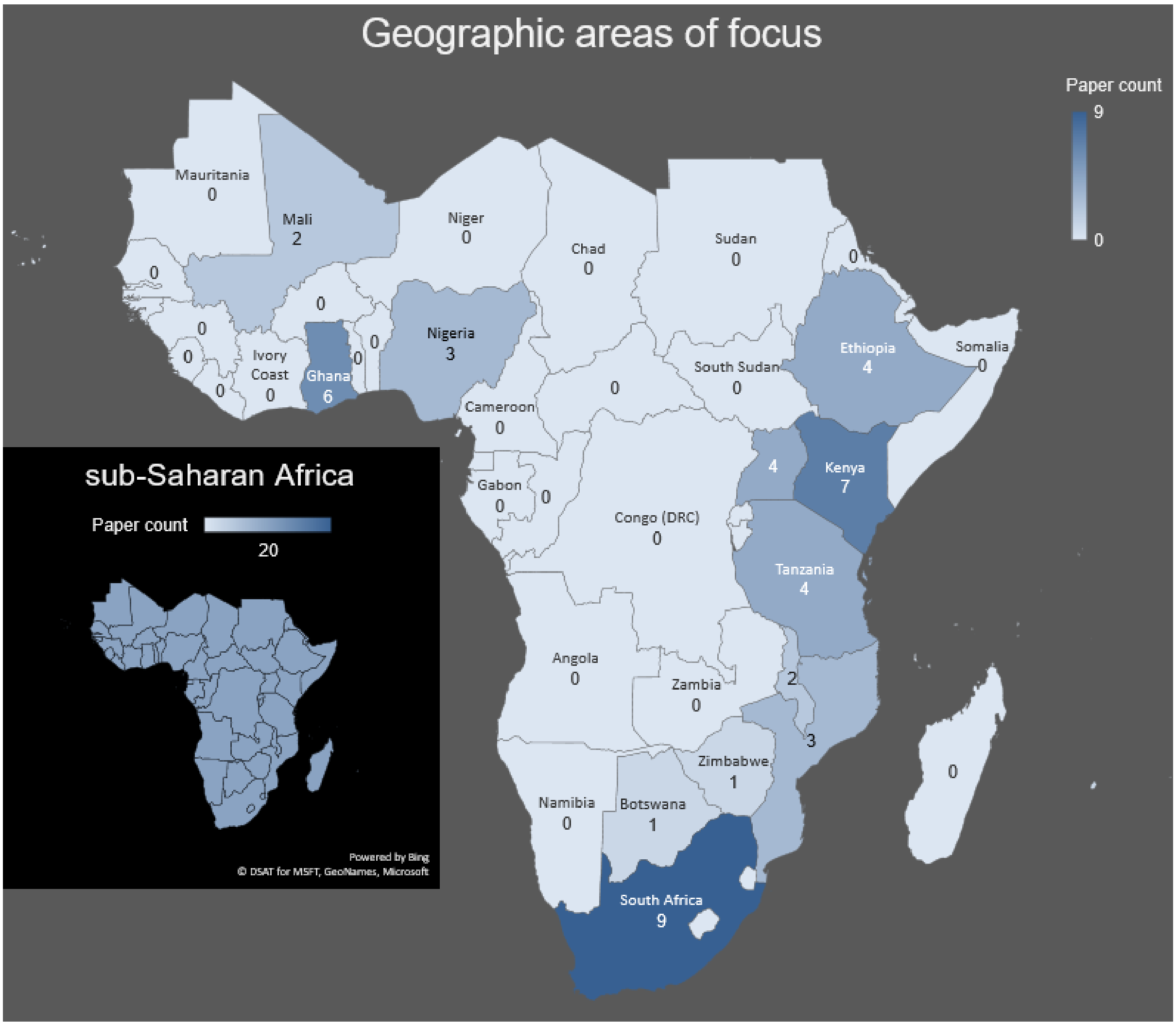

Figure 4-8 - Geographic focus areas of studies included in the systematic comparative literature review

Building upon Section 3.3.4, Figure 4-9 highlights the different TT methods identified per paper. It is important to note that these vehicles of transfer have been utilised as the unit of analysis for the study. Figure 4-9 also highlights that the SSA region contains examples of modern technology transfer techniques, such as FDIs and joint ventures. However, a substantial percentage of traditional TT projects have also been identified. Figure 4-9 concludes research question 1 of the systematic comparative literature review.

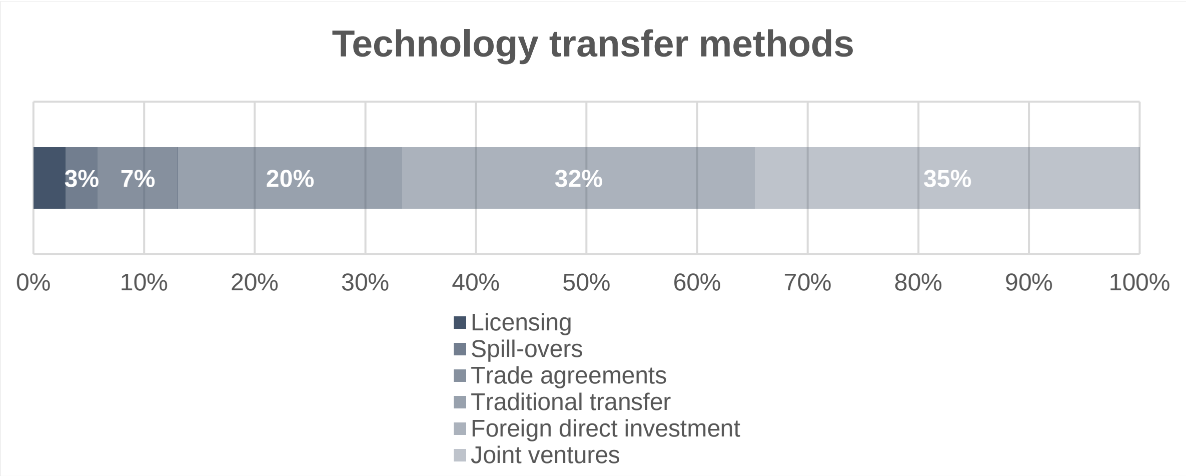

Figure 4-9 - Breakdown of identified technology transfer methods

4.3.3 Stakeholders

Figure 4-10 and Figure 4-11 serve to partly answer research question 2, shown in Table 4-2, by highlighting the entities discussed in the literature that constitute the transferors as well as providing their motivations for SSA-based TT ventures. As many of the studies involved the TT methods of FDIs and joint ventures, the resulting data indicated that foreign governments, companies and universities were mentioned in 72% as the transferors (Geissbuhler *et al.*, 2003; Renard, 2011; Cleeve, 2012).

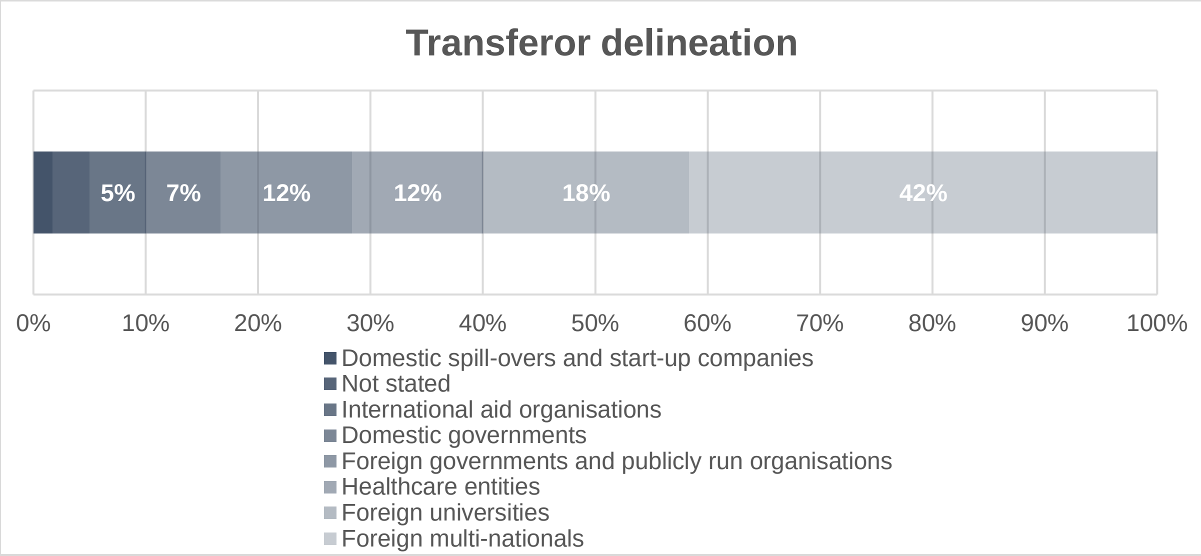

Figure 4-10 - Transferor delineation

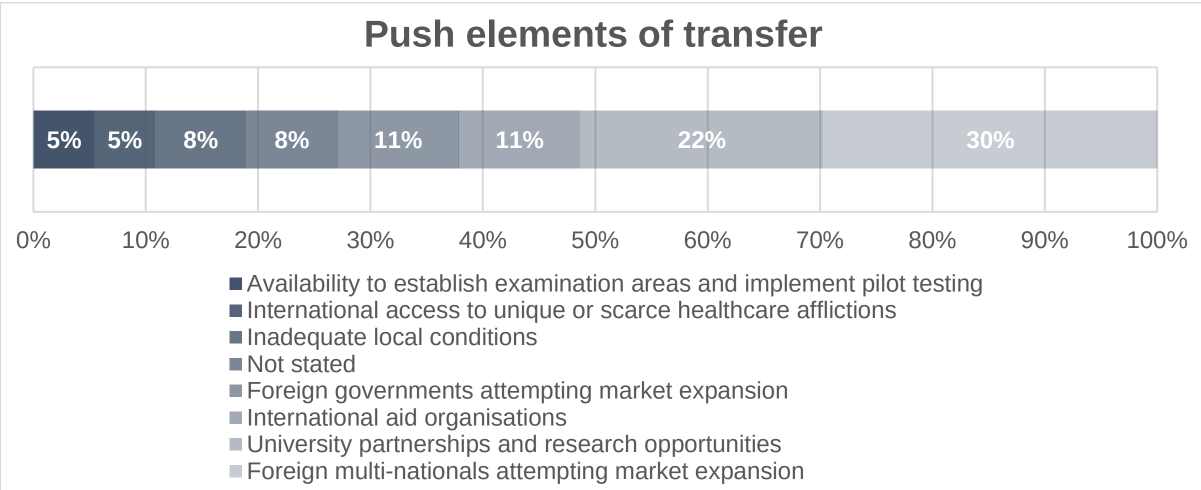

Figure 4-11 - Push elements identified for each technology transfer venture

Figure 4-11 highlights SSA countries' propensity towards foreign investments (Barthel *et al.*, 2008; Renard, 2011; Anyanwu, 2012). This indicates that most SSA countries have implemented a combination of conducive trade policies and regulatory frameworks (Barthel *et al.*, 2008; Mutula, 2008). Another significant conclusion has been that the motivation for TT partly results from poor local conditions. This includes references to the "brain drain" where local professionals are transferred to developed countries. However, in these instances, SSA has effectively been losing its technology and knowledge flows (Chanda, 2002; Meso *et al.*, 2009).

Figure 4-12 and Figure 4-13 serve to complete research question 2 of the systematic comparative literature review by depicting the entities which literature highlighted constitute the transferees, as well as providing their motivations for SSA-based TT ventures. When

Figure 4-12 and Figure 4-13 are jointly examined, it may be concluded that the systematic comparative literature review supports SSA's proclivity towards FDIs. However, the literature items show that widespread dissemination of the transferred technologies has been categorically absent as the systematic comparative literature review indicated that only 2% of transferred technologies resulted in domestic start-up companies (Philip F. Musa *et al.*, 2005; Bagayoko *et al.*, 2006).

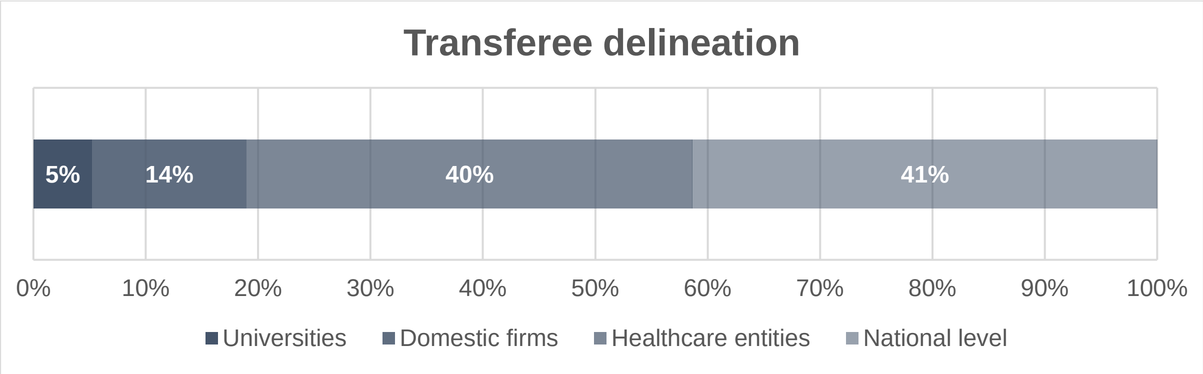

Figure 4-12 - Transferee delineation

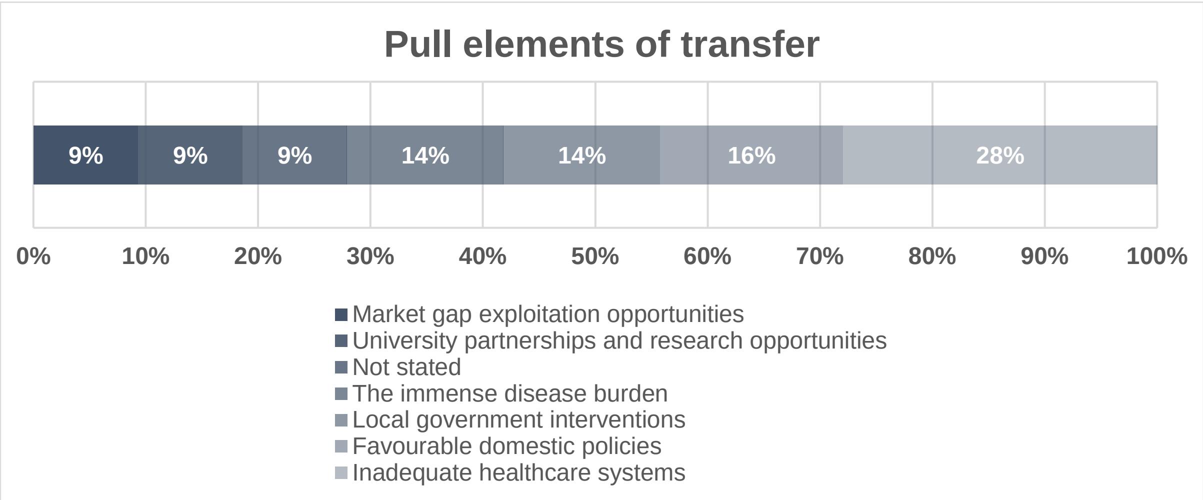

Figure 4-13 - Pull elements identified for each technology transfer venture

Figure 4-12 depicts a significant flow of technology towards either an individual healthcare centre or a nationwide healthcare operation. Figure 4-13 reinforces the notion established in Section 3.3.3.1, that favourable government free trade policies have been uncovered through the review to serve as a primary foundation for TT to occur (Bartels *et al.*, 2009; Nygaard *et al.*, 2013). While university joint venture studies were limited, the systematic comparative literature review did indicate that North-to-South tertiary educational operations in healthcare have been possible, albeit on a small scale (Kimaro *et al.*, 2005; Bagayoko *et al.*, 2006). Furthermore, two individual case studies proved that these operations may be constructed upon validated north to north frameworks currently being utilised throughout the developed world (Ansari *et al.*, 2001; Bagayoko *et al.*, 2006).

The systematic comparative literature review identified that 42% of the case studies' pulling force has been attributed to the poor SSA healthcare environment and the immense disease burden (Johnston *et al.*, 2004; Piotti *et al.*, 2007). However, several of the studies explicitly stated they had been initiated to enable healthcare professionals from developed countries with access to medical cases they would not be able to access elsewhere (Geissbuhler *et al.*, 2003; Coulborn *et al.*, 2012). Thus, the SSA disease burden has been a partial driver for health-related TT in SSA.

4.3.4 Hard infrastructure outcomes

Section 4.3.4 aims to answer research question 3, with Figure 4-14 presenting the systematic comparative literature review's conclusions regarding physical infrastructure requirements per division of TT, shown in Figure 4-7. Figure 4-14 highlights that telecommunications infrastructure such as wireless networks, landlines, and mobile data services have been universally required regardless of the technology division (Geissbuhler *et al.*, 2003; Fuchs *et al.*, 2008; Kariuki, 2009). Additional requirements such as internet access, either satellite or fibre-based, and stable power supply have also been deemed universal (Akinsola, 2005; Lucas, 2008; Latourette *et al.*, 2011). However, Figure 4-17 also depicts the complex nature of the Health Information Systems (HIS) in SSA, as a variety of infrastructure components will be required. Internet access, implicit knowledge flows, HIS and telemedicine transfers require a greater variety of hard infrastructure when compared with the other technology classes identified in Figure 4-7.

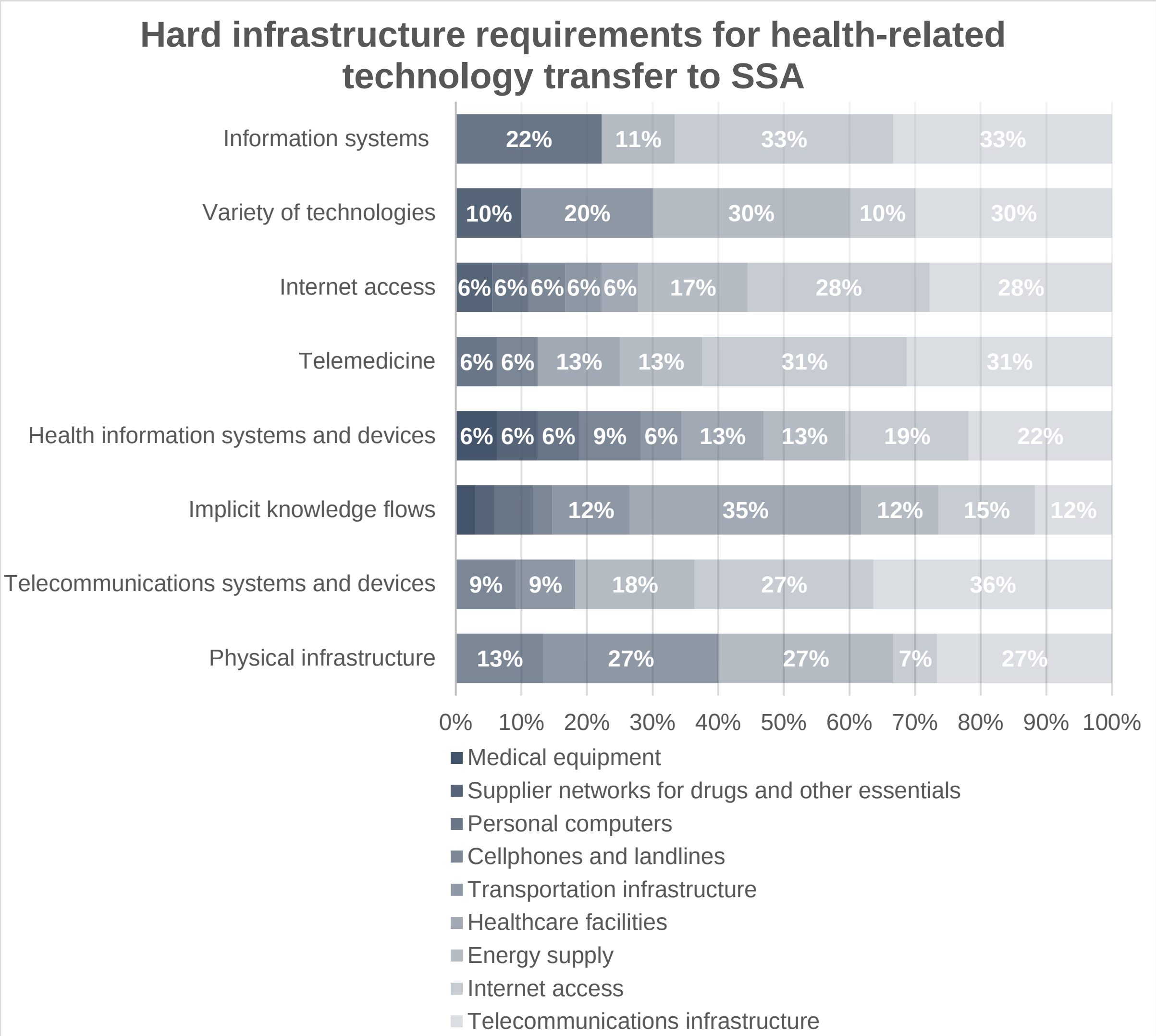

Figure 4-14 - Physical infrastructure requirements per technology division

All of these divisions, bar internet access, have particular importance to health-related TT, as literature argues these represent several cornerstones of e-Health TT to SSA (Nhampossa, 2005; Mengiste, 2010; Shiferaw *et al.*, 2012). As a result, Figure 4-15 has been constructed to provide an abridged version of Figure 4-14 by explicitly presenting the requirements of the e-Health related divisions of implicit knowledge flows, HIS and telemedicine.

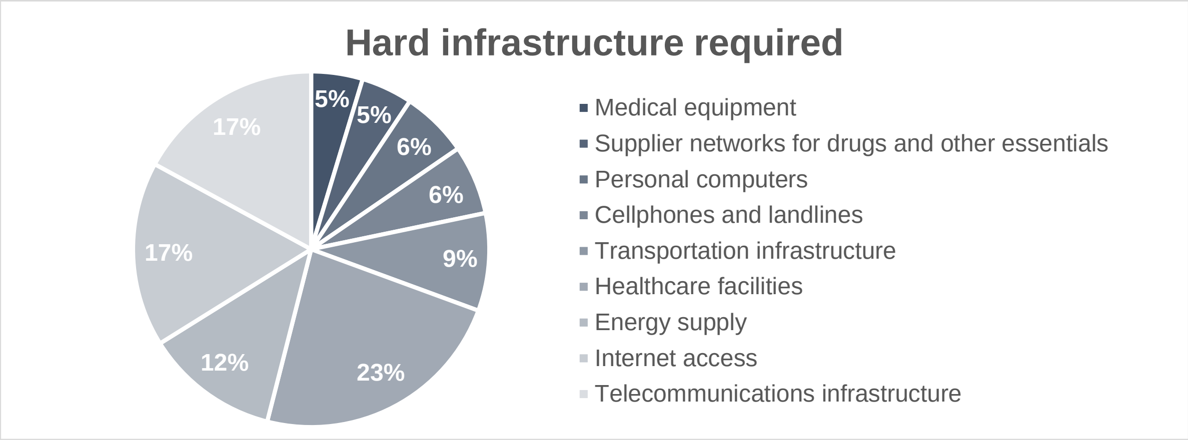

Figure 4-15 - Physical infrastructure requirement breakdown for all e-Health related divisions

Literature sources from both Chapter 3 and Chapter 4 have categorically stated that internet access, power supply and telecommunication infrastructure constitute the basic hard infrastructure requirements for any health-related TT (Geissbuhler *et al.*, 2003; Bagayoko *et al.*, 2006; Hoekman *et al.*, 2006; Latourette *et al.*, 2011). However, 25% of the literature items shown in Appendix B have concluded that SSA healthcare facilities may not possess the capability to utilise or adopt potential e-Health-related TTs (Geissbuhler *et al.*, 2003; Kimaro *et al.*, 2005; Meso *et al.*, 2009; Shiferaw *et al.*, 2012; Wamala *et al.*, 2013). Figure 4-14 and Figure 4-15 serves to answer research question 3 of the systematic comparative literature review.

4.3.5 Soft infrastructure outcomes

Section 4.3.5 attempts to answer research question 4 by providing insight into the intricacies of the intangible systems required by health-related TT ventures in SSA. Figure 4-16 summarises all the intangible systems identified in the systematic comparative literature review with Figure 4-17, Figure 4-18 and Figure 4-19 explicitly focussing on the e-Health cornerstones of HIS, telemedicine and implicit knowledge flows.

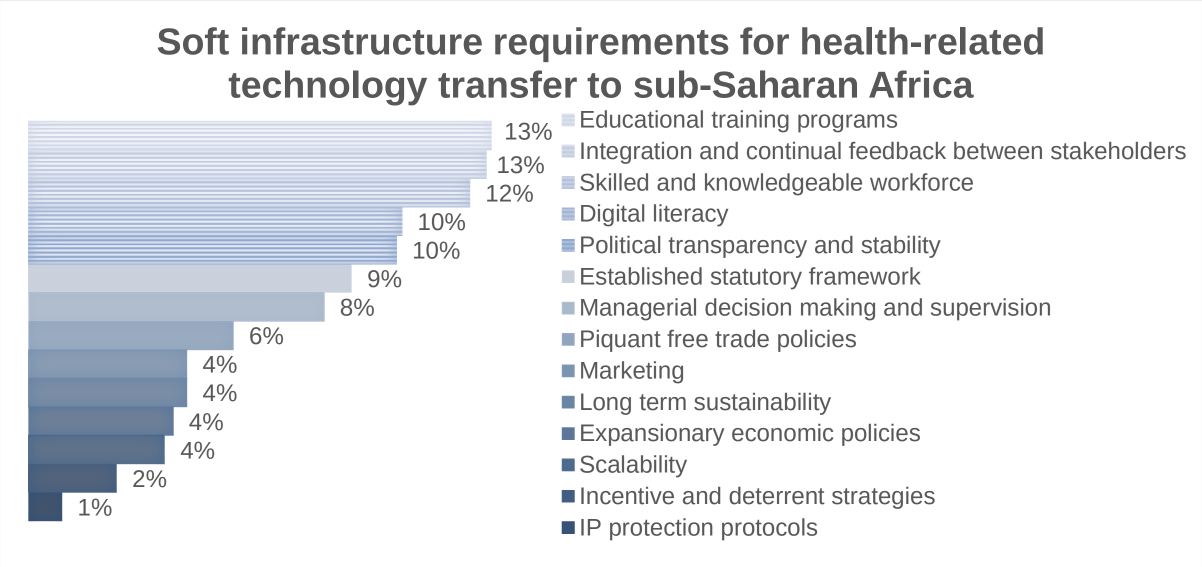

Figure 4-16 - Intangible infrastructure requirements for health-related technology transfer to sub-Saharan Africa

The systematic comparative literature review identified multiple intangible infrastructure requirements, seven of which accounted for 75% of the fourteen identified in total. Education, integration and communication between stakeholders, digital literacy, political stability and the level of human knowledge capacity among the labour market have been routinely stated as fundamental to the transferor (Bartels *et al.*, 2009; Mars, 2010; McKerlich *et al.*, 2013; Wamala *et al.*, 2013). If these requirements were not present, the transferor would either attempt to establish them in the transfer environment or abandon the TT venture (Ansari *et al.*, 2001; Heeks, 2002).

While Chapter 3 indicated that IP protection and licensing may be beneficial to TT (Hoekman *et al.*, 2006; Bozeman *et al.*, 2015), the systematic comparative literature review established that for SSA context these have been negligible with only two case studies referring to licensing advantages (Nhampossa, 2005; Ssewanyana *et al.*, 2007). Marketing and free trade policies have also been widely regarded as beneficial to health-related TT but these become immaterial if the more predominate soft infrastructure requirements are not in place (Chanda, 2002; Salicrup *et al.*, 2006).

When analysing the cornerstone divisions of e-Health in isolation, Figure 4-17, Figure 4-18 and Figure 4-19 underpin that the literature acknowledges educational programs and a skilled workforce represent primary soft infrastructure requirements (Karari *et al.*, 2011; Aranda-Jan *et al.*, 2014). However, political transparency becomes more influential as healthcare has primarily been championed by the domestic public sector (Akinsola, 2005; Schuppan, 2009; Cleeve, 2012). As a result, multi-nationals display hesitancy when committing resources into a foreign country which may be burdened by corruption or poor governmental procedures as TT failure becomes more probable (Renard, 2011).

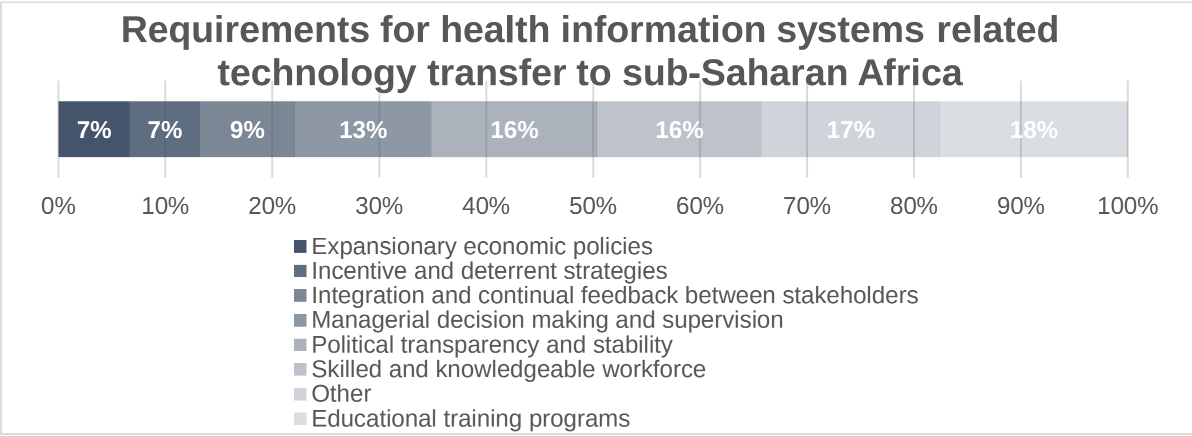

Figure 4-17 - Intangible infrastructure requirements of health information systems

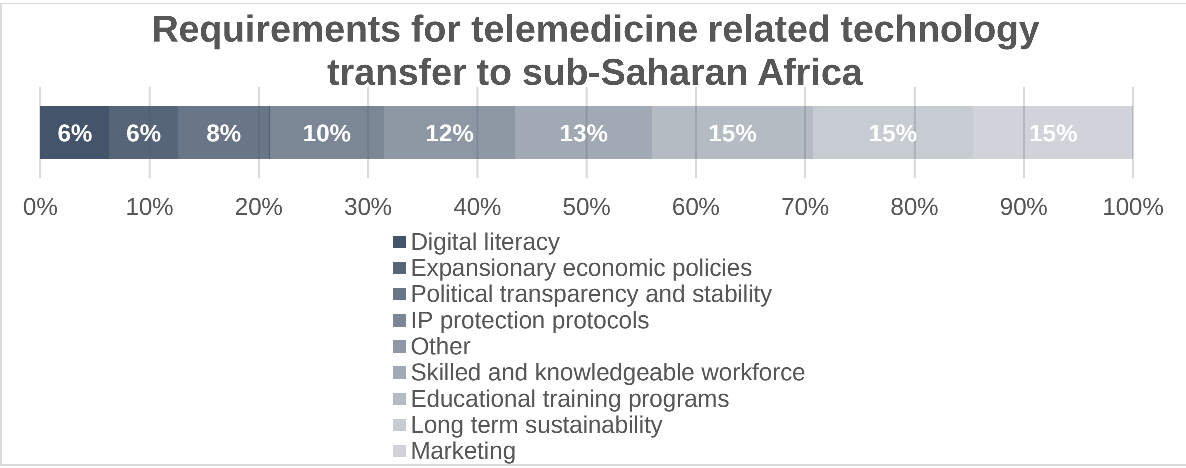

Figure 4-18 - Intangible infrastructure requirements of telemedicine

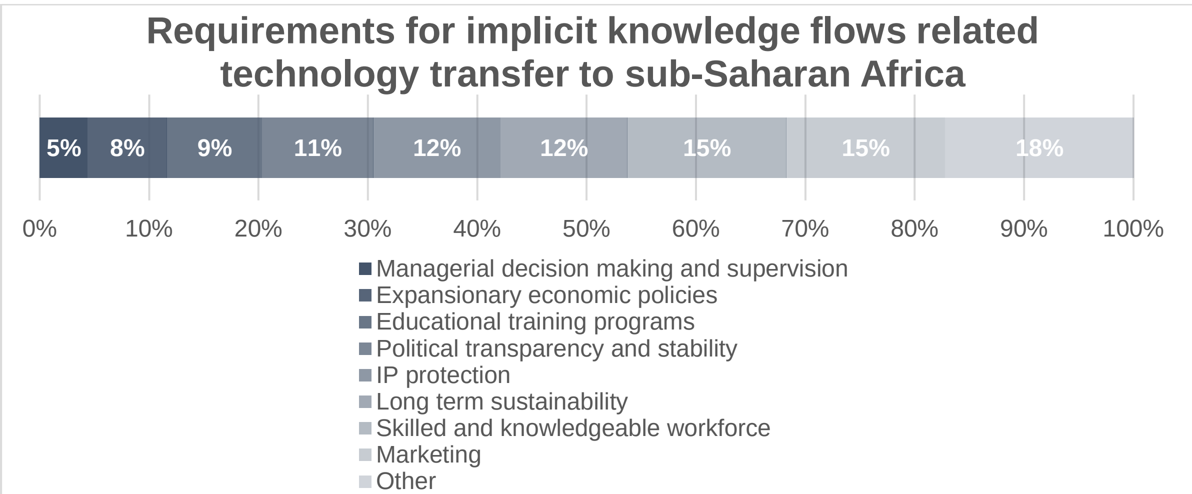

Figure 4-19 - Intangible infrastructure requirements of implicit knowledge flows

The systematic comparative literature review concluded that due to poor marketing schemes, healthcare institutes, professionals and even domestic governments were unfamiliar or oblivious to the transferred health technologies (Mutula, 2008). Thus, a strong marketing campaign has been identified as a primary requirement for the success of health-related TT (Bartels *et al.*, 2009). Case studies surrounding telemedicine and implicit knowledge flows also highlighted the requirement for sustainability procedures as short term unsustainable success has been a frequent occurrence (Shiferaw *et al.*, 2012; Wamala *et al.*, 2013; Aranda-Jan *et al.*, 2014). Figure 4-17, Figure 4-18 and Figure 4-19 conclude research question 4 of the systematic comparative literature review.

4.4 Chapter 4: Conclusion

The systematic comparative literature review in this chapter classifies the prevalence of established TT methods as discussed in the literature for the SSA context. The review has also identified from published sources that in terms of e-Health related TT the main transferors are multi-nationals and universities with the primary goal of expanding their market reach into the largely unsaturated area of SSA. Similarly, domestic conditions, largely created through policy actions, are geared towards attracting FDI from the developed world.

Telecommunications infrastructure, stable power supply and internet access dominate TT's requirements for physical infrastructure while education, training programs and a skilled domestic workforce are the major soft infrastructure requirements. When focussing on the e-Health components of the review, technology marketing programs and transparent domestic governments have also been deemed as substantial soft infrastructure requirements. Table 4-6 provides a summary of the systematic comparative literature review's research questions along with the corresponding figures that complete them.

Table 4-6 - Systematic comparative literature review's research question summary

Research question 1:	What are the major TT methods being utilised in SSA?	Refer to: Figure 4-9
Research question 2:	Who are the major stakeholders and what are their motivations in a SSA based TT venture?	Refer to: Figure 4-10; Figure 4-11; Figure 4-12; Figure 4-13
Research question 3:	Which physical infrastructure will be required in SSA for health-related TT to occur?	Refer to: Figure 4-14; Figure 4-15
Research question 4:	Which intangible infrastructure will be required in SSA for health-related TT to occur?	Refer to: Figure 4-16; Figure 4-17; Figure 4-18; Figure 4-19

Chapter 5. Conceptual framework development

Chapter 5 documents the development of the preliminary conceptual framework. The framework is based on the outcomes obtained from Chapter 3 and Chapter 4, with emphasis placed upon the various TT models, first identified in Section 3.3.7 and subsequently elucidated on in Appendix A. Initially, the research methodology followed in Chapter 5 is discussed in Section 5.1 followed by a discussion of the evaluation of the two-stage technology transfer model evaluation in Section 5.2, and a discussion of the evaluation and the amalgamation of the most prevalent TT models provided in Section 5.3. The resulting preliminary conceptual framework is thereafter presented in Section 5.4. The consolidation of the preliminary conceptual framework, through the use of evaluation instruments, is shown in Chapter 6. The key objectives of Chapter 5 are summarised in Figure 5-1 and the purpose of Chapter 5 within this research document is shown in Table 5-1.

Table 5-1 - The role of Chapter 5 within the research structure

<table>
<tr><th colspan="8">Document framework</th></tr>
<tr><td rowspan="2">Research objectives</td><td>i.</td><td>i. & ii.</td><td>i. & ii.</td><td>ii. & iii.</td><td>ii. & iii.</td><td>iii.</td><td>iii.</td></tr>
<tr><td colspan="4"></td><td colspan="2">iv.</td><td></td></tr>
<tr><td>Conceptual Framework Analysis phases</td><td>Map data sources</td><td>Categorise data</td><td>Identify concepts</td><td>Deconstruct concepts</td><td>Integrate concepts</td><td>Synthesis</td><td>Validate</td></tr>
<tr><td rowspan="2">Corresponding chapters</td><td colspan="2">Problem statement
Chapter 1</td><td colspan="3">Comparative literature review
Chapter 4</td><td colspan="2">TT facilitation tool
Chapter 6
Chapter 7</td></tr>
<tr><td></td><td colspan="3">Conceptual literature review
Chapter 3</td><td colspan="2">Conceptual framework
Chapter 5</td><td></td></tr>
</table>

Key outcomes

- Construct TT model evaluation criteria utilising elements identified during the completion of the literature reviews
- Evaluate and rank all identified TT models
- Amalgamate the highest-ranking TT models
- Syndissertation of a preliminary conceptual framework from the deconstructed TT models
- Supplement the conceptual framework by incorporating core elements identified during the completion of the literature reviews

Figure 5-1 - Key objectives of Chapter 5

5.1 Research methodology: Chapter 5

The research methodology of Chapter 5 is structured in such a way to enable the completion of phase 5 and phase 6 of the Conceptual Framework Analysis guidelines, shown in Figure 2-7. As the conceptual framework is tailored to health-related TT to SSA, the models identified in Table 3-14, requires an evaluation process to ensure their validity with respect to health-related TT as well as for developing country context. Section 5.1.1 illustrates the two-stage evaluation procedure undertaken to eliminate comparably irrelevant TT models and extract the TT models which exhibit maximum utility. The first evaluation stage utilised the Dynamic Research Configuration Criteria (Schut *et al.*, 2014), refer to Section 5.1.1.1, with the second stage utilising critical elements identified during the concluding sections of Chapter 3 and Chapter 4.

Section 5.1.2 depicts the method that is followed to conflate the final TT models and the outcomes of Chapter 3 and Chapter 4 into the practical clusters that create the foundation of the conceptual framework. This section thus provides a methodology that enables the completion of phase 5 of the Conceptual Framework Analysis guidelines. Phase 6 is subsequently completed after synthesising the results obtained from the integration phase into the conceptual framework; this is discussed in Section 5.4.

5.1.1 Evaluation of technology transfer models

The TT models summarised and outlined in Table 3-14 in Appendix A have been evaluated using Dynamic Research Configuration Criteria (Schut *et al.*, 2014), refer to Section 5.1.1.1, along with the critical factors identified in Chapter 3 and Chapter 4. The evaluation process consisted of two stages with the first stage consisting of individually analysing TT models to determine their general suitability. The TT models which progressed past the first evaluation stage had then been subject to an additional evaluation process to determine explicit suitability. To ensure promising features of inferior models could be captured, all rejected TT models have been screened for unique features that may provide additional or complementary utility to the conceptual framework.

An outline of the complete evaluation process is provided in Figure 5-2. The use of dual-stage evaluation allowed for all models to be evaluated by recognised academic evaluation criteria as well as supplementary criteria identified during Chapter 3 and Chapter 4. Thus, the models would be screened for structure, features, usability, content while also being ranked amongst each other.

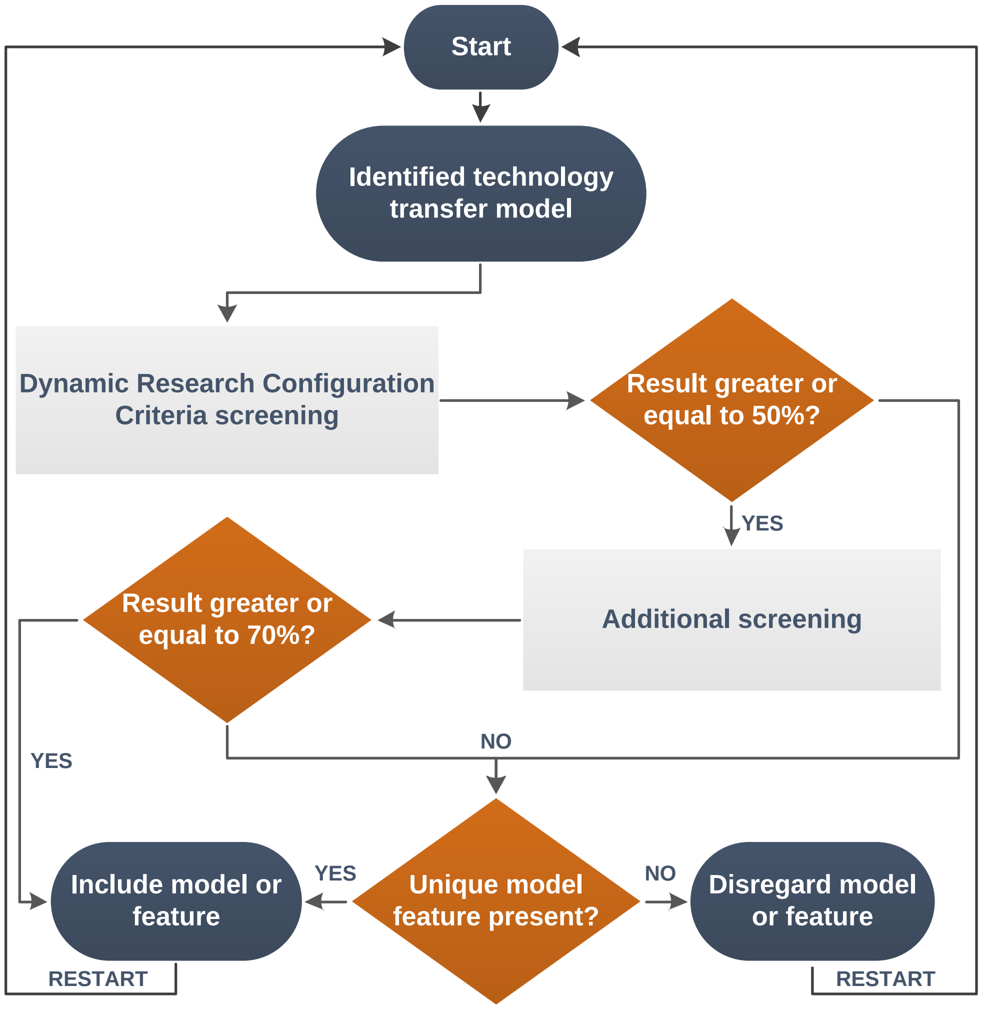

Figure 5-2 - Technology transfer models' evaluation process

5.1.1.1 Dynamic Research Configuration Criteria

The Dynamic Research Configuration Criteria has been chosen to evaluate the TT models as it provides researchers with multi-level evaluation criteria that encompasses many of the constructs required in a TT venture (Schut *et al.*, 2014). Figure 5-3 illustrates an example of the Dynamic Research Configuration Criteria for a project in the agricultural sector.

The evaluation framework investigates various scales, stakeholders, research-stakeholder interface, knowledge management and innovation management. These issues have been deemed critical by the systematic conceptual literature review undertaken in Chapter 3. Thus, the Dynamic Research Configuration Criteria had been deemed applicable for evaluating models pertaining to TT. Consequently, these criteria will be used to evaluate the selected TT models in order to ensure that only the TT models which align with this research project's aim and objectives, outlined in Section 1.4, are utilised.

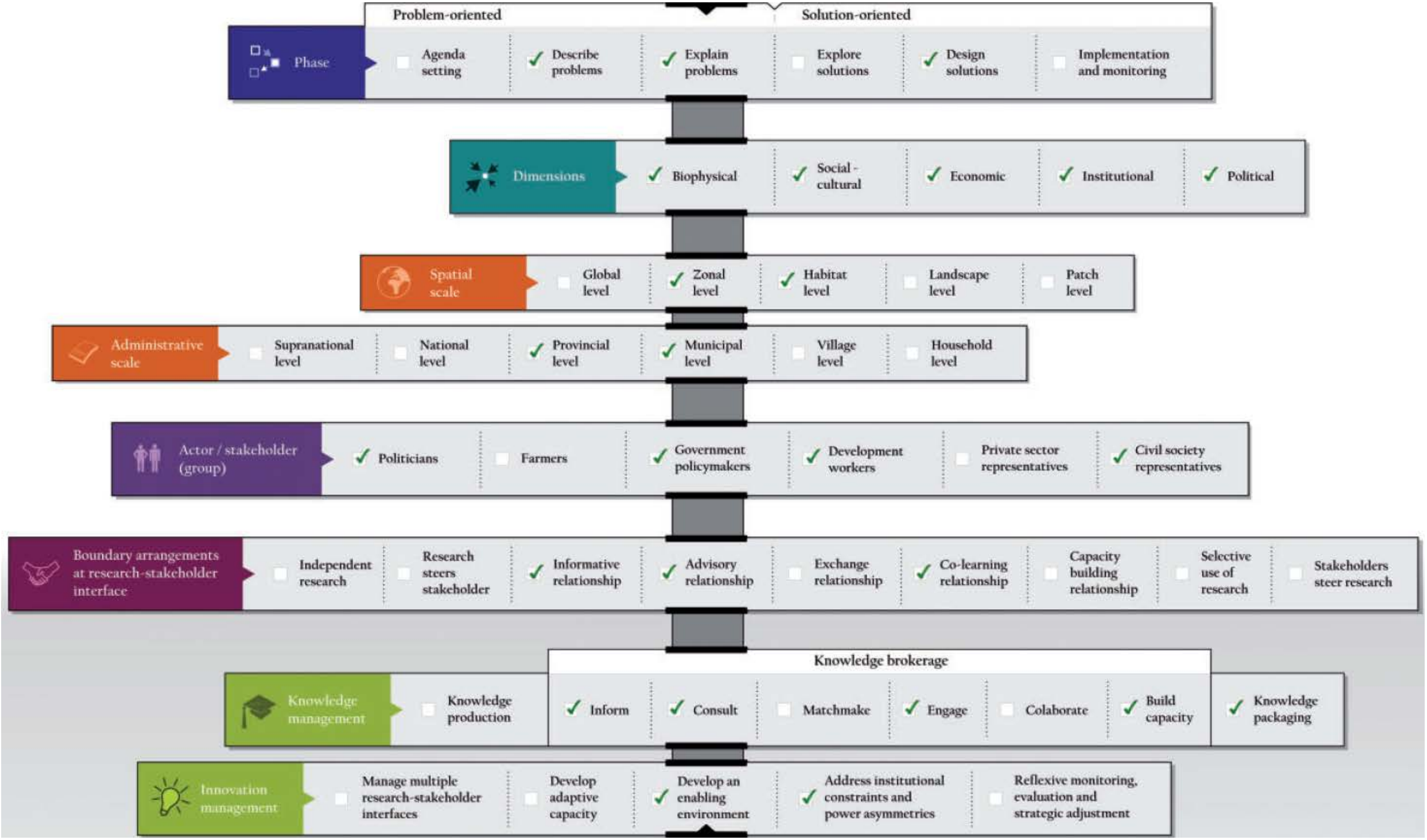

Figure 5-3 - Example of a dynamic research evaluation framework for agriculture (Schut *et al.*, 2014)

While Figure 5-3 provides an agricultural example of a completed evaluation by means of the Dynamic Research Configuration Criteria, several alterations have been made to ensure the final criteria reflect a TT environment. Changes to the dimensions, stakeholder group and involvement, spatial scale, administrative scale, knowledge management and innovation management have been incorporated from the resulting outcomes of Section 3.3 and Section 4.3 (Rebentisch *et al.*, 1995; Bozeman, 2000; Nhampossa, 2005; Golob, 2006; Hoekman *et al.*, 2006; Ann *et al.*, 2008; Mutula, 2008; Ramanathan, 2011; Shiferaw *et al.*, 2012; Bradley *et al.*, 2013; Bozeman *et al.*, 2015; Handoko *et al.*, 2016). The final blank evaluation template used for the first stage of the screening process is outlined in Table 5-2.

Table 5-2 - Revised Dynamic Research Configuration Criteria (derived from Schut et al. 2014)

Dynamic Research Configuration Criteria for a technology transfer context							
General criteria	Dimensions	Legal +1	Social +1	Economic +1	Institutional +1	Political +1	
General criteria	Stakeholder involvement	Public sector +1	Transferor +1	Transferee +1	TTO +1	Multi-nationals +1	Domestic firms +1
General criteria	Knowledge management	Knowledge production +1	Information channel +1	Consultation channel +1	Collaboration channel +1	Capacity building channel +1	
General criteria	Innovation management	Multiple research-stakeholder interfaces +1	Development of adaptive capacity +1	Development of an enabling environment +1	Addressing of constraints +1	Adaptive monitoring and strategic adjustment +1	
Research aim specific criteria	Spatial scale	Patch level +0	Landscape level +1	Zonal level +2	Global level +3		
Research aim specific criteria	Administrative scale	House level +0	Village level +1	Municipal level +2	Provincial level +2	National level +3	Supra-national level +3
Research aim specific criteria	Stakeholders' relationship	Isolated venture +0	Informative relationship +1	Advisory relationship +2	Exchange relationship +2	Co-learning relationship +3	Capacity building relationship +3

General TT criteria have been allocated a single mark, while the criteria directly relating to the research aim have been assigned an increasing scale. An individual TT model may adhere to multiple sub-sections for each of the general criteria but may only adhere to a single sub-section for each of the research aim-specific criteria. As shown in Figure 5-2, a TT model had to obtain at least eighteen of the thirty marks available in Table 5-2 to progress to the second evaluation stage. Although the marking system chosen for the model evaluation is arbitrary, it has been based on a previous example of an evaluation completed with the Dynamic

Research Configuration Criteria (Schut *et al.*, 2014). The first stage of the TT model evaluation process is presented in Section 5.2.1.

5.1.1.2 Supplementary evaluation criteria

This stage explicitly focusses on the elements of TT that have been categorically outlined as compulsory throughout literature. While several elements stem from the conceptual literature review presented in Section 3.3, the majority have been derived from the systematic comparative literature review as these directly adhere to the required geographic scope of SSA and industry sector of healthcare.

General TT criteria, shown in Table 5-3, have again been allocated a single mark, with an individual TT model able to adhere to multiple sub-sections for each of the general criteria. However, in contrast to the first stage of the TT model evaluation process, an individual model may only obtain a maximum of one mark for each of the general criteria. If a model does not adhere to any sub-sections of a general criterion it will have been assigned a mark of zero, and as with the first stage of the evaluation process, half marks may not be obtained. This ensures that the supplementary evaluation criteria identify models which contain elements directly linked to the critical requirements of a co-creation TT conceptual framework. Thus, this second evaluation focusses on ensuring models recognise these requirements to an extent.

Table 5-3 - Supplementary evaluation criteria

Additional evaluation criteria for a health-related SSA TT context: General criteria				
Implicit knowledge	Transfer of personnel	Codification of implicit knowledge		
Hard infrastructure	Analysis of transfer environment's physical infrastructure	Identifying hard infrastructure barriers		
Commercialisation	Technology roll out protocols	Management of technology for economic profit	Marketing of technology to potential funders	
Soft infrastructure	Training programs present	Incentive programs present	Collaboration programs present	
TT appraisal methods	Managerial checklists for TT process	Best practices for individual stages of TT	Revision protocols during and after TT process	
Marketing and advertising	Marketing of initial discovery or technology	Marketing to potential transferees	Advertising campaigns from start-up transferees	Advertising to different stakeholder groups
Change management	Integration protocols	Collaboration between transferor and transferee	Continued involvement of transferor after TT has been completed	Adaptive capability management of transferee

As shown in Figure 5-2, a TT model had to obtain at least five of the seven marks available in Table 5-3 to be included in the final pool of TT models. As before, the marking system of the supplementary evaluation criteria is arbitrary but serves to identify the TT models most aligned with the research objectives of this dissertation. The second stage of the TT model evaluation, using the supplementary evaluation criteria, is presented in Section 5.2.2.

5.1.2 Integrating concepts

Phase 5 of the Conceptual Framework Analysis, integrating concepts, requires the integration of identified concepts into concise clusters. To create these clusters, all major themes identified during the literature reviews are amalgamated. These amalgamations have then been conflated in conjunction with the resulting TT models and features, obtained from the two-stage evaluation process, to create a five-phase structure which serves as the skeleton structure of the conceptual framework. This integration methodology is discussed in Figure 5-4 with the completed integrated clusters shown in Section 5.3.

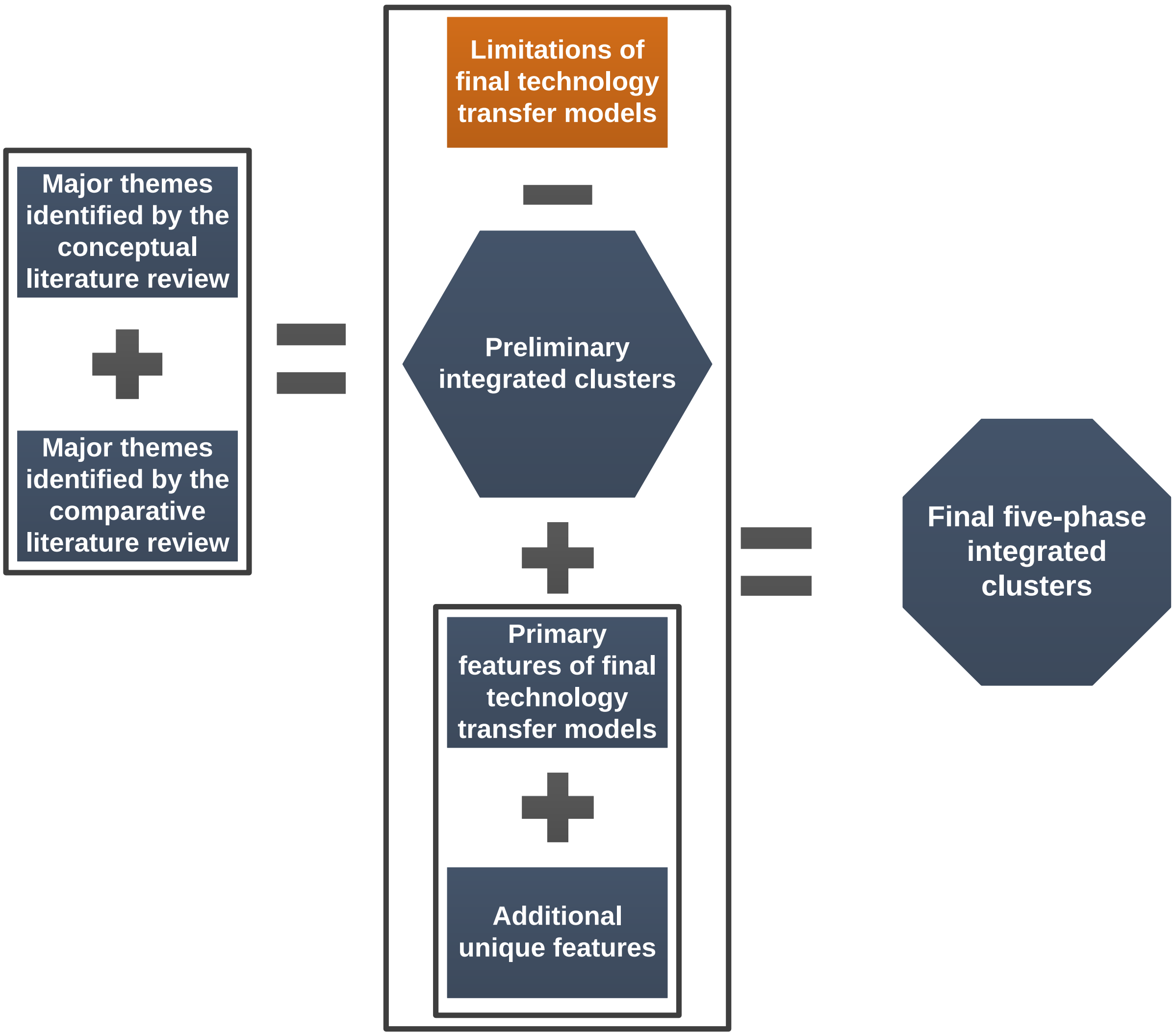

Figure 5-4 - Integration methodology

5.2 Two-stage technology transfer model evaluation

This section summarises the results of the two-stage TT model evaluation process. The first stage of the evaluation, shown in Section 5.2.1, produced four models for further screening. Subsequently, during the second TT model evaluation stage, shown in Section 5.2.2, an additional four TT models were eliminated after failing to acknowledge multiple TT requirements. The final three TT models include the Revised Levels of Involvement model, the Alternative Model of University TT and the Revised Contingent Effectiveness model. A single additional unique feature in the form of the stage-gate mechanism, obtained from the Stage-Gate model, has also been highlighted for use in the conceptual framework.

5.2.1 First stage of technology transfer model evaluation

As stated in Section 5.1.1.1, each model identified during the systematic conceptual literature has been subject to the Dynamic Research Configuration Criteria, shown in Table 5-2. This process is governed by the model evaluation flowchart shown in Figure 5-2. The individual grading tables of all thirteen TT models, identified in Section 3.3.7 and discussed in Appendix A, are provided in Appendix C.1. A summary of the first stage of the evaluation's results is presented in Table 5-4.

In instances where a TT model's original and revised version both achieved a pass mark, only the revised model is selected for further analysis. This ensures that the most prevalent models are included in the analysis, whilst eliminating repetition and/or duplication. The TT models that have achieved a grade mark higher than eighteen include: (i) the Revised Levels of Involvement model, (ii) the Interactive Broadcasting model, (iii) the Alternative Model of University TT, and (iv) the Revised Contingent Effectiveness model. These five models are highlighted in Table 5-4. Lastly, the revision mechanism from the Stage-Gate model has been included for further utilisation to ensure a degree of risk management and quality control will be incorporated into the framework's development.

Table 5-4 - Summarised results of the first stage evaluation of technology transfer models

	General criteria				Research aim specific criteria			
	Dimensions	Stakeholder involvement	Knowledge management	Innovation management	Spatial scale	Administrative scale	Stakeholder's relationship	Score
The Chantramonklasri model	1	0	2	0	2	2	1	8
Levels of Involvement model	**2**	**2**	**3**	**3**	**3**	**3**	**2**	**18**
Organisational Capabilities-Based model	0	2	3	4	2	1	2	14
Contingent Effectiveness model	**4**	**2**	**2**	**3**	**3**	**3**	**2**	**19**
Traditional TT model	2	4	3	1	2	1	0	13
Revised Levels of Involvement model	**2**	**4**	**3**	**5**	**3**	**3**	**2**	**22**
Interactive Broadcasting model	**2**	**2**	**3**	**3**	**3**	**3**	**2**	**18**
Traditional Model of University TT	4	4	2	1	2	2	2	17
Stage-Gate model	3	1	3	2	2	2	2	15
Policy Integration model	1	2	2	1	3	2	3	14
Alternative Model of University TT	**4**	**5**	**5**	**3**	**2**	**2**	**3**	**24**
Revised Contingent Effectiveness model	**4**	**2**	**3**	**3**	**3**	**3**	**2**	**20**
Knowledge in Technology Adoption model	**0**	**2**	**5**	**1**	**2**	**2**	**3**	15

5.2.2 Second stage of technology transfer model evaluation

After the initial TT model evaluation was completed in Section 5.2.1, the second stage evaluation of the resulting models is undertaken. This second stage ensures that each successful model must adhere to the evaluation criteria relevant to the fundamental requirements of health-related TT to SSA. As before, the second stage evaluation has been governed by the model evaluation flowchart shown in Figure 5-2. The individual grading tables of all seven models have been provided in Appendix C.2, with a summary of the second stage of the evaluation's results presented in Table 5-5.

The models that have achieved a grade mark higher than four included: (i) the Revised Levels of Involvement model, (ii) the Alternative Model of University TT and (iii) the Revised Contingent Effectiveness model all of which have been highlighted in Table 5-5. No additional unique features have been identified during the second stage evaluation.

Table 5-5 - Summarised results of the second stage evaluation of technology transfer models

		General criteria							
		Implicit knowledge	Hard infrastructure	Commercialisation	Soft infrastructure	TT appraisal methods	Marketing and advertising	Change management	Score
TT models	Revised Levels of Involvement model	1	0	1	1	1	1	0	5
	Interactive Broadcasting model	1	0	1	1	0	0	1	4
	Alternative Model of University TT	1	0	1	1	0	1	1	5
	Revised Contingent Effectiveness model	1	1	1	1	1	1	1	7

5.3 Construction of the conceptual framework's phases

Section 5.3 aims to complete the integration process described in Figure 5-4. As such, a summary of the selected TT models' characteristics, features and limitations are provided in Figure 5-5, Figure 5-6 and Figure 5-7 with the final integration of the outcomes of the selected TT models, shown in Table 5-6. Table 5-6 also presents the five clusters into which all identified elements have been incorporated.

Primary characteristics of the selected technology transfer models

Revised levels of involvement model

- The model provides managerial guidelines for each phase of TT whilefocussing on the importance of commercialisation in the final phase.
- The model emphasises optimisation while aiming to balance conflicting TT outcomes.
- The model highlights the importance of implicit knowledge transfer and promotes training and education programs.

Alternative model of university technology transfer

- The model focusses on research-based TT, while providing guidelines for implicit knowledge transfer between universities and domestic firms or multi-nationals.
- The model provides an inherent stakeholder analysis and provides suitable transfer methods for multiple cases.
- The model explains how to progress through the phases of TT while simultaneously providing insight of how stakeholders may influence each phase.
- The model promotes continual learning to refine current and future TT ventures.

Revised contingent effectiveness model

- The model explicitly analyses the transferor, transferee, transfer method, transfer object and transfer environment.
- The model enables TT evaluation by reviewing the transfer object's effectiveness when utilised by the transferee.
- The model accounts for stakeholder collaboration and suggests interactive feedback loops to promote communication.

Figure 5-5 - Summary of the primary characteristics of the selected technology transfer models

Unique features of the evaluated technology transfer models

Revised levels of involvement model

- The model provides best practices for each phase of TT through utilising the Technology Transfer Grid.
- The Technology Transfer Grid promotes the optimisation of motivation, equivocality, distance and communication.

Alternative model of university technology transfer

- The model provides guidelines tailored to university-based TT.
- The model clearly highlights the roles of TTOs in TT ventures.

Revised contingent effectiveness model

- The model provides Technology Transfer Effectiveness Criteria as well as managerial best practices to adhere to each criterion.
- The model recognises the need to evaluate the social welfare elements of TT.

Stage-gate model

- The model utilises revision check points, or stage-gates, to determine the feasibility and impact of TT continuation.

Figure 5-6 - Relevant unique features of all technology transfer models identified

Limitations of the approved technology transfer models

Revised levels of involvement model

- The model does not consider the requirement or influence of a regulatory structure.
- The model does not consider the requirement for change management in the TT process.
- No consideration is given to the infrastructure requirements of TT.

Alternative model of university technology transfer

- The model can only be utilised for university-based TT.
- The model has not been conducive towords the TT methods of FDIs, traditional transfer and trade agreements.
- The model does not consider the requirement for change management in the TT process.

Revised contingent effectiveness model

- The model does not perform stakeholder analysis and focusses on the transferor and transferee in isolation.
- The model does not consider the requirement or influence of a regulatory structure.

Figure 5-7 - Limitations and oversights of the approved technology transfer models

Table 5-6 - Integrating all identified concepts into clusters

Key themes identified in Chapter 3 and Chapter 4	Section reference	Cluster
Evolution of technology transfer	Section 3.3.1	Technology development
Introduction phase of technology transfer	Table 3-10	
Alternative model of university technology transfer	Figure 5-5 - Figure 5-7	
Classification of the transferor, transferee and transfer object as well as the interaction between them	Figure 5-5 - Figure 5-7	
Identification of stakeholders and their responsibilities	Section 3.3.3	Technology analysis
Technology transfer barriers	Section 3.3.6.1 - 3.3.6.3	
Identification of stakeholders, their responsibilities and motivations	Section 4.3.3	
Infrastructure requirements	Section 4.3.4 and Section 4.3.5	
Interactions between stakeholders	Section 3.3.3 and Section 3.3.5.3	Transfer method application
Technology transfer methods	Section 3.3.4	
The role of knowledge transfer	Section 3.3.5	
Technology transfer methods	Figure 4-9	
Collaboration between stakeholders	Section 4.3.5	
Adoption phase of technology transfer	Table 3-10	Change management
Technology transfer barriers	Section 3.3.6.4	
The Technology Transfer Grid	Figure 5-5 - Figure 5-7	
Utilising the transfer environment's available infrastructure	Section 4.3.4 and Section 4.3.5	
Integration phase of technology	Table 3-10	Commercialisation
Revised Levels of Involvement model	Figure 5-5 - Figure 5-7	
Technology transfer Effectiveness Criteria	Figure 5-5 - Figure 5-7	
Implementing outcomes from previous technology transfer ventures	Figure 5-5 - Figure 5-7	
Requirement for marketing	Section 4.3.5	
Achieving sustainability	Section 4.3.5	

5.4 The conceptual framework for health-related technology transfer

The five resulting clusters from the integration phase, phase 5 of the Conceptual Framework Analysis, are utilised to facilitate a TT venture through its typical maturity cycle as shown in Figure 5-8. Thus, Figure 5-8 has been derived from Table 5-6, and serves as the outline of the conceptual framework shown in Figure 5-9. The five phases of the conceptual framework are structured in such a way to promote co-creation principles due to the proclivity of stakeholder collaboration, integration and knowledge transfer in Table 5-6 as well as the frequent occurrence of these elements in both Chapter 3 and Chapter 4 and the selected TT models.

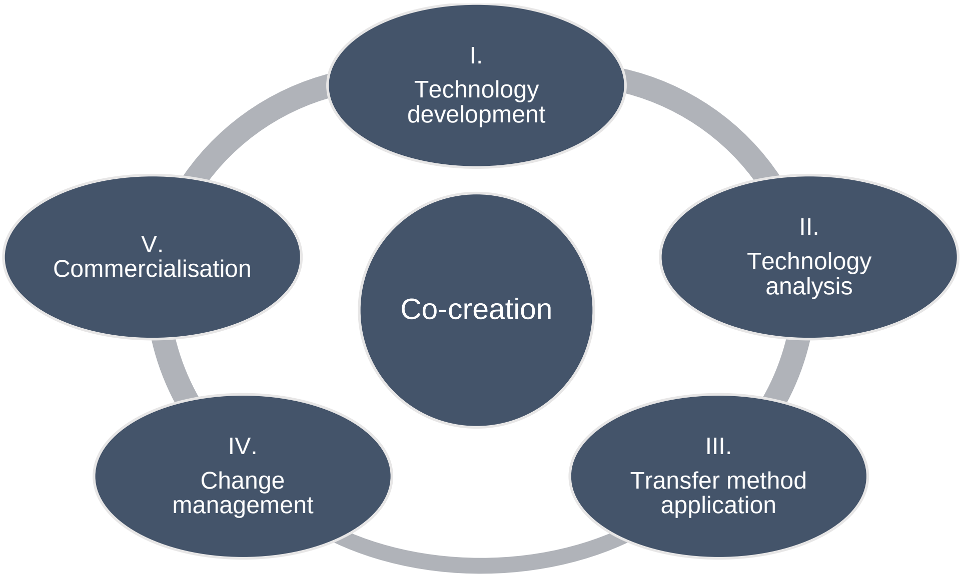

Figure 5-8 - Outline of the conceptual framework

Each phase of the conceptual framework contains a series of interconnecting nodes. Nodes may be linked within a phase as well as across phases. Thus, the framework encourages all users to familiarise themselves with the entire process before initiating Phase I. Section 5.4.1 to Section 5.4.5 provide an exposition of the framework by detailing the considerations and best practices for all nodes as well as the required relationship linkages between nodes and phases. Lastly, the co-creation outcomes for each phase are outlined throughout Section 5.4.1 to Section 5.4.5.

To improve the framework's conciseness all referencing has been omitted from the tables and figures presented in Section 5.4. However, all academic literature sources utilised during the creation of the conceptual framework have been made available for review in Appendix D. The sub-sections of Appendix D present the references corresponding to the individual phases of the conceptual framework.

The framework aims to assist a user in constructing a TT team which can subsequently progress through the five phases of the framework. This transfer team will initially comprise of the primary TT stakeholders, the transferor and transferee, but will continually be expanded to include additional stakeholder entities that either possess utility for individual TT phases or for the TT as a whole. The framework attempts to guide the transferor team by providing multiple considerations and best practices for the technology's development, analysis and subsequent transfer. After the technology has been transferred, several change management practices have also been provided which, when implemented in conjunction with the commercialisation phase, will provide the TT with a basis to achieve sustainability and further its dissemination.

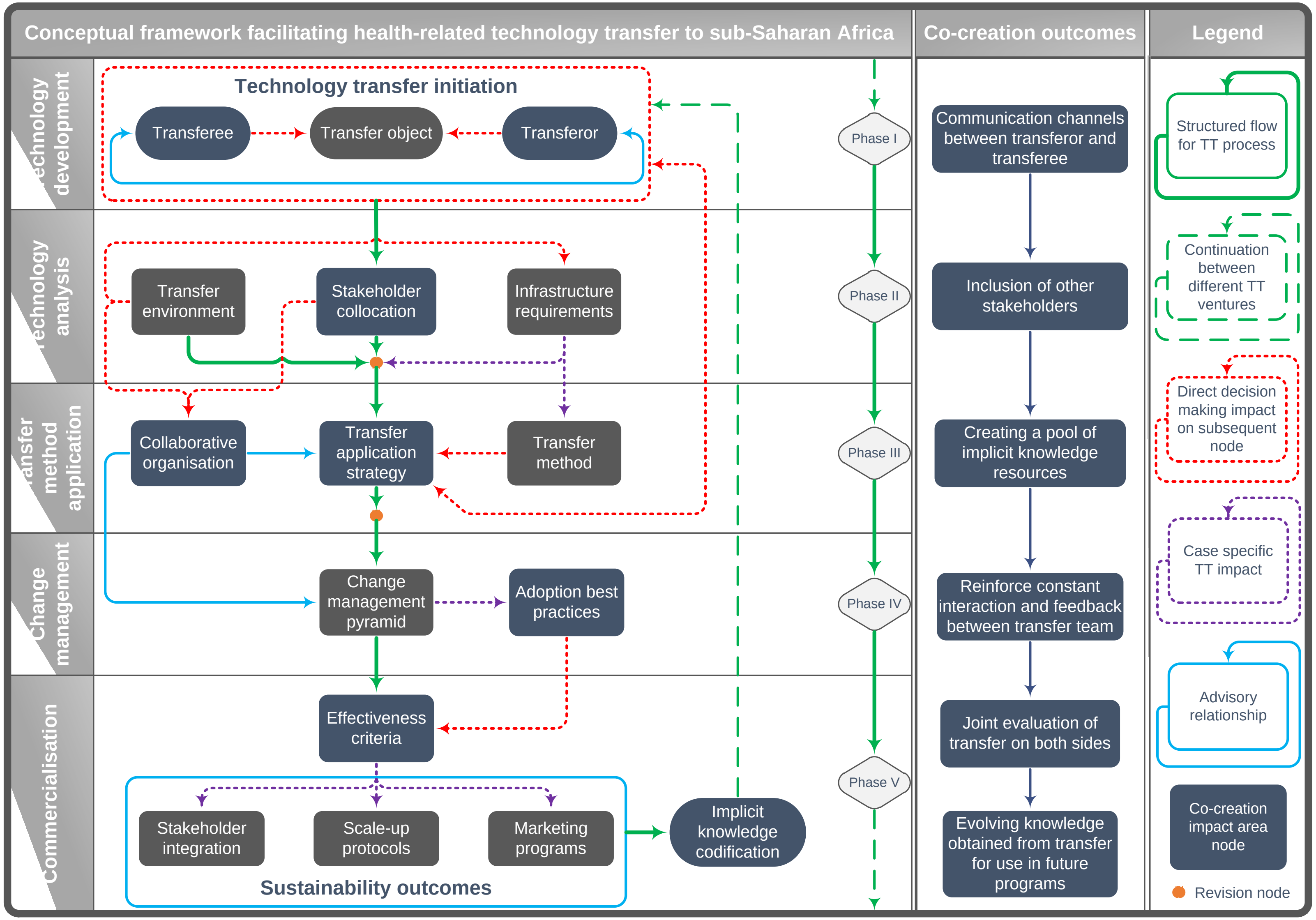

Figure 5-9 - Preliminary conceptual framework facilitating health-related technology transfer to sub-Saharan Africa

5.4.1 Phase I: Technology development

When reviewing Figure 5-10, Phase I of the TT framework revolves around the transferee, the transfer object and the transferor. The systematic conceptual literature review highlighted these three nodes as universal starting points of analysis for all pending TT ventures (Teece, 1977; Bozeman, 2000; Bradley *et al.*, 2013). In addition, the systematic comparative literature review indicated that the transfer object's development serves as a common TT initiation point. However, in Chapter 4 it was also highlighted that transfer objects may be at various stages of maturity when transferred. Thus, the framework has been structured to create a common base which provides all TT ventures with a universal starting point.

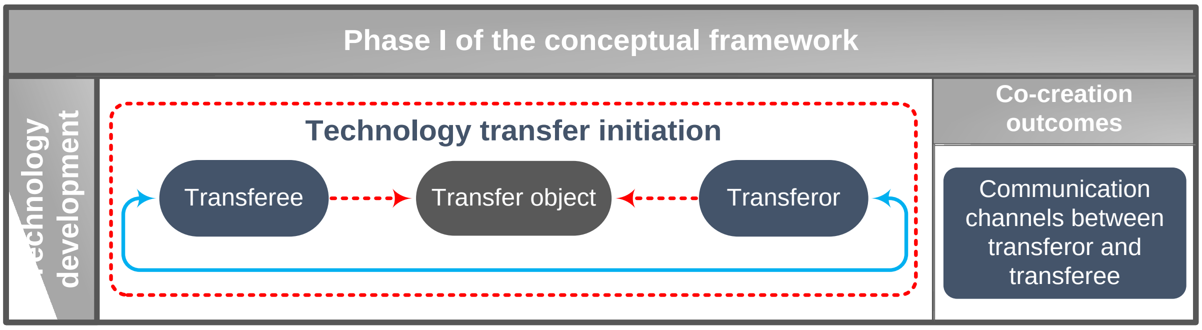

Figure 5-10 - Phase I of the conceptual framework

The transferee and transferor are likely to impart direct influence over the transfer object, while the inverse may not always remain constant (Ramanathan, 2011; Manimala *et al.*, 2013). Thus, while multiple case studies analysed during the completion of Chapter 4 utilised the transfer object as an initiation node, this framework encourages the user to either utilise the transferee or transferor node. However, due to the interlinked nature of these nodes (Bozeman, 2000; Bradley *et al.*, 2013), utilisation of the transfer object as an initiation point has not been categorically excluded from Phase I of the framework.

All three nodes, i.e. the Transferee, Transferor and Transfer object, must be incorporated, regardless of the chosen initiation node, before Phase I can be concluded. The various case studies analysed during Chapter 3 and Chapter 4 highlighted the probable failure of TT ventures founded upon isolated considerations. Accessibility and other constraints may restrict the user to a solitary node consideration when first initiating the TT. However, the framework's design attempts to alleviate these constraints by rapidly forcing joint integration between all three nodes.

The remainder of Section 5.4.1 highlights the individual consideration of the technology development nodes, while Section 5.4.1.3 provides an instrument to interlink the nodes and ensure that the co-creation outcome of Phase I can be achieved. Before the user commences with Phase I, careful consideration must be paid to the knowledge codification best practices illustrated in Table 5-27. This will aid in ensuring that a uniform standard can be established for data capturing and subsequent maintenance of such data when progressing through the conceptual framework. Every node completed in this conceptual framework must adhere to these data capturing best practices shown in Table 5-27.

5.4.1.1 The transferee and the transferor

Table 5-7 outlines all characteristics that must be considered by the user. At this point, it is important to state that the *"user"* may refer to multiple stakeholders as it is the stakeholder initiating the TT. For most cases, this will either be the transferee or transferor. As stated in the guidelines for the revision node in Phase II, these characteristics must also be routinely re-examined as the TT venture progresses. The considerations shown in Table 5-7 will also facilitate the development of the required communication channels between the transferor and transferee.

Table 5-7 - Considerations for the transferee and the transferor nodes

Node: Transferee	
Primary focus	**The transferee's capability to participate in the technology transfer**
Considerations	- The transferee's primary motivations and pulling forces behind the proposed TT. - The economic scale of the transferee and the transferee's available resources that could sustainably be committed to the transfer. - The transferee's constituents and the relationships between these constituents if the transferee comprises out of more than a single entity. - The transferee's current experience surrounding TTs and access to codified knowledge of previous transfers of a similar nature. - The transferee's available personnel capable of TT facilitation, transfer object training and stakeholder communication. - The scale of the transferee's internal and external marketing department. - The availability of a TTO, either directly or indirectly, in the transferee's setting. - The transferee's opportunity cost of the transfer.
Node: Transferor	
Primary focus	**The transferor's capability to participate in the technology transfer**
Considerations	- The transferor's primary motivations and pushing forces behind the proposed TT. - The transferor's constituents and the relationships between these constituents if the transferor comprises out of more than a single entity. - The transferor's current technology development and TT experience as well as access to codified knowledge of previous transfers of a similar nature. - Identifying the transferor's political and social constraints as well as evaluating how these constraints may restrict transferor's ability to perform the proposed TT. - The transferor's available personnel capable of TT facilitation, transfer object training and stakeholder communication. - The manner and totality of the transferor's legal ownership of the transfer object. - The availability of a TTO, either directly or indirectly, in the transferor's setting. - The transferor's opportunity cost of the transfer.

The transferee and transferor constitute the primary stakeholders in every TT venture (Bozeman *et al.*, 2015). They may often serve as the transfer's economic, social or political pull and push force and to ensure a successful TT venture, they must actively be incorporated throughout the transfer (Bozeman, 2000; Handoko *et al.*, 2016). Thus, the user must ensure detailed appraisal of these stakeholders by documenting their resources, motivations, constraints, experience, industry and legal system.

It will not be uncommon for the user of this TT framework to appropriate the role of either the transferee or transferor and, although rare, in select intra-firm transfers the user may appropriate both the roles of transferor and transferee. In such instances, the user should progress through Phase I by incorporating a third party, such as a TTO, or through self-analysis.

Table 5-8 provides the user of this framework with various considerations surrounding the relationship between the transferee and transferor as well as managerial best practices. These managerial best practices have been expanded upon in Figure 5-11 and Figure 5-12 to provide the user with an instrument with which to establish the co-creation transfer team required to champion the transfer.

Table 5-8 - Preliminary stakeholder considerations and best practices

Relationship: Transferor and transferee	
Primary focus	**Establishing the required relationship between the primary stakeholders**
Considerations for the initial transfer team	- The potential exists for both a positive and a negative correlation between the geographic distance of the stakeholders and the effectiveness and frequency of their communications. - The transferee and transferor may adhere to different economic, social and political constraints. - The similarities and discrepancies of the legal system in which both stakeholders operate. - The mutual communication methods available to the stakeholders. - What protocols have been put in place for implicit knowledge transfer. - The feasibility and opportunity cost for co-creation TT considering both stakeholder's perspectives, agendas and available resources.
Managerial best practices for the initial transfer team	- The creation of a strategic business alliance will ensure the promotion of a co-creation TT team. - The magnitude of the difference between the stakeholder's social, economic and political constraints should be counterbalanced by predefined and integrated business strategies from both stakeholders. - A predefined communication system should be incorporated along with daily communication between the transferee and transferor. - Both the transferee and transferor should assign dedicated personnel to the TT with the aim of creating a transfer team capable of outlining and achieving the TT's objectives and prerequisites. - The transferor should create training programs for the transferee to accommodate for lacking experience. - A managerial hierarchy should be created. - The managers of this hierarchy should motivate the transfer team through incentives and advertising previous successes. - Both stakeholders should be actively involved in the design or modification of the transfer object to promote adoption in Phase IV.

5.4.1.2 The transfer object

While the transferee and transferor represent the primary stakeholders, the transfer object represents the central nexus of the entire transfer (Bozeman, 2000; Ramanathan, 2011; Handoko *et al.*, 2016). The transfer object may comprise multiple forms of tangible and intangible objects such as physical artefacts, raw resources, tooling, software systems, knowledge, and safety protocols. Although certain transfer object characteristics remain universal regardless of form, the variety of transfer object forms requires that required knowledge for utilisation also be evaluated (Handoko *et al.*, 2016). Thus, Table 5-9 has been segmented to ensure the user identifies the appropriate explicit and implicit knowledge characteristics which may accompany the transfer object.

Transfer objects often require a combination of both explicit and implicit knowledge, an example being the transfer of experienced manufacturing personnel (Handoko *et al.*, 2016). This dual knowledge requirement will typically be more prevalent in intangible transfer objects or when the knowledge requirements may be ambiguous. Regardless, the user must evaluate both segments of Table 5-9 to ensure that the transfer team has been made aware of the different knowledge requirements of the proposed transfer object.

Table 5-9 - The transfer object's considerations

Node: Transfer object	
Primary focus	**Deconstructing the transfer object's characteristics**
Universal transfer object considerations	
- The transfer object's ability to be transferred. - The industries or sectors in which the transfer object operates. - The transfer object's legal protection. - The purpose and utility of the transfer object for both transferee and transferor. - The transfer object's maturity and total useful life. - The systems, if any, within which the transfer object functions. - The sub-systems required, if any, for the transfer object to effectively operate. - The technological complexity of the transfer object in terms of ease of manufacturing, utilisation, modification and maintenance.	
Explicit knowledge considerations	**Implicit knowledge considerations**
- The form or system in which the codified knowledge regarding the transfer object has been stored. - The complexity of this codified knowledge. - Any legal constraints preventing access to codified knowledge and its duplication or dissemination. - Potential language barriers prohibiting effective explicit knowledge transfer.	- The form or system in which the implicit knowledge regarding the transfer object has been stored. - The feasibility of effective implicit knowledge transfer through modern communication channels. - The success of any previous attempts at implicit knowledge codification regarding the transfer object or a transfer object of a similar nature. - The feasibility of the codification of the implicit knowledge regarding the transfer object. - The possibility of personnel transfer acquainted with the transfer object characteristics. - Cultural or social constraints barring implicit knowledge transfer.

5.4.1.3 Establishing the co-creation transfer team

The structure of Phase I has been designed to ensure that the user identifies the characteristics of all three primary nodes required at any TT's initiation. This ensures that the framework provides accessibility to any potential user, regardless of which TT stakeholder they may be affiliated with. While, at first, these nodes may be individually evaluated, Section 5.4.1.3 emphasises the first co-creation outcome of the conceptual framework. Referring to

Figure 5-10, the relationships between the nodes consist of the interactions between the transferee and transferor as well as their influence over the transfer object.

The conceptual framework aims to ensure that the transferee and transferor form a relationship to either create a new transfer object, or to modify an existing transfer object into a form which may be conducive to the individual goals of both the transferee and transferor. To aid in establishing this relationship, a preliminary stakeholder screening instrument has been provided in Figure 5-11 which outlines various levels of co-creation a transfer team may adhere to. These levels are based on the quality and frequency of the interactions between the transferor and transferee. The user must implement Figure 5-11 in conjunction with Figure 5-12 to determine the current status of the relationship between the primary stakeholders and subsequently attempt to assimilate the characteristics of the higher levels depicted in Figure 5-12.

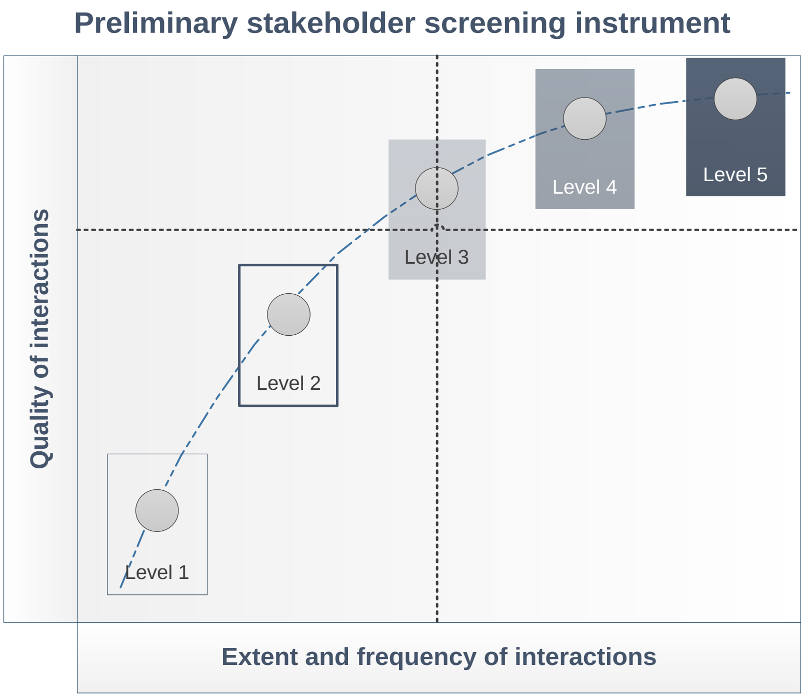

Figure 5-11 - Preliminary stakeholder screening instrument

The transferor and transferee should in all scenarios attempt to attain a Level 5 relationship; the criteria of which has been shown in the extended stakeholder level screening instrument, shown in Figure 5-12. However, if the transferor and transferee suffer from monetary or time-related restrictions, a Level 3 relationship will provide a sufficient foundation for the subsequent phases of this framework. As the extended stakeholder screening instrument provides the foundations to accommodate more complex relationships between the multiple stakeholders incorporated in Phase II, the framework strongly denounces further progression until a Level 3 relationship has been attained.

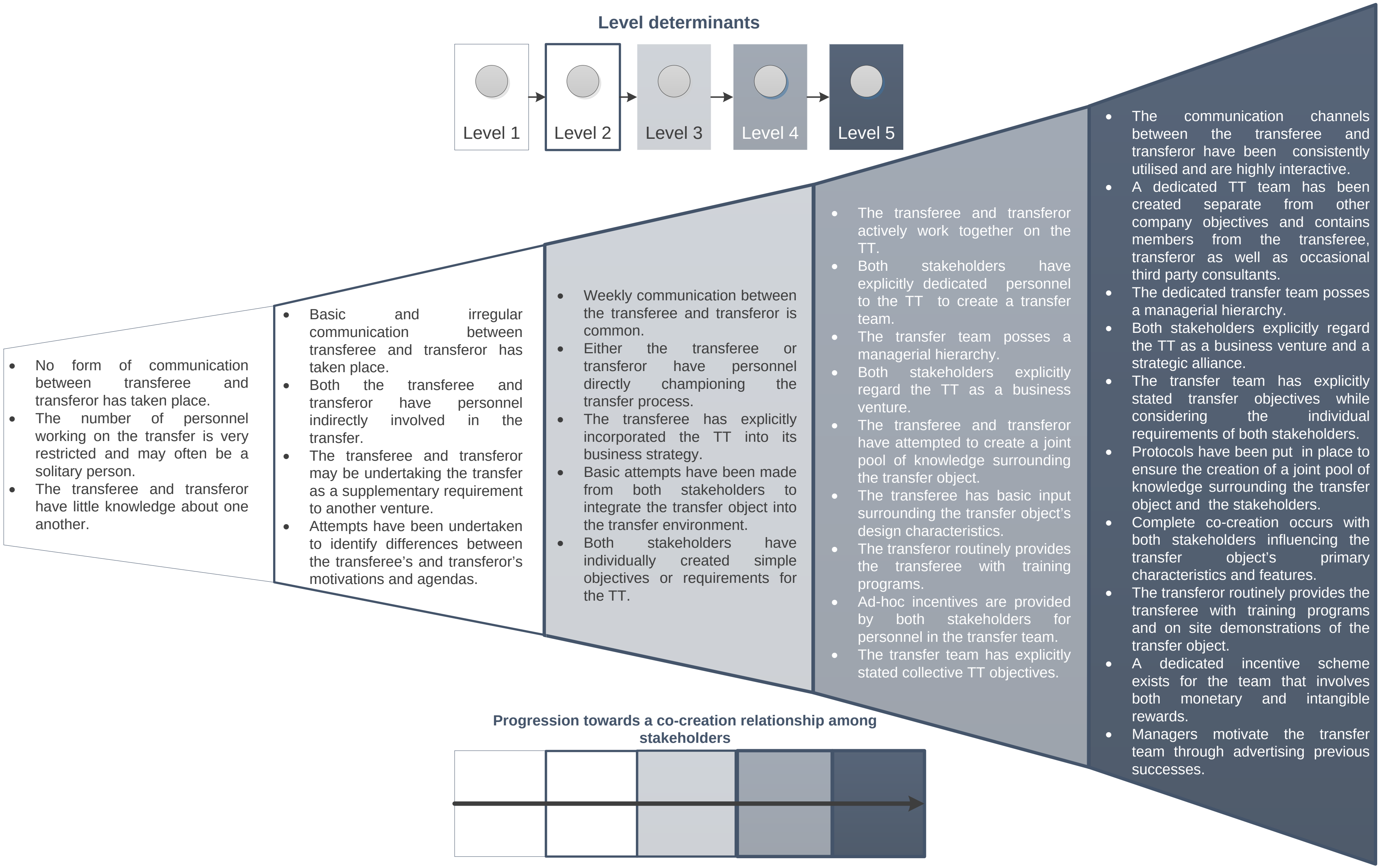

Figure 5-12 - Extended stakeholder screening instrument

5.4.2 Phase II: Technology analysis

When reviewing Figure 5-13, the second phase of the conceptual framework aims to broaden the pool of potential stakeholders that may be advantageous to the TT venture. As such, Phase II provides an expansion of the preliminary stakeholder analysis completed during Phase I. This broadened stakeholder analysis ensures that all relevant stakeholders are identified, in addition to promoting integration and co-creation policies between all parties involved in the TT. Furthermore, the primary stakeholder roles, responsibilities, key considerations and managerial best practices are outlined in Figure 5-14.

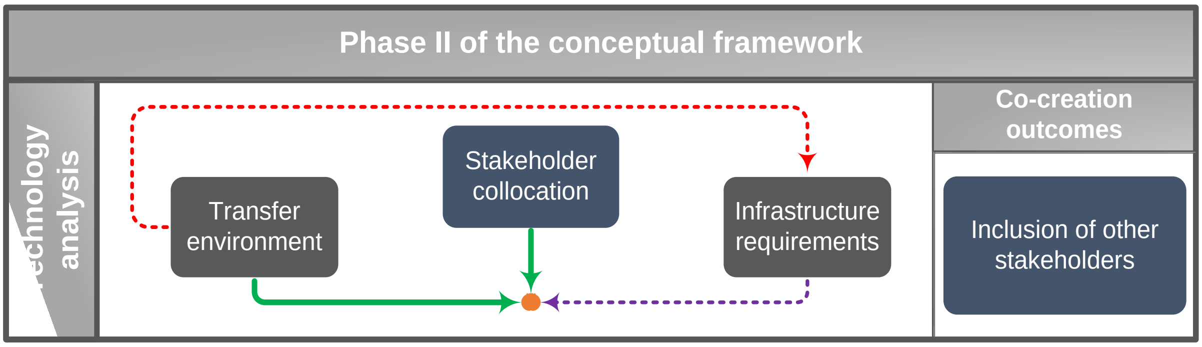

Figure 5-13 - Phase II of the conceptual framework

Phase II also allows the user to screen the transfer environment, also known as the transferee's environment, and provides an instrument with which the user may compare the transferee's and transferor's technology environments[5]. Thus, when combined with the transfer object considerations of Phase I, Phase II will enable the user to develop a foundation where the major sub-system requirements, inadequacies and transfer object characteristics have been documented. These identified elements allow the user to allocate the provided managerial best practices to the predetermined stakeholder roles and responsibilities shown in Figure 5-14.

The framework proposes that the user incorporates hard and soft infrastructure components while evaluating the transfer environment. These additional transfer environment considerations have been included in accordance with the outcomes of Chapter 4. The analysis of the transfer environment also marks the first node in the framework that has been specifically tailored to health-related TT to sub-Saharan Africa.

[5] The technology environment refers to the transferor's or transferee's immediate market environment and encapsulates the setting's social, political, cultural, economic, scientific, structural, geographic and technological characteristics (Rebentisch *et al.*, 1995; Bozeman, 2000; Golob, 2006; Hoekman *et al.*, 2006; Mutula, 2008; Bradley *et al.*, 2013; Bozeman *et al.*, 2015; Handoko *et al.*, 2016)

Lastly, Phase II forces the evaluation of the TT's current state when completing a revision node. This stage-gate feature attempts to mitigate compounded future loss by halting the transfer process if the results of Phase I and Phase II indicate that a successful TT venture will be improbable (Ramanathan, 2011). The revision node requires the user to systematically evaluate several outcomes from the first two phases while providing both a summary of guidelines and potential warning signals.

5.4.2.1 Stakeholder collocation

This node is founded upon the preliminary stakeholder screening instrument. As such, the user must ensure that the characteristics of high-level co-creation remain constant irrespective of the stakeholder additions to the transfer team. The alignment of stakeholder agendas with regards to integration and co-creation should be a critical outcome when completing all phases of this conceptual framework (Nhampossa, 2005; Smith *et al.*, 2008).

Constructed upon the outcomes of Section 3.3.2, the complete stakeholder collocation, depicted in Figure 5-14, includes the public sector, primary research institutions, multi-nationals and TTOs in addition to the joint transfer team that has been established in Phase I. This collection of stakeholders represents the major participants that would typically be required for a successful health-related TT venture (Philip F Musa *et al.*, 2005; Hoekman *et al.*, 2006; Mazurowski, 2006; Anderson *et al.*, 2007; Ryu *et al.*, 2010; Zhang *et al.*, 2016). The inclusion of additional stakeholders ensures the framework does not disregard case-specific or unorthodox stakeholders.

Figure 5-14 also highlights the primary roles and responsibilities of the TT's stakeholders. While narrowing the scope of this framework to health-related TT to developing SSA countries may eliminate or reinforce certain attributes, TT allows for substantial divergences with regards to the allocation of stakeholder roles and responsibilities (Ansari *et al.*, 2001; Siegel *et al.*, 2004; McKerlich *et al.*, 2013). As such, the framework does not attempt to limit the user by assigning definite roles and responsibilities to specific stakeholders. Consequently, the user will not be required to incorporate all the extended stakeholders shown in Figure 5-14 if they have been deemed gratuitous. However, modular guidelines have been provided in Table 5-10 which outline the typical roles certain stakeholders would champion along with best practices for all primary roles. Similarly, Table 5-11, Table 5-12 and Table 5-13 provide managerial best practices for all responsibilities outlined in the complete stakeholder collocation.

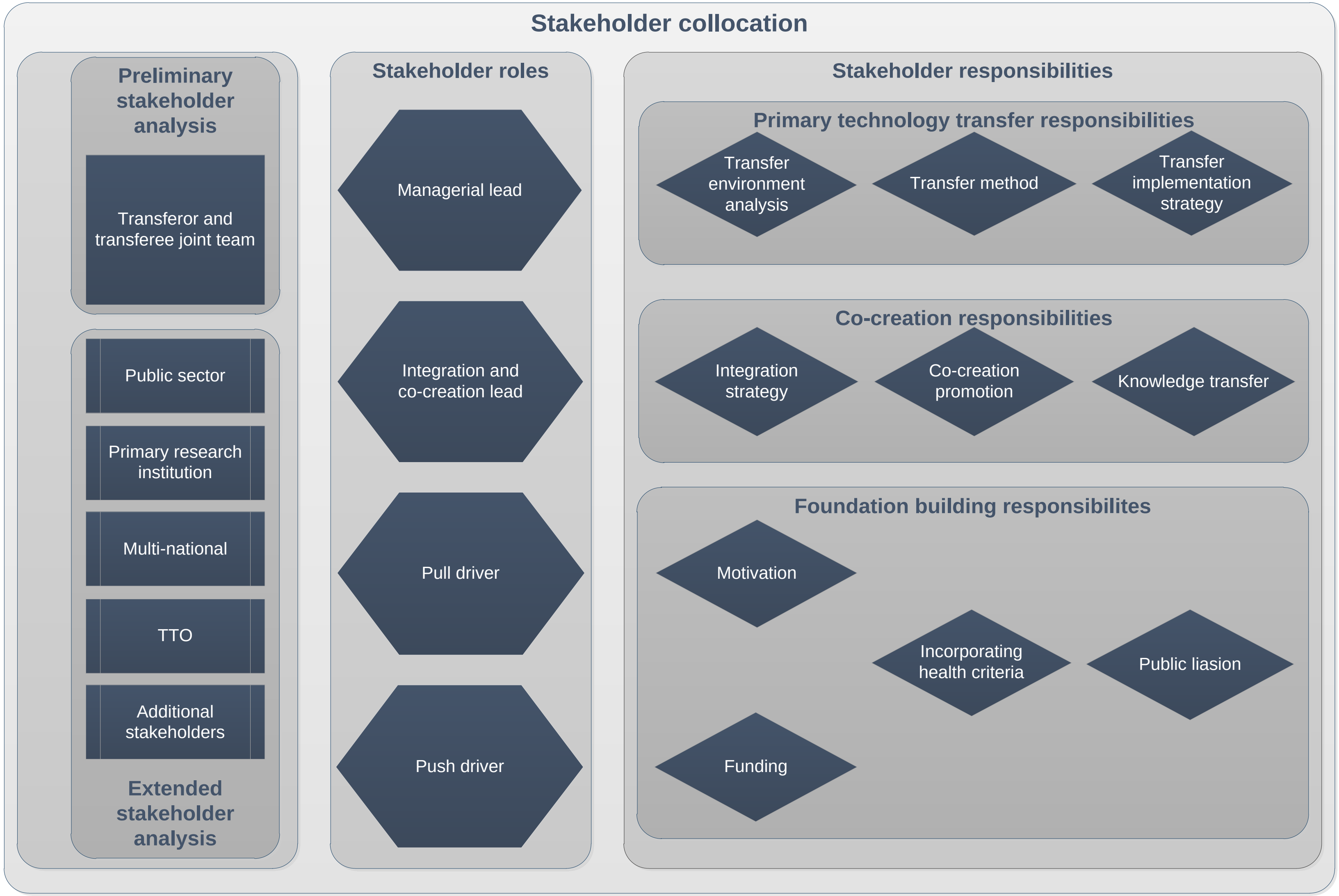

Figure 5-14 - Complete stakeholder collocation

Table 5-10 - Stakeholder roles

Node: Stakeholder collocation	
Primary focus	**Classification of stakeholders' roles**
Managerial lead	- This role can be appropriated by an individual or by a section of the joint transfer team shown in Figure 5-14. - This role will be responsible for championing the TT venture in terms of the transfer environment screening, transfer method selection and the transfer method implementation strategy as well as ensuring overall stakeholder integration. - They may also serve as either the push or pull driver for the TT. - This role must actively be integrated into all nodes of the TT framework. - The managerial team will be partly responsible for the revision process and the subsequent continuation or termination decision at both revision nodes.
Integration and co-creation lead	- This role will be responsible for stakeholder integration and ensuring collaboration with the appropriate public-sector division. - A key role will be to ensure co-creation of knowledge among stakeholders and they should devise a protocol to ensure that a pool of knowledge will be created and documented. - This role will also involve the search for additional stakeholders that may either be a requirement or serve as a benefactor to the TT venture. - This role will also be responsible to either directly or indirectly champion the codification of all TT outcomes for future usage.
Pull driver	- The pull driver serves as the driving force which brings the transfer object to the transferee and into the transfer environment. - This role may include supporting the transfer with respect to funding and personnel. - The pull driver should focus on exploiting domestic market gaps, easing the healthcare burden and implementing local health initiatives. - This role must strongly promote domestic public-sector collaboration and the establishment or refinement of policy implementations conducive to health-related TT. - An important responsibility of this role will be local advertising to promote market-wide adoption after the initial transfer.
Push driver	- The push driver serves as the driving force to push the transfer object from the transferor towards the transferee and into the transfer environment. - This role will often be appropriated by multi-nationals, foreign governments and primary research institutions or a combination of these three stakeholders. - The primary funding will usually be provided by the stakeholder that fulfils this role. - Market expansion and international research collaborations often serve as the motivation for the push driver. It is thus important to align the improvement of local healthcare infrastructure with these agendas.

Despite the freedom permitted for the allocation of roles and responsibilities to stakeholders, it is imperative that all roles and responsibilities have been assigned to at least one stakeholder (Kimaro *et al.*, 2005; Smith *et al.*, 2008). Failure to assign all the roles and responsibilities as shown in Figure 5-14 could potentially undermine the success of any TT venture. As such the revision node in Phase II will continually disallow progression until the appropriate stakeholders have been assigned to their corresponding roles and responsibilities.

Table 5-11 - Stakeholder responsibilities

Node: Stakeholder collocation	
Primary focus	**Managerial best practices for stakeholders' responsibilities**
Transfer environment analysis	Refer to Table 5-14
Transfer method	Refer to Table 5-19, Table 5-20 and Table 5-21
Transfer implementation strategy	Refer to Figure 5-21

Table 5-12 - Co-creation responsibilities

Node: Stakeholder collocation	
Primary focus	**Managerial best practices for co-creation responsibilities**
Integration strategy	- It will be imperative that the TT venture has an explicitly defined stakeholder integration strategy accessible by all current and potential stakeholders. - Each stakeholder must have a single or collection of roles assigned to them based on their individual capabilities and motivations. - All roles shown in Figure 5-14 must have single or multiple stakeholders assigned to it. This ensures that all primary stakeholders will be informed of their requirements and improves accountability and transparency in the subsequent phases of the TT venture.
Co-creation promotion	- To promote co-creation, the transfer team must aim to adhere to the higher levels of the expanded stakeholder instrument provided in Figure 5-12. - Each stakeholder involved should commit active personnel to the transfer team. - In instances where an individual stakeholder's constraints restrict high levels of co-creation, the transfer team must document managerial actions and transfer strategies. This documentation must then be relayed to ensure passive stakeholders have been informed of high-level transfer activities regardless of their individual constraints.
Knowledge transfer	- The joint team should adopt a standardised method to codify both explicit and implicit knowledge. Subsequently, training regarding this codification method should be made available to all stakeholders. - A document should be constructed that codifies the transfer object's characteristics, sub-system requirements, maintenance schedule and supply chain operations. - Personnel that understands both transferee and transferor cultures, politics and languages must be incorporated into the knowledge transfer process. - When implicit knowledge transfer is required, site visits and temporary personnel transfer must be prioritised.

Table 5-13 - Foundation building responsibilities

Node: Stakeholder collocation	
Primary focus	**Managerial best practices for foundation-building responsibilities**
Motivation	- If previous successful TT ventures of similar nature are available, the managerial hierarchy should promote these accomplishments to both motivate and educate the transfer team. - The implementation of an intangible rewards system that recognises noteworthy contributions of individual transfer team members should be considered for motivational purposes.
Funding	- It will be imperative to the TT venture that a funding plan is created, and it must be routinely updated. - Each stakeholder must be aware of this plan and the expected magnitude and duration of their individual contributions. - The transfer team must consider funding in conjunction with the transfer environment, infrastructure requirements and transfer object characteristic to establish a detailed budget. - This responsibility will often be assigned to a combination of the transferor, transferee and the public sector with contributions from a multi-national expected when present.
Incorporating health criteria	- A guideline should be provided by the transfer team that ensures all stakeholders can accommodate the variances between their TT experiences and the implicit requirements of health-related TT. This guideline should be outlined in conjunction with transfer object analysis shown in Table 5-9. - A list must be populated of health-specific requirements, separate of the general TT requirements, for use in the screening of the transfer environment and future evaluation.
Public liaison	- An individual within the transfer team must explicitly be appointed as the public liaison. This party should ultimately be knowledgeable on the public sector's general procedures and health-related policies. If such an individual does not exist within the transfer team third party consultation must be incorporated. - An agenda should be constructed by the transfer team outlining the public liaisons objectives as well as a review process to ensure these objectives have been met. - It is important for the public liaison to interact with both the transferee's and transferor's governments in instances where they differ. - The public liaison is encouraged to populate a list of TT requirements that can only be overcome with aid of the public sector.

5.4.2.2 Transfer environment and infrastructure requirements

Although several transfer environment considerations have been derived from general TT principles, this section has wholly incorporated the health-related transfer determinants identified in Chapter 4. This has been especially prevalent in the infrastructure requirements and mitigation procedures, shown in Table 5-15 and Table 5-16. Table 5-14 aims to link the transfer object, outlined in Table 5-9, with the proposed transfer environment.

Table 5-14 - Transfer environment considerations

Node: Transfer environment	
Primary focus	**The suitability of the transfer object in the transfer environment**
Transfer environment considerations	- The availability and quality of the required hard and soft infrastructure components. - The variances in the supply, manufacture and maintenance capabilities of the transfer environment and the environment in which the transfer object had originated. - The economic structure of the transfer environment as well as current and future market situation. - The appropriateness and marketability of the transfer object in the transfer environment. - Differing user requirements for the transfer object. - Any potential transfer environment alterations required to accommodate the transfer object. - The import duties, quotas or tariffs applicable to the transfer object. - Differences in support or litigation provided by the transferee's public sector when compared to the transferor's public sector.
Managerial best practices	- The transfer team should consist of personnel capable of analysing the transfer environment from multiple perspectives such as economic, social, cultural and political viewpoints. - Designated personnel must be assigned to the evaluation of the transfer environment's market demand and requirements, healthcare system, public sector and the applicable transfer object supply chain. The framework recommends these evaluations be assigned to personnel with experience in these respective fields. - Specific emphasis must be placed on identifying market conditions as the appropriateness and marketability of the transfer object within the transfer environment will partly determine the commercialisation outcome of the transfer object. - The transfer environment and transfer object considerations should be completed in conjunction with one another. Obstacles created by either may be overcome through alterations to the other. However, the framework encourages the transfer team to alter the transfer object whenever possible due to financial and time implications. - Ensuring the availability and quality of infrastructure components will generally lie outside the scope of a transfer team. However, mitigation practices for lacking infrastructure have been provided in Table 5-15 and Table 5-16.

The transfer environment's hard and soft infrastructure requirements have been derived from the systematic comparative literature review, specifically from the results shown in Figure 4-14 and Figure 4-16. Additional requirements such as free trade policies (Schiff *et al.*, 2013) and the sustainability of TTOs (Ann *et al.*, 2008) have also been considered due to their prominence in Section 3.3.6.

To ensure comprehensiveness, Table 5-15 and Table 5-16 provides the user with a guided checklist for all the general infrastructure requirements of healthcare TT ventures to SSA countries. However, it is important to note that only in very select cases will the transfer environment adhere to all these requirements. Thus, this framework provides the user with managerial mitigation practices which may be implemented by the transfer team to ensure the

TT venture will not be rendered immobile by a missing infrastructure component. These mitigation practices have been created deductively from the results of case studies analysed during the systematic comparative literature review.

Furthermore, an even rarer instance would be an individual TT venture that considers every requirement as an absolute necessity. It is thus important to evaluate the infrastructure requirements in conjunction with the results of the transferee, transferor, transfer object and stakeholder collocation nodes. This will ensure that the user does not commit resources to a mitigation process for a lacking infrastructure component that will ultimately prove to be redundant. Additionally, although the list of infrastructure requirements is extensive, it may not be exhaustive. Unique cases of SSA TT may require supplementary infrastructure requirements not included in Phase II of this framework.

A managerial mitigation practise that has not explicitly been included in either Table 5-15 or Table 5-16, has been public sector interventions. However, when medium or large-scale TT ventures have been initiated, the framework requires that the transfer team, particularly the public liaison, must integrate the local public sector into the TT. While this may result in additional government-imposed requirements, it will also facilitate public investment into domestic infrastructure. This collaboration between the transfer team and the public sector allows for a mutually beneficial foundation where infrastructure could be developed in exchange for the transfer object (Mosse *et al.*, 2005). This will be especially prevalent for health-related TT as these transfers typically align with the domestic government’s healthcare objectives.

Table 5-15 - Health-related technology transfer's hard infrastructure requirements and managerial mitigation practices

Node: Infrastructure requirements	
Primary focus	**Potential hard infrastructure required for health-related TT to SSA countries**
Hard infrastructure requirements	**Managerial mitigation practices**
Internet access and telecommunication infrastructure	- The transfer team should attempt to access the international fibre cables running down the African East and West coast, such as the SEACOM cable via an internet service provider. For landlocked countries, this will require government intervention and should be a priority for the public liaison role. - Remote satellite internet access provides a user with stable internet access but requires high capital expenditure and may only be feasible when a multi-national has been incorporated as a stakeholder. - Offline data capture allows users to complete tasks with basic computer or stationary equipment which can, in turn, be transmitted when internet access or telecommunication becomes available. This strategy may be implemented in rural areas after which the data could be transported to an urban centre with improved internet capabilities. - Communication consists of many forms, some which may serve as substitutes for one another. Email, landlines, e-communication, cell phones, faxes should all be compared for individual TT ventures to ascertain which will be the most accessible. - Infrastructure development to create internet access points. This will only be economically and politically feasible for either long-term FDIs or major joint ventures with the public sector, but it will result in constant internet access and ICT at lower variable cost than the alternatives.
Power supply	- For instances where the TT venture has been plagued by unstable electricity, implementing some form of back-up supply that can operate for short periods should be considered. Examples include an uninterrupted power supply, battery systems, fuel-powered generators and even small-scale solar panels. - For instances where a TT venture does not have access to a national power grid, the transfer team should consider the power requirements of the transfer and the economic cost of personal power generation. A more economical solution will be the modification of the transfer object to function with smaller amounts of electricity. - For larger TT ventures that have long life-cycles, the transfer team should consider the feasibility of a small-scale electricity generating plant in conjunction with the public sector. Again, the quality of the public liaison role will be of high importance.
Healthcare facilitates, services and devices	- Inadequate healthcare infrastructure may represent a substantial barrier as it will typically fall outside of the transfer scope for most TT ventures. Altering the transfer object to operate with the available healthcare infrastructure may often constitute the most feasible solution. - When the transfer object requires a select healthcare device or system to operate, the transfer team should consider incorporating this sub-device into the overall TT venture. Thus, the transfer object will comprise of both the sub-device and main transfer object.
Transportation infrastructure	- Transportation infrastructure development would typically be unfeasible for most TT ventures. Mitigation practices should rather focus on eliminating the requirement for frequent transport through communication devices and decentralisation of the transfer object's impact area whenever possible.

Table 5-16 - Health-related technology transfer’s soft infrastructure requirements and managerial mitigation practices

Node: Infrastructure requirements	
Primary focus	**Potential soft infrastructure required for health-related TT to SSA countries**
Soft infrastructure requirements	**Managerial mitigation practices**
Health-related education	- Lacking health-related education presents similar challenges when compared to lacking health-related hard infrastructure. As such, altering the transfer object to operate with the available health-related education may often constitute the most feasible solution. - The framework also encourages the transfer team to facilitate the dissemination of knowledge surrounding the transfer object thus inherently improving the health-related education of the domestic workforce. - Site visits to the transferor, education and training programs may all serve to mitigate inadequate health-related education.
Integration between stakeholders	- Refer to the integration and co-creation best practices shown in Table 5-12.
Digital literacy	- As stated in Phase I, the transferor should implement training programs irrespective of the current level of digital literacy in the transfer environment. These training programs should preferably be completed directly by personnel, however, online training programs will be adequate for most cases. - While these training programs may not be tailored specifically to the improvement of digital literacy, the transfer team should include fundamental computer training for all TTs to developing nations.
Political transparency and an established legal framework	- Lack of political transparency in the transfer environment may be mitigated through efforts by the transfer team to incorporate domestic human rights groups currently active in the region. Similar attempts should be made to incorporate non-profit healthcare organisations when political transparency has been deemed an important transfer requirement. - When TT occurs across borders and involves multiple countries, the transfer team must identify the most politically stable nation with established legal frameworks and utilise this country as the base for the TT to neighbouring regions. - When the transfer object surrounds e-Health, the transfer team should look to market the potential benefit that e-Government systems such as e-Health may contribute towards political transparency and efficiency. - When the transfer environment has been deemed to possess an insufficient legal framework, the transfer team may utilise licensing agreements and IP to provide international legal protection for the transfer object.
Sustainable technology transfer offices	- The sustainability of TTOs will be heavily reliant on external monetary and personnel support. Thus, when the transfer team incorporates a TTO as a stakeholder protocols should be instated that ensure the TTO has accessed to the necessary resources. - TTOs may be strengthened through knowledge sharing with the remainder of the transfer team. Obtaining high levels of co-creation shown in Phase I will thus inherently promote sustainable TTOs. - When a TTO does not exist in the transfer environment, the transfer team should evaluate the opportunity cost of formulating a TTO. However, the marginal level of output that a newly created TTO provides, may often not justify its monetary start-up cost.

5.4.2.3 Revision of the outcomes of phase I and phase II

The conceptual framework is constructed to ensure that transfer teams with limited TT experience can instigate healthcare TT facilitation by progressing through a series of dynamic nodes. However, among the literature items analysed during the systematic comparative literature review is Chapter 4, multiple accounts had been uncovered of transfer teams blending Phase I, Phase II and Phase III into a single process. Due to the inconsistent outcomes of these case studies, no definite relationship can be asserted between this approach and the eventual success of the TT venture. Thus, the framework acknowledges that the user may seek to concurrently progress through Phases I to III. Therefore, a revision node has been inserted both in Phase II and Phase III to ensure resources will not be overcommitted towards improbable TTs.

Through a combination of Figure 5-15 and Table 5-17, the framework provides the user with a revision instrument. By utilising the information gathered in conjunction with the transfer team that has been created in the preceding nodes of Phase I and Phase II, this evaluation instrument will provide the managerial hierarchy with a screening protocol to evaluate the practicability of the continuation of the TT venture. Collaboration with third-party stakeholders should be considered to limit bias during this revision process.

The instruments and considerations provided in Phase I and Phase II have been restated in Figure 5-15 to evaluate any TT inadequacies. However, it is important to consider that the purpose of this revision node will be to mitigate losses of idealistic TT ventures before substantial resources have been committed. Thus, when the revision process indicates a TT venture has been constrained by insurmountable barriers or does not possess numerous progression indicators, the managerial hierarchy should terminate the TT venture if these obstacles cannot be addressed. However, when the revision node highlights large-scale adherence with only isolated barriers, the TT should not be terminated.

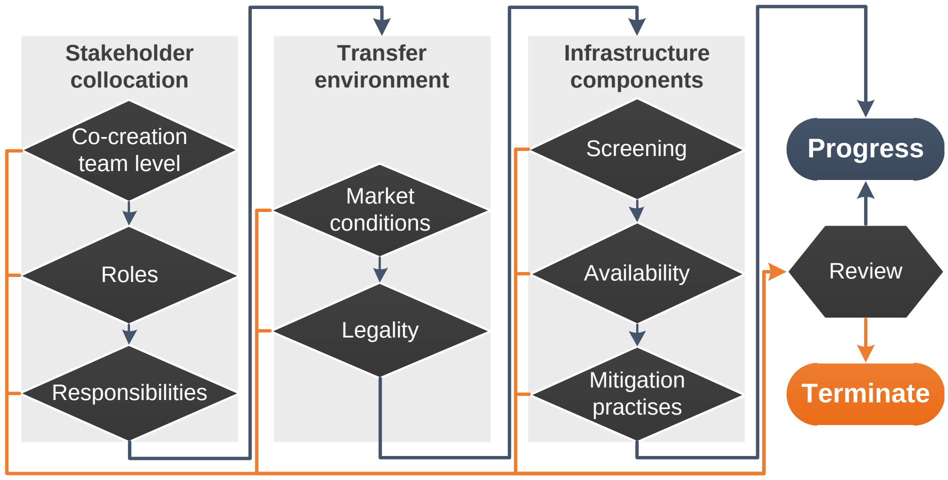

Figure 5-15 - Revision process before continuation to Phase III

Table 5-17 - Revision process before continuation to Phase III

Node: Revision node			
Primary focus		Determining if the technology transfer justifies continuation	
Indicators		Progression indicators	Revision indicators
Stakeholder collocation	Co-creation team level	- The transfer team adheres to the characteristics of a level 3 co-creation team or higher, shown in Figure 5-12. - Similarly, the stakeholders added in Phase II, refer to Figure 5-14, have been incorporated in a manner that maintains the high-level of co-creation, shown in Figure 5-12.	- The transfer team adheres to the characteristics a level 1 or level 2 co-creation team, shown in Figure 5-12. - One or multiple of the additional stakeholders incorporated during Phase II has a detrimental effect on the transfer team's co-creation characteristics.
	Roles	- Each stakeholder has clearly defined roles in the transfer process. All roles shown in Figure 5-14 have an assigned stakeholder.	- Stakeholder roles have not been documented or have been vaguely defined. Some roles shown in Figure 5-14 have no explicitly assigned stakeholders.
	Responsibilities	- Each stakeholder has clearly defined responsibilities with regards to the transfer process. All responsibilities shown in Figure 5-14 have been assigned to at least one stakeholder. - Documentation has been created that outlines the TT's verified funding sources as well as the public-sector integration strategy.	- Stakeholder responsibilities have not been documented or have been vaguely defined. Some responsibilities shown in Figure 5-14 have no explicitly assigned stakeholders. - The transfer team has made no formal budgetary considerations, or no contact has been made with the appropriate public-sector branch.
Transfer environment	Market conditions	- The transfer team has performed an economic analysis of the transfer environment. - Preliminary market predictions regarding the transfer object's demand and supply indicate that a sustainable transfer will be attainable.	- No formal market analysis has been undertaken. - Market conditions indicate that the transfer environment's economy will be unsuitable for the transfer object.
	Legality	- The transfer object may legally be utilised in the transfer environment without any modification. - Simple alterations to the transfer object will ensure its legality in the transfer environment.	- The transfer object cannot be legally utilised in its current state in the transfer environment. - A legal transfer object will require substantial modification to either the transfer object or the legal structure of the transfer environment.
Infrastructure components	Screening	- Formal infrastructure screening has been undertaken and all redundant requirements of Table 5-15 have been disregarded.	- The transfer team utilises the requirements stated in Table 5-15 as universal rather than identifying case-specific requirements.
	Availability	- All hard and soft infrastructure components required are readily available in the transfer environment.	- Several infrastructure requirements are wholly or partially inadequate to the TT's requirements.
	Mitigation practices	- For infrastructure requirements that are unavailable, the transfer team has created documented mitigation practices derived from a combination of the transfer team's experience and those provided in Table 5-15.	- No predefined mitigation practices have been created. - The transfer team accepts the mitigation practices provided in Table 5-15 as universal.
	Review	- The issue leading to the review process can be circumvented through feasible alteration to the transfer team, transfer object or the transfer environment.	- The issue leading to the review process cannot be circumvented through feasible alteration to the transfer team, transfer object or the transfer environment.

5.4.3 Phase III: Transfer method application

Phase III of the conceptual framework aims to provide the user with a screening instrument with which the TT elements, outlined during Phase I and Phase II, may be conflated with established TT methods. The established TT methods have been elucidated during Section 3.3.4 and subsequently tailored to the healthcare sector during the completion of Chapter 4. Derived from these results, Section 5.4.3.2 provides identifiers and best practices for all relevant transfer methods as well as supplementary guidelines for less prominent methods.

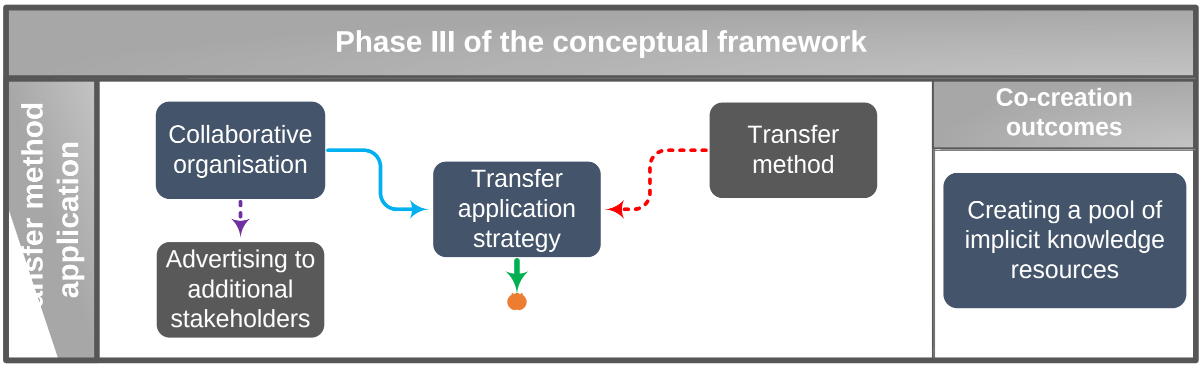

Figure 5-16 - Phase III of the conceptual framework

Phase III also attempts to consolidate the transfer team, that has been established during Phase I and expanded in Phase II, to create a comprehensive collaborative entity with the primary agenda of facilitating co-creation TT. The final collaborative entity should consist out of a pool of implicit knowledge resources educated on healthcare, TT and the region of SSA. The structure of the collaborative entity should also ensure a snowball effect, where additional stakeholders will be continually identified and incorporated into the TT when possible.

Lastly, an additional revision node has been included to ensure the user has adhered to all requirements before the TT can be finalised. This revision node does not include aspects of Phase I and Phase II but instead has been structured to review the functionality of the collaborative entity, the suitability of the transfer object and the transfer method application strategy.

5.4.3.1 Collaborative organisation

As stated in Phase I, the primary stakeholders of a TT, the transferee and transferor, wield most of the authority over the transfer object. Figure 5-17 provides an abridged TT example by illustrating how the primary stakeholders can utilise transfer instruments to push or pull the transfer object into the transfer environment. By promoting a collaborative organisation founded upon the considerations of Phase I and Phase II, the TT barrier of technology suitability can be addressed (Shamsavari, 2006).

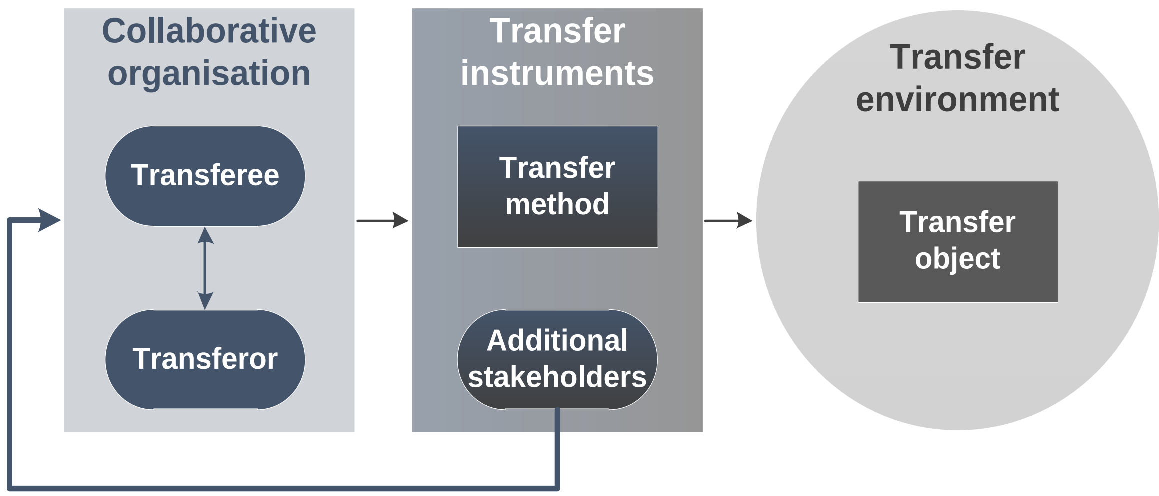

Figure 5-17 - Simplified process for transferring the transfer object into the transfer environment

The collaborative organisation differs from the stakeholder collocation and the stakeholder co-creation instrument as the latter does not focus on achieving comprehensive stakeholder integration. Instead, the collaborative organisation node aims to provide guidelines, shown in Table 5-18, to ensure that the transferee and transferor engage in a collaborative organisation which shall, in turn, reduce the gap between the transfer object's and the transfer environment's actuality. The various transfer methods, provided in Section 5.4.3.2, must be utilised in conjunction with Table 5-18 to further ensure the transfer object's suitability in the transfer environment.

Table 5-18 - Co-creation best practices to ensure the transfer environment will be suitable for the transfer object

Node: Collaborative organisation
Primary focus: Co-creation best practices to ensure the transfer object's suitability
Best practices
- When possible, the transferor and transferee should create a co-creation development team where the transfer object has been jointly created by both parties to function within their respective environments. - When the transfer object already exists, the transferor and transferee should create a co-creation alteration team where both stakeholders attempt to jointly modify the existing transfer object to suit the proposed transfer environment. - The collaborative organisation should not attempt to ensure transfer object suitability in isolation. The entire transfer team created in previous phases must be consulted. - As stated in Phase I, the transferor should engage with the transferee to ensure that their motivations, agendas and desired outcomes have been understood and documented. - The results of the transfer object evaluation, completed in Phase I, should be utilised to create a document of the various transfer object characteristics. These characteristics should be ranked according to the total amount of resources required to alter them. - The results of the transfer environment screening, completed in Phase II, should be utilised to create a document of the various transfer environment elements. These elements should be ranked according to the total amount of resources required to alter them. - A subsequent document must then be created comparing the required transfer object and transfer environment alterations to ensure suitability will be feasible. The transfer team must consider the varying options and adopt a guideline explicitly dictating which transfer object or transfer environment alterations need to occur. - To aid in the transfer environment alteration, the entire transfer team should continually seek to advertise to additional stakeholders capable of assisting with landscape change. The public liaison role, shown in Figure 5-14, will typically be required to ensure public sector assistance for this process.

When the outcomes of Phase I and Phase II indicate that the transfer object will likely not be suited to the proposed transfer environment, the framework recommends that, whenever possible, the transfer object be altered first. It is argued that this solution will require less economic, social and political resources (Bozeman, 2000; Ramanathan, 2011). However, if the transfer environment must be altered in some way, then the co-creation transfer team established in Phase II can if need be, aid the primary stakeholders in altering the transfer environment into a more conducive setting. As shown in Figure 5-17, additional stakeholders capable of altering the transfer environment must also be incorporated into the TT as required.

5.4.3.2 Transfer method

As shown in Figure 5-18, the final transfer method utilised in any TT venture must be incubated during Phase I and Phase II and should never be formulated in isolation. To this extent, the user of this conceptual framework must incorporate the stakeholders' considerations, and the transfer object and transfer environment requirements into the selected transfer method. Thus, Figure 5-18 depicts the scope of the transfer method application strategy that the transfer team must create after the appropriate transfer method has been assigned. A codified document, in accordance with the best practices shown in Section 5.4.5.3, should be created, clearly illustrating this strategy by conflating the various outcomes of Phase I, Phase II and Phase III.

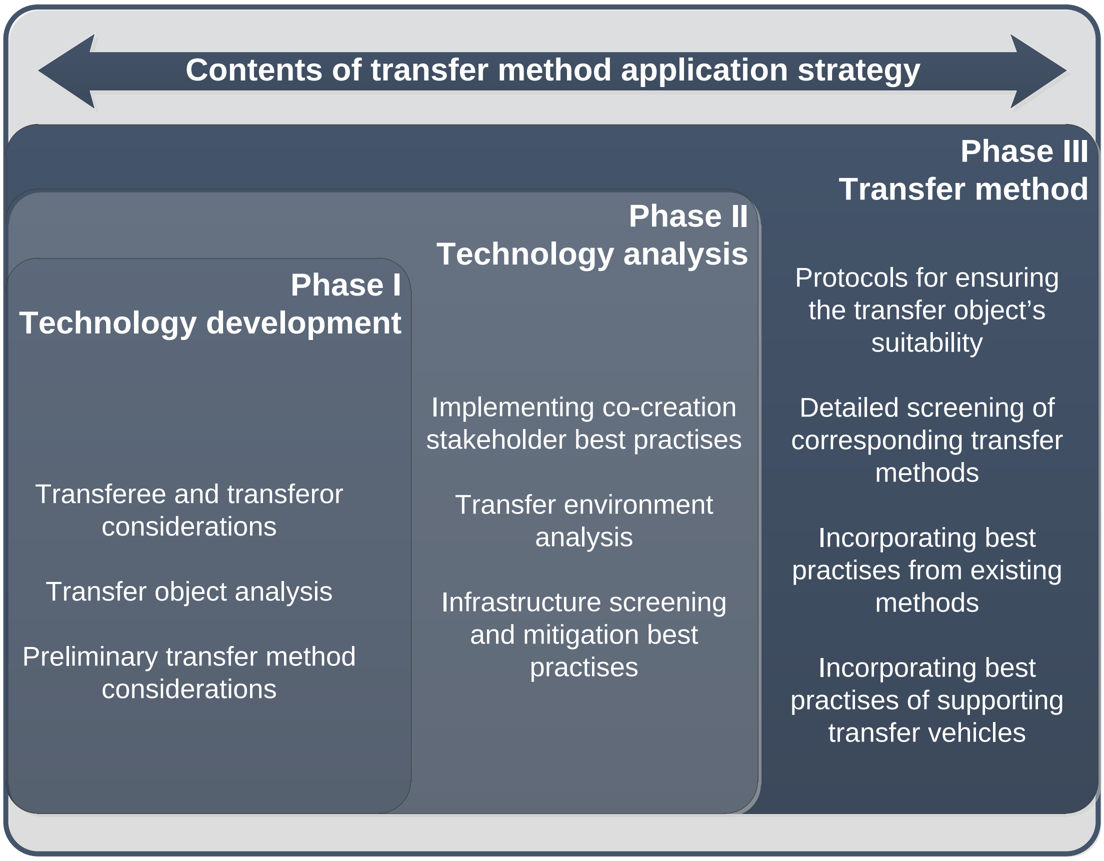

Figure 5-18 - Conflating the required outcomes for health-related technology transfer to sub-Saharan Africa

Section 3.3.4 indicated that the TT methods of FDIs and joint ventures exhibit features closely aligned with the co-creation outcomes of this framework. Contrastingly, cases of the traditional TT method have historically not been concerned with ensuring stakeholder integration or collaboration and thus could be considered an obsolete TT method (Shamsavari, 2006). However, after reviewing the TT method composition of the systematic comparative literature review, shown in Figure 4-9, traditional TT is included in this study as it accounts for a significant percentage of the health-related TT case studies in SSA.

Table D-13 in Appendix D is constructed to provide an instrument with which the transfer team may allocate a TT method suited to the TT characteristics established during Phase I and Phase II. A summary of the complete instrument is provided in Table 5-19. The transfer team is thus provided with the options of traditional TTs, FDIs and joint ventures due to the prominence of these methods and their conducive characteristics.

Managerial best practices for each method have also been subsequently provided in Table 5-20. The framework acknowledges that for select instances a TT venture may adhere to multiple characteristics of multiple TT methods. In such instances, the user should incorporate the best practices of all the applicable TT methods.

Table 5-19 - Primary transfer method selection

Node: Transfer method		
Primary focus	**Selection of the appropriate transfer method**	
Transfer methods characteristics		
Traditional technology transfer	**Foreign direct investments**	**Joint ventures**
- Stakeholder involvement is often poor with limited collaboration present. - The transfer will often be driven in isolation by either the transferor or transferee. - It is not uncommon for the pull driver to dominate with no explicit push element present at all.	- The primary identification criteria for an FDI is the transferor's motivation. This generally revolves around the acquisition of the transfer environment's tangible and intangible resources. - FDI TTs have exclusively been utilised for large-scale projects on a national and provincial level. - Due to the high resource commitments, FDIs will never be utilised to facilitate small-scale TTs.	- Of all transfer methods, joint ventures typically exhibit the strongest forms of stakeholder involvement and collaboration. - The public sector of the transferee will be strongly involved in joint venture TTs. - It is quite common for a TTO to be incorporated as a stakeholder, particularly when research institutions serve as a TT stakeholder.

As with the primary TT methods, best practices have also been provided for supplementary TT methods. These secondary methods have been demoted as they account for an insignificant percentage of the TT case studies analysed in the systematic comparative literature review, refer to Section 4.3.2.

Another consideration that led to the demotion of these supporting methods was that they rarely occur in isolation, an example being spill-overs, which will typically be intertwined with the more prominent TT methods of FDIs or joint ventures (Javorcik *et al.*, 2005). However, the user should still apply the best practices of the supplementary transfer methods when possible, as they actively promote the dissemination of any TT venture.

Lastly, all TTO considerations have been omitted in the Transfer method node due to the conclusions obtained from Section 3.3.3.2. TTOs utilised as transfer methods often present far less utility than when they are actively incorporated into the transfer team as a stakeholder (Ryu *et al.*, 2010).

The transfer method node marks the point where the user must complete the codified Transfer method application strategy[6]. This strategy should already exist, but may still be segmented depending on the manner in which Phase I, Phase II and Phase III are completed. The conceptual framework has been structured to promote linkages between all nodes but in instances where these linkages remain vague, the user must ensure that these relationships have been updated in the transfer method application strategy.

Thus, the user must incorporate all the considerations, outcomes and best practices of the first three phases into a single transfer method application strategy. This codified transfer method application strategy will, in turn, be utilised to facilitate the initial TT of the transfer object into the transfer environment while incorporating the appropriate stakeholders and transfer method. This initial transfer will subsequently be reinforced in Phase IV and Phase V where the transfer object's adoption and sustainability will be prioritised.

[6]The transfer method application strategy should contain the transfer team's codified outcomes of the first three phases of the conceptual framework. This strategy will be utilised to transfer the transfer object into the transfer environment and should be derived during the completion of Section 5.4.1, Section 5.4.2 and Section 5.4.3

Table 5-20 - Best practices for primary transfer methods

<table>
<tr><th colspan="3">Node: Transfer method</th></tr>
<tr><th colspan="3">Primary focus: Highlighting best practices for the selected transfer method</th></tr>
<tr><th colspan="3">Universal best practices</th></tr>
<tr><td colspan="3">- The domestic public sector must be incorporated into all TT activities. This becomes imperative when the scale of the transfer exceeds firm level. Governments must be encouraged to revise free trade policies and ICT and telecommunication infrastructure expansion in addition to the improvement of the digital literacy of the population.
- Investment from any source that can be relayed into the transfer environment’s healthcare infrastructure will aid in the mitigation of health-related TT barriers in SSA.
- The transfer team must assign roles and responsibilities, refer to Figure 5-14, to the collaborative organisation to ensure communication linkages and the aligning of motivations.
- All small-scale transfers should be structured to ensure that scalability remains feasible. TTs that serve as pilot testing operations should have a predefined document depicting this proposed scaling process.
- TT methods that require intensive capital funding to achieve results that only benefit a select portion of the population, will typically not be recommended unless they serve as a foundation for future health projects.
- It will be imperative that the transfer team acknowledge the gap between the transfer object’s design and the transfer environment’s reality. The transfer team is encouraged to conduct continual site visits during the transfer process.</td></tr>
<tr><th>Traditional technology transfers</th><th>Foreign direct investments</th><th>Joint ventures</th></tr>
<tr><td>- When traditional TT has been incorporated, it will be imperative to ensure the transfer method is supplemented with high levels of collaboration.
- Traditional TT cannot be recommended when the transfer team does not adhere to a Level III collaboration team or higher as shown in Figure 5-12.
- This framework encourages the user to incorporate the best practices from joint ventures when utilising a traditional transfer method to account for the limitations of this transfer method.</td><td>- By providing investors with intangible incentive packages the likelihood for capital investment into the transfer environment will be greatly improved. This will also help to negate any existing financial barriers.
- The transfer team must ensure that there are protocols in place that ensure the transferee will be able to utilise the transfer object in their own context. Thus, a co-creation approach is highly recommended.
- A detailed cost-benefit analysis should be implemented to ensure that the capital investment does not undermine existing social, cultural and political structures.
- The transfer team must ensure that attracting powerful stakeholders does not become their sole priority. The priority must remain that of knowledge transfer from the transferor to the transferee.</td><td>- For health-related transfers, programs should be in place to stimulate community involvement and participation.
- Joint ventures between developing SSA countries should be prioritised when possible to ensure maximum knowledge dissemination.
- For health-related transfers, it is recommended that personnel from the transferor accompany the transfer object for a predetermined period.
- The transfer team must be encouraged to present workshops that ensure all stakeholders will be trained to an equivalent level with regards to digital literacy before the TT progresses.</td></tr>
</table>

Table 5-21 - Best practices for supporting transfer methods

Node: Transfer method	
Primary focus	**Incorporating supporting transfer methods**
Supporting methods	**Best practices**
Licensing	- While licensing negatively impacts the total knowledge dissemination throughout the transfer environment, it may provide the funding required for a sustainable TT. - When funding has been a key barrier to the TT, the transfer team should pursue licensing options in conjunction with a predefined plan to relay a percentage of the licensing income into the current TT.
Trade agreements	- All forms of TT will benefit from conducive free trade policies. While this may fall outside the scope of the users of this framework, attempts must be made to collaborate with the public sector and attempt to influence policy decisions. - FDIs are inherently linked with free trade policies and there will be a positive correlation between the transfer team's free trade promotion and the transfer environment's appeal for FDIs.
Spill-overs	- When possible, the transfer object should be made available to all parties in the transfer environment. This includes access to the design and the knowledge required to utilise the transfer object.

5.4.3.3 Revision of the integration outcomes of Phase I through Phase III

The second revision node has been incorporated into the conceptual framework partly to ensure that the transfer team has evaluated all the available transfer methods while documenting the primary and supplementary practices required to implement the transfer strategy. This node also reviews how the transfer team's chosen method corresponds to the suitability of the transfer object in the transfer environment.

However, the primary aim of the second revision node is to ensure that the user of this framework has conflated all the outcomes of Phase I, Phase II and Phase III into a complete set of codified of plans outlining the TT's application strategy. These codified plans will, in turn, provide the transfer team with a base guideline for progressing through Phase IV and Phase V, while also partly completing the requirements of the codification node shown in Phase V. As before, the transfer team must utilise the revision diagram shown in Figure 5-19 with the corresponding categories shown in Table 5-22.

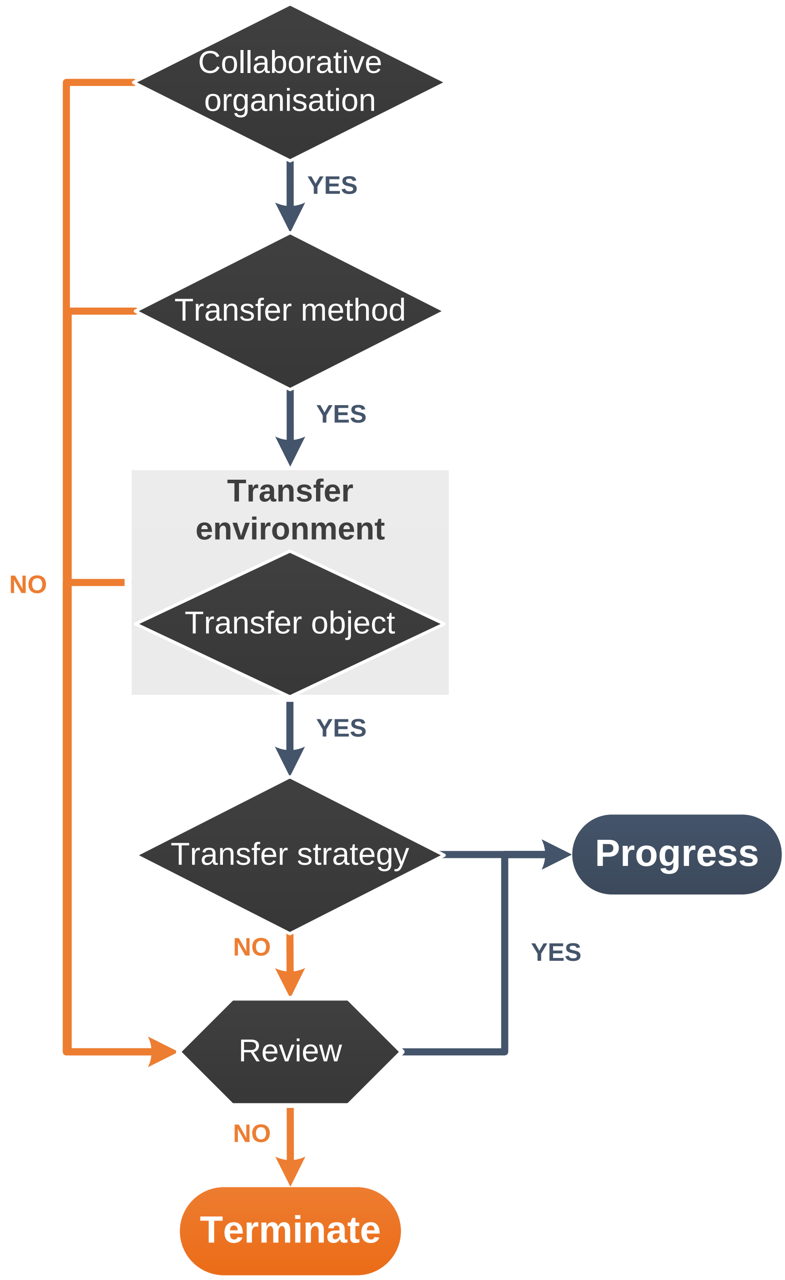

Figure 5-19 - Revision process before continuation to Phase IV

Table 5-22 - Revision process before continuation to Phase IV

Node: Revision node		
Primary focus	**Does the transfer justify continuation**	
Indicators	**Progression indicators**	**Revision indicators**
Collaborative organisation	- The transferee and transferor have collaborated to ensure that the transfer object can be effectively utilised in both of their environments. - The transferee and transferor have ensured that their motivations and agendas will be mutually beneficial towards the TT. - The collaborative organisation has actively incorporated stakeholders assisting in the alteration of the transfer environment when possible.	- Little to no collaboration has occurred between the primary stakeholders to ensure the transfer object remains functional in the transfer environment. - Multiple stakeholders have attempted to promote the transfer object's suitability in isolation.
Transfer method	- The transfer team has familiarised themselves with the characteristics of all primary and supplementary transfer methods. - The transfer team has assigned a transfer method suitable to the TT's requirements. - In instances where traditional TT has been chosen as the primary method, the transfer team has created documented protocols to mitigate this method's poor stakeholder involvement. - The transfer team has incorporated supplementary transfer methods whenever possible.	- The transfer team has assigned a transfer method before considering all available options. - No additional measures have been incorporated to ensure stakeholder involvement when utilising the traditional transfer method. - Supplementary transfer methods have been disregarded.
Suitability	- The transfer object can still be effectively utilised given the transfer environment's factor endowment. - The transfer object holds potential value to both the users and customers of the transfer object. The transfer object thus holds inherent marketability characteristics. - The transfer environment is naturally conducive to the transfer object.	- The transfer object cannot be effective when removed from the factor endowment of the environment for which it has been created. - The transfer team has difficulty marketing the transfer object to both its potential users and customers. - Either the transfer object or transfer environment must be altered to create a conducive setting.
Transfer method application strategy	- The transfer team has created a transfer method application strategy document outlining all transfer object and transfer environment characteristics. - This document also depicts all stakeholders that have been incorporated as well as their assigned roles and responsibilities, with the current stakeholder co-creation level noted. - The assigned transfer method and required mitigation practices to ensure the transfer object's transfer and subsequent suitability have been explicitly outlined in this document. - This document has been distributed to all stakeholders involved in the TT.	- No complete document exists depicting the transfer method application strategy. - A transfer method strategy has been documented but has been vaguely defined or has omitted key elements. - A complete transfer method application strategy document has been created but has only been made available to select stakeholders.
Review	- The issue leading to the review process can be circumvented through feasible alteration to the transfer team, transfer object or the transfer environment.	- The issue leading to the review process cannot be circumvented through feasible alteration to the transfer team, transfer object or the transfer environment.

5.4.4 Phase IV: Change management

Phase IV of the conceptual framework aims to provide the primary stakeholders with guidelines to perform the necessary change management required to ensure the sustainability of the transfer object. These guidelines should be implemented posthumously and, unlike the transfer method application strategy, are structured to facilitate the transfer of the transfer object into the transfer environment. Thus, Phase IV holds the transfer object's uptake, adoption and dissemination as the primary outcomes.

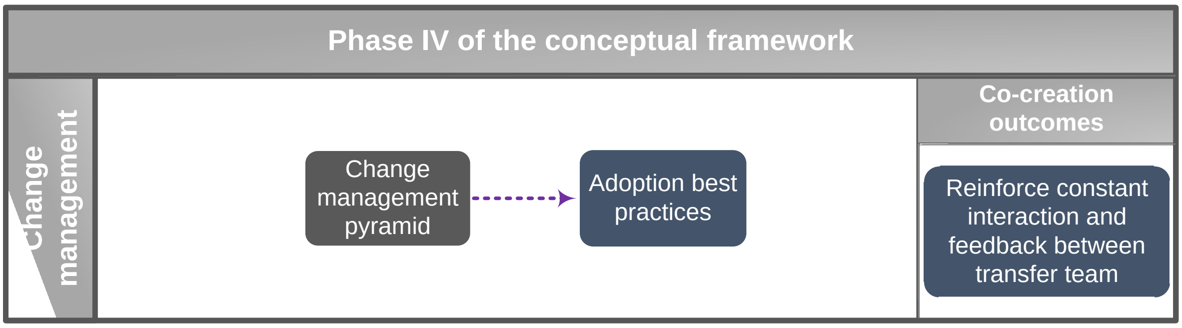

Figure 5-20 - Phase IV of the conceptual framework

The guidelines have been divided into multiple levels to refine the transfer team's focus when addressing the individual facets of change management. These levels have been structured in a two-sectioned pyramid format, depicted in Figure 5-21, which must be completed sequentially. The change management pyramid aims to create a "co-creation bridge" which will enable continual communication, assistance and regulation between all stakeholders.

The first section provides guidelines for the primary stakeholders in isolation, shown in the bottom level of Figure 5-21. Emphasis has been placed upon various areas which the transferor and transferee should individually promote or mitigate. These guidelines, shown in Table 5-23, are derived from a combination of the Revised Levels of Involvement model, shown in Figure A-6, and supplementary considerations identified during the completion of the systematic comparative literature review, shown in Section 4.3.

The second section, shown in the top level of Figure 5-21, provides change management recommendations for the complete transfer team, first established in Phase II. This section aims to cement the adoption of the transfer object in the transfer environment and create the foundations for the TT's sustainability protocols presented in Phase V. The co-creation change management best practices are shown in Table 5-24.

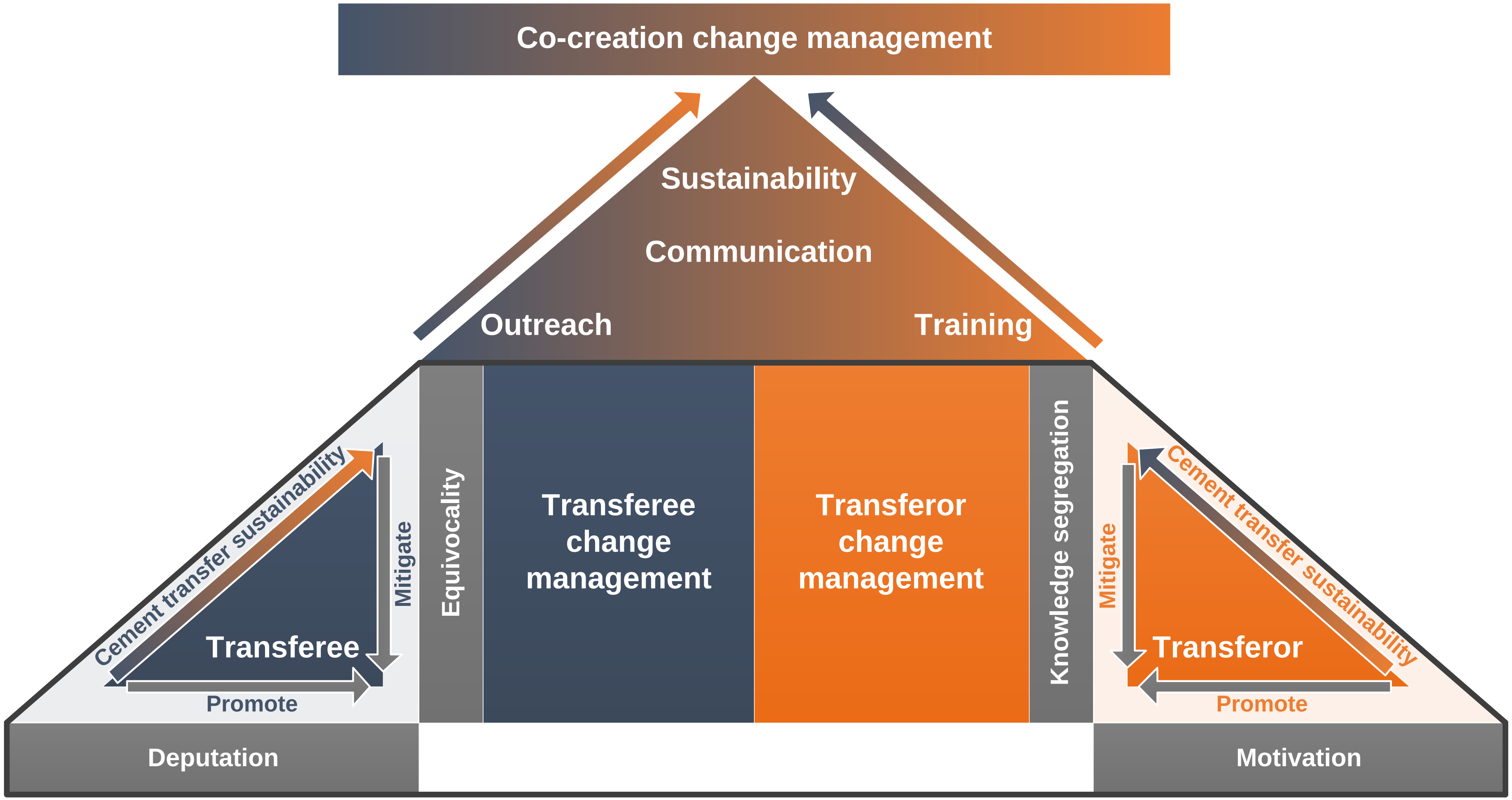

Figure 5-21 - Co-creation change management pyramid

Table 5-23 - Individual change management best practices for the transferee and transferor

Node: Change management pyramid		
Primary focus: Change management areas of focus for transferor and transferee		
	Transferee change management	**Transferor change management**
Promote	**Deputation** - After the transferee has taken possession of the transfer object they should designate either an individual or a team to monitor and disseminate the transfer object throughout the transferee's establishment. - This deputy should be clearly highlighted within the transferee's establishment and be given the authority to implement positive and negative incentive schemes focused on increasing the transfer object's dissemination. - This authority should liaise with the corresponding transferor entity, to determine their best practices for the transfer object's adoption. - This authority should also be familiar with the transferee's previous TTs. A subsequent guideline, which highlights both successful and failed previous best practices, should be created. This authority will also be responsible for documenting current best practices for future use. - When permittable, this authority should incorporate local stakeholders, within the immediate transfer environment, and spread all adoption best practices to promote the TT's dissemination.	**Motivation** - After the transferee has taken possession of transfer object, the primary change management best practise for the transferor must be to stimulate continual involvement in the TT. The transferor should thus incorporate an incentive program which rewards the personnel based on their involvement. - Incentives programs should range from monetary rewards, peer recognition and intangible personnel rewards such as public exposure. - The amount of personnel committed to the TT by the transferor should be reduced, depending on the future requirements of the TT. The smaller active personnel base will, in turn, allow for simplified, and often more economical, incentive reward schemes. - The transferor could attempt to obtain funding for continual personnel involvement from both the transferee and the transfer environment's public sector.
Mitigate	**Equivocality** - The TT's objectives created during Phase I and Phase II must be updated after the transfer object has been obtained by the transferee. These objectives must be altered to shift focus from acquisition toward sustainability. The continual revision of these objectives throughout the transfer object's maturity cycle will also be highly beneficial. - At this point of the transfer, the transferee entity to which the transfer object's knowledge has been provided should create codified documents which can be utilised in training sessions. - The transferee should mandate training and educational sessions to all personnel in the transferee's immediate sphere. Direct training should be utilised whenever possible and on-site demonstrations of the technology should be prioritised. - The outcomes of these training sessions should be explicitly stated to all participants. A formal revision protocol should also be created aimed at monitoring the transfer object's adoption rate and documenting identified adoption barriers.	**Knowledge segregation** - The transferor should create a channel aimed at providing transfer object-related assistance when required. This channel can range from a dedicated contact person to an active tool depending on the nature of the transfer object. - This framework encourages the transferor to hold formal training sessions for the transferee as often as possible. On-site visits by transferor personnel will be highly advantageous to the transfer object's adoption in the transfer environment. - If the transferor has already produced an internal training program surrounding the transfer object, it is recommended that an invitation be sent to the transferee to attend these internal training programs either in person or electronically.

Table 5-24 - Co-creation change management best practices

Node: Adoption best practices	
Primary focus	Creating an environment capable of sustaining the technology transfer
Co-creation change management	
Outreach	- After completing the transfer of the transfer object into the transfer environment, multiple stakeholders often disband from the transfer team. The transferor and transferee should thus attempt to retain these stakeholders and assign new stakeholder roles promoting adoption rather than transfer. - After the transfer has been completed, additional stakeholders should be sought out that may be beneficial to the transfer object's adoption. Often these stakeholders comprise of ground-level health clinics and healthcare professionals as well as domestic non-profit organisations. - Retaining the services of TTOs, when utilised, must be prioritised as these entities will be skilled at promoting local adoption. - Similarly, retaining the services of the public liaison stakeholder will be critically important.
Training	- The training programs surrounding the transfer object that have been created in the initial phases of the TT must not be discontinued. Instead, the scope of their audience must be altered to also involve the domestic healthcare community rather than the original TT stakeholders. - The transferor and transferee should conduct local training sessions in tandem. - An important consideration regarding training must be the promotion of knowledge dissemination. To this extent, this framework strongly recommends that transfer object training must be accompanied with the knowledge of how to train others. Thus, training sessions aimed at training local communities on how to train other local communities should be incorporated. - Training programs should be extended to administrative staff and not be isolated to healthcare professionals. - The adoption of any healthcare TT will, to some extent, depend on the public sector's ability to train staff. Training programs aimed at promoting adoption should thus be conducted in conjunction with the public sector. - The transfer team should be encouraged to incorporate different forms of training procedures. For example, an e-Health transfer object will be very conducive to online training and will, in turn, reinforce the digital literacy skills required to utilise the transfer object.
Communication	- The change management best practices shown in Table 5-24 require individual actions from the transferor and transferee. As such, the primary stakeholders must ensure that they re-align their TT agendas after completing their individual change management procedures. - The communication channels and methods established at the commencement of the TT should be revised. Interacting with local communities in developing nations will often require a different form of communication when compared to stakeholder communication. - These revised communication methods should be standardised and documented to ensure uniformity. This will, in turn, simplify training programs.
Sustainability	- The primary sustainability barrier faced by all TTs has been funding. Thus, it becomes imperative for the transfer team to revise the funding document, established during Phase II, to incorporate new methods of funding. Monetising the transfer object without reducing its adoption capabilities must be prioritised. - The transfer team should reinforce the market analysis division or personnel. Predicting future market needs and supply chain forces will both alleviate funding restraints and allow for marketing campaigns tailored to the market conditions. - The transfer team should ensure that a high-level co-creation transfer team remains intact. - The revision and alteration of the transfer object should be implemented continually to further refine the transfer object and promote adoption. This will greatly rely on the relationship between the transferor and transferee. - The transfer team should continually evaluate new technologies that may be beneficial to the transfer object's impact and adoption.

5.4.5 Phase V: Commercialisation

Phase V of the conceptual framework marks the end of the TT. By the commencement of Phase V, the transfer object has been successfully introduced into the transfer environment with both the transferor and the transferee implementing the required change management actions provided in Phase IV.

Phase V allows the primary stakeholders to evaluate the TT by providing an instrument with which the relative success of multiple TT outcomes may be measured and documented for future use. This instrument evaluates both the tangible and intangible benefits and sacrifices of the TT. Phase V also provides knowledge codification guidelines that must be incorporated throughout each node of the conceptual framework as stated in Section 5.4.1.

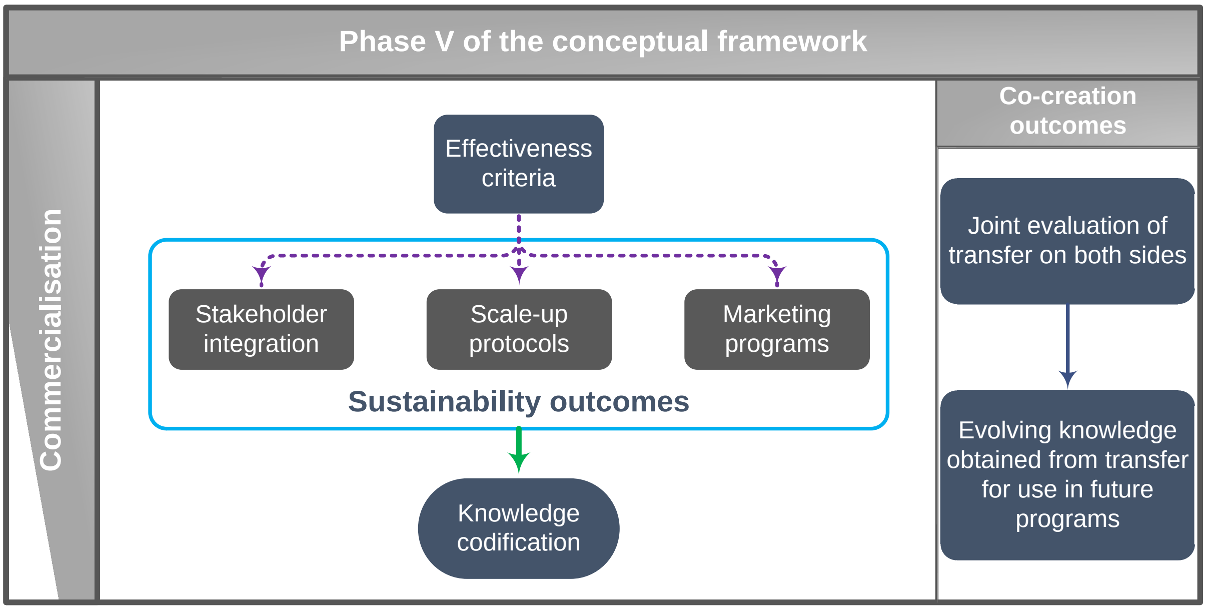

Figure 5-22 - Phase V of the conceptual framework

However, the primary aim of Phase V is to reinforce the sustainability of the TT through promoting the dissemination of the transfer object. To this extent, various recommendations aimed at updating the stakeholders involved while retaining high levels of interaction have been provided. Various scale-up protocols and marketing recommendations are also outlined.

5.4.5.1 Evaluation of the technology transfer's impact

The evaluation instrument, presented in Table 5-25, has been included in Phase V to allow the primary stakeholders to gauge the relative success of the TT venture. This evaluation instrument has been founded upon to outcomes of the Revised Contingent Effectiveness model, described in Appendix A.12, and presents multiple yardsticks with which the outcomes of a TT may be judged. It is important to note that for select TT ventures, the achievement of a single yardstick may still represent a favourable TT outcome. It is thus important for the transfer team to cross-evaluate the outcomes of the final evaluation with the TT's objectives defined during Phase I. This cross-evaluation should be clearly outlined in the final documentation of the TT venture. The codification of the evaluation instrument's outcomes must emphasise both the successful and unsuccessful TT outcomes.

By partly splitting the evaluation instrument into the perspectives of the primary stakeholders, both the transferee and the transferor will also have access to tailored documentation for future usage. This will also simplify future TT ventures when a different transferor or transferee attempts to access the required documentation.

Lastly, the outcomes of the evaluation must be utilised to finalise the sustainability protocols developed in Section 5.4.5.2. Multiple outcomes obtained from the evaluation instrument should be relayed into a marketing strategy to ensure that emphasis has been placed upon realised TT victories.

Table 5-25 - Final evaluation instrument for the technology transfer

Node: Effectiveness criteria		
Primary focus	**Evaluating the technology transfer from the primary stakeholder's perspectives**	
Effectiveness criterion	**Transferee's considerations**	**Transferor's considerations**
Market impact	- Has the transferee been able to utilise the transfer object to the same extent as the transferor? - Did the transfer object have a tangible impact on the transferee's sales or profitability?	- Did the transferred technology have an impact on the transferor's sales or profitability? - Have new tangible or intangible resources been acquired as a result of the TT?
Public value	- Aside from monetary objectives, how did the transfer object improve the transfer environment? - Has the transferee's marketability, public image or social reach improved as a result of the TT?	- Has the transferor's marketability, public image or social reach improved?
Political	- Did the transferee benefit politically from participating in the transfer? - Did the TT result in new healthcare policies for the transfer environment? - Has the TT resulted in the transferee to be noted by the public sector?	- Did the transferor benefit politically from participating in the transfer? - Has a channel been established between the transferor and the public sector?
Human capital	- Did the transfer lead to an increase in the transferee's capacity to conduct or utilise research? - Has the educational level of the transferee's personnel increased as a result of the transfer?	- Did the transferor's human knowledge capital increase as a result of the technology transfer? - Have additional training mechanisms been established as a result of the technology transfer?
Revision nodes	- Has a significant amount of issues been uncovered by the revision nodes? - Could the issues uncovered by the revision nodes have been circumnavigated? - How effectively did the transfer team collaborate to mitigate and red flags uncovered by the revision nodes?	
Economic development	- Did the transfer object lead to additional economic development or serve as the foundation for other products or services? - Have any additional start-ups been created resulting from the TT? - Have other firms in the transfer environment implemented the transfer object in their operational activities? - Have other firms in the transfer environment implemented knowledge transferred in their operational activities?	
Opportunity cost	- What other projects were dismissed to pursue the TT? - What other knowledge or training opportunity was dismissed to pursue the TT?	
Healthcare reach	- Did the TT improve the healthcare reach of the transfer environment? - Did the TT improve the speed or accuracy of healthcare in the transfer environment? - Have any health collaborations been established during the transfer? - Did the TT improve the marketability or appeal of health technologies in the transfer environment?	

5.4.5.2 Ensuring the sustainability of the technology transfer

When evaluating the TT models shown in Appendix A, commercialisation and the sustainability of the transfer object generally lies outside the scope of most TT ventures. The outcomes of Section 3.3.2 and Chapter 4 reinforce this argument with only the TT spill-overs focussing on commercialisation efforts.

However, despite the lack of a commercialisation perspective in TT literature, Section 5.4.5.2 has been incorporated into the conceptual framework to promote the sustainability of health technologies after the transfer object has been successfully introduced into the transfer environment. To accomplish this, several recommendations regarding continued stakeholder integration, scale-up protocols and marketing strategies have been provided in Table 5-26.

Table 5-26 - Recommendations to promote the transfer object's sustainability

Node: Sustainability outcomes	
Primary focus	**Promoting the sustainability and expansion of the transfer object**
Stakeholder integration	- The transfer team should continue to implement the extended stakeholder screening instrument shown in Figure 5-12 during the commercialisation process. - After completing the transfer of the transfer object, stakeholder involvement should be revised as multiple stakeholders may no longer be required. - Similarly, additional stakeholders should be incorporated if they could be of potential benefit to the transfer object's dissemination. - Depending on the outcome of the selected transfer method in Table 5-20 and Table 5-21, the revised transfer team should actively seek out relevant parties in the public healthcare sector, domestic firms and entrepreneurs capable of establishing spill-overs or start-ups surrounding the transfer object.
Scale-up protocols	- As previously noted, commercialisation will tend to lie outside the scope and expertise of the transfer team. Thus, the transfer team should actively incorporate a stakeholder knowledgeable in licensing and commercialisation activities. - It will be the responsibility of the licensee to oversee the commercialisation activities surrounding the transfer object. However, the transfer team should have established pre-defined legal terms to ensure the transfer object's future management aligns with the agenda of the original transfer. - The commercialisation of a health technology will generally be founded upon two primary business strategies. The technology can be presented to the end-user free of charge and be funded by the marketing of the public value of the technology. Alternatively, the technology may be licensed, and service charges will apply to the end-user. - However, the chosen business strategy will be case-specific, and this framework does not promote one above the other. The licensee and transfer team should, however, have a predefined business strategy before the transfer object's expansion may commence.
Marketing strategies	- The marketing strategy should revolve around the successful outcomes of the TT identified in Table 5-25. - The general marketing strategies should be tailored to the transfer object in question as well as the business strategy chosen for the transfer object's commercialisation. - It is, however, important for the transfer team to distinguish between the end-user of the transfer object and the client who commissioned it. For health technologies, these two entities will almost never be the same. - When advertising to potential clients not involved in the creation of the transfer object, the marketing strategy should revolve around how the transfer object will solve the client's problem. How the transfer object will benefit the end-user, typically the patient, should not be prioritised over the client's priorities when dealing with isolated health practitioners. - However, when advertising to the national public health sector, marketing of the patient's benefits should be prioritised over the health practitioner's benefits.

5.4.5.3 Considerations for knowledge documentation

As stated at the commencement of Phase I, the user must review Section 5.4.5.3 before the commencement of any potential TT. Table 5-27 provides the user with various standardisation best practices which should, in turn, ensure uniformity in the data capturing process (Rebentisch *et al.*, 1995). The transfer team must implement these best practices throughout all nodes of the conceptual framework. This will aid the current transfer team in completing the revision nodes in Phase II and Phase III as well as the overall TT evaluation in Phase V. It also serves as a common language with which stakeholders may communicate which in turn limits miscommunication and want of understanding while also bridging potential cultural or language differences (Rebentisch *et al.*, 1995; Malik, 2002; Ramanathan, 2011; Handoko *et al.*, 2016).

While the current TT will benefit from a formal codification protocol, this section has also been incorporated to serve future TTs of a similar nature. Access to codified practices of previous TTs will provide future transfer teams with implicit knowledge understanding, motivational practices and stakeholder integration procedures.

Table 5-27 - Codification best practices

Node: Knowledge codification	
Primary focus	**Ensuring uniform and comprehensive knowledge capture**
Best practices for codification	- All documentation captured should be completed in a predefined business language understood by all the primary stakeholders. - All data captured during the TT should be documented in a predefined measurement system, such as SI units. - All documentation and communication among stakeholders should be completed in a predefined style with stakeholders being encouraged to adopt a universal organisational routine with regards to formalised communication. - Predefined data capturing should be outlined for various forms of communication along with methods to ensure adherence. - Uniformity will be promoted if dedicated personnel have been assigned to the TT's knowledge capturing process. These personnel should preferably be provided by both the transferor and transferee. - When evaluating the stakeholders in Phase II, care should be given to language barriers. While all stakeholders may understand a language, various levels of comprehension often arise. This has been especially pronounced in SSA countries. - When possible, translating all codified documentation into a second langue will be highly advantageous. - Consideration must be given to data storage and where possible an electronic system has been recommended. Care should also be taken to ensure duplicates will be removed. - With regards to the implicit knowledge of individual stakeholders, the framework recommends developing a standard set of questions to capture the nuances of how stakeholders completed their roles and responsibilities. - A predefined structure for the documented knowledge base must be outlined before the commencement of Phase I. This structure should be able to accommodate the accumulating knowledge base as the TT progresses.

A final checklist has also been provided in Table 5-28 which the transfer team should review after the completion of each phase. This will confirm that the required documentation has taken place before progressing to the next phase. The framework does not encourage the transfer team to complete the documentation after the completion of the entire framework as several implicit knowledge details may not be captured.

Table 5-28 - Final check list for required documentation after the completion of each phase

Check list	
Phase I	- The completed codification standards and practices for the proposed TT. - The characteristics of the transferee. - The characteristics of the transferor. - The characteristics of the transfer object and its knowledge considerations. - The current level of the co-creation transfer team.
Phase II	- All additional stakeholders incorporated along with their motivations and capabilities. - A chart indicating which stakeholders have been assigned to various roles and responsibilities. - The transfer environment's characteristics. - The hard and soft infrastructure required and identified lacking infrastructure. - The mitigation practices implemented for lacking infrastructure. - The current level of the co-creation transfer team. - The potential warning indicators identified during the revision node.
Phase III	- All additional stakeholders incorporated along with their motivations and capabilities. - The required alterations to the transfer object and transfer environment. - The applicable transfer method(s) chosen. - The completed transfer methods application strategy. - The current level of the co-creation transfer team. - The potential warning indicators identified during the revision node.
Phase IV	- The change management procedures for the transferee. - The change management procedures for the transferor. - The change management procedures to promote the sustainability of the TT. - The current level of the co-creation transfer team.
Phase V	- The outcomes of the TT from the transferee's perspective. - The outcomes of the TT from the transferor's perspective. - All scale-up and marketing procedures implemented to promote the sustainability of the TT. - The current level of the co-creation transfer team. - An overarching TT document outlining all facets of the transfer.

5.5 Chapter 5: Conclusion

Chapter 5 presents the development of the preliminary conceptual framework aimed at facilitating health-related TT to SSA. This chapter utilised a dual screening method to identify existing TT models aligned with the overarching aim of this dissertation. To create the framework, these models, along with an additional stage-gate feature, have been deconstructed to identify components which may be utilised in addition to the combined outcomes of Chapter 3 and Chapter 4.

The completed preliminary conceptual framework has been presented in Figure 5-9 and explicated in Section 5.4. All literature sources used in the creation of this conceptual framework have been presented in Appendix D. A summary of the conceptual framework has been provided in Figure 5-23 and outlines the main elements of all five phases.

Phase I:
Technology development

Phase I of the framework focusses on identifying the characteristics of the transfer object and the primary TT stakeholders as well as establishing a co-creation transfer team.

Phase II:
Technology analysis

Phase II aims at expanding this transfer team by incorporating additional stakeholders while highlighting their roles and responsibilities with respect to the TT. The transfer environment screening, with emphasis on infrastructure screening, has also been outlined in Phase II. Phase II concludes by providing a revision node to ensure the TT justifies continuation.

Phase III:
Transfer method application

Phase III aims to ensure the suitability of the transfer object in the proposed transfer environment by providing the primary stakeholders with various best practices. The characteristics of various TT methods and supplementary transfer methods along with best practices have also been outlined in Phase III for the transfer team to evaluate and incorporate. Phase III also ensures that the outcomes of the first three phases have been conflated into a transfer method application strategy. As with Phase II, a revision node has been provided at the end of Phase III.

Phase IV:
Change managment

Phase IV provides the transferor, transferee and overall transfer team with various change management procedures aimed at ensuring the adoption of the transferred technology. These procedures also serve as the basis of TT's sustainability, a primary focus of Phase V.

Phase V:
Commercialisation

Phase V also provides the primary stakeholders with an evaluation instrument, allowing both to review the TT's outcomes. Lastly, Phase V provides codification standards which should be applied during all phases of the conceptual framework. A checklist has also been provided to ensure that the required data capturing has occurred after the completion of each phase.

Figure 5-23 - Summary of the preliminary conceptual framework for health-related technology transfer

Chapter 6. Conceptual framework evaluation

Chapter 6 documents the three levels of evaluation instruments applied to the preliminary conceptual framework as presented in Section 5.4. The evaluation procedure is implemented in three consecutive stages, the first of which utilises the outcomes of multiple semi-structured interviews with TT and healthcare industry experts, the results of which are presented in Section 6.3. Section 6.3.3 presents the results of the second level of evaluation where a survey is administered to healthcare practitioners, TTO employees and university personnel with relevant field experience. Lastly, the results of the final level of evaluation are shown in Section 6.5 and surround the outcomes of healthcare TT case studies completed in SSA.

The outcomes of Section 6.3, Section 6.4 and Section 6.5 have subsequently been utilised to construct the final TT tool which is shown in Chapter 7 by consolidating the preliminary conceptual framework with the outcomes of the three evaluation procedures. These evaluation procedure outcomes are shown in Section 6.3.3, Section 1.1.1 and Section 6.5.4 respectively. The main outcomes of Chapter 6 have been summarised in Figure 6-1 and the purpose of Chapter 6 within this research document is shown in Table 6-1.

Table 6-1 - The role of Chapter 6 within the research structure

<table>
<tr><th colspan="8">Document framework</th></tr>
<tr><td rowspan="2">Research objectives</td><td>i.</td><td>i. & ii.</td><td>i. & ii.</td><td>ii. & iii.</td><td>ii. & iii.</td><td>iii.</td><td>iii.</td></tr>
<tr><td colspan="5"></td><td colspan="2">iv.</td></tr>
<tr><td>Conceptual Framework Analysis phases</td><td>Map data sources</td><td>Categorise data</td><td>Identify concepts</td><td>Deconstruct concepts</td><td>Integrate concepts</td><td>Synthesis</td><td>Validate</td></tr>
<tr><td rowspan="2">Corresponding chapters</td><td colspan="2">Problem statement
Chapter 1</td><td colspan="3">Comparative literature review
Chapter 4</td><td colspan="2">TT facilitation tool
Chapter 6
Chapter 7</td></tr>
<tr><td></td><td colspan="3">Conceptual literature review
Chapter 3</td><td colspan="2">Conceptual framework
Chapter 5</td><td></td></tr>
</table>

Key outcomes	
	Outline the research methodology for the semi-structured interviews, the survey and the case studies
	Describe and explain the outcomes obtained from the interviews conducted with TT industry experts
	Describe and explain the outcomes obtained from the survey results
	Describe and explain the outcomes obtained from the healthcare case studies

Figure 6-1 - Key objectives of Chapter 6

6.1 Conceptual framework evaluation: the rationale

After the completion of the conceptual framework development, shown in Chapter 5, the legitimacy and utility of the preliminary framework's content and structure for the proposed industry sector (i.e. healthcare) and geographic region (i.e. SSA) requires evaluation. Due to the volume and complexity of the conceptual framework's technology transfer content, stakeholders, relationships, healthcare requirements and the geographic application scale, the implementation of a single evaluation instrument is deemed insufficient to adequately substantiate the developed conceptual framework in its entirety. An overview of the overarching evaluation procedure, including the sequence and focus areas of the individual evaluation instruments, is provided in Figure 6-2.

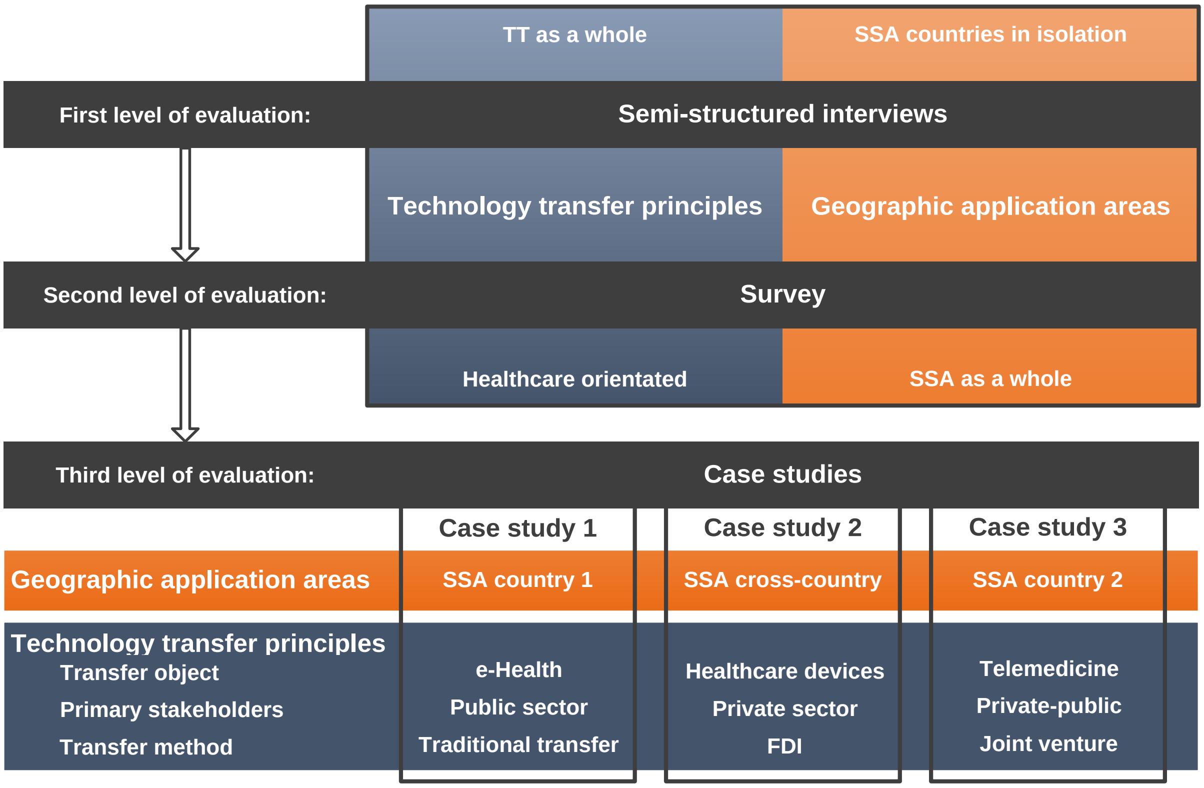

Figure 6-2 - Evaluation procedure of the preliminary conceptual framework

The first level of evaluation is represented by semi-structured interviews with healthcare and TT industry experts. These interviews directly focus on validating the high-level content and structure of the conceptual framework. As the semi-structured interviews are the first level of evaluation, interview questions aim to evaluate both the universal and health-specific principles of TT applied within the conceptual framework. The geographic application area of the semi-structured interviews is limited to South Africa, as shown by Figure 6-15.

The second level of validation is represented by a survey. The survey is partly constructed from the outcomes of the first level of evaluation, a detail further discussed in Section 6.2.2. This allows the survey to reinforce and improve the outcomes of the semi-structured interviews while also enabling the cross-examination of outcomes obtained from different evaluation instruments.

However, the survey primarily aims at improving the relevance and utility of the conceptual framework with respect to the overarching aim of this research document, as first outlined within Section 1.4. Thus, the survey attempts to narrow the focus of the evaluation procedure from universal TT principles towards outcomes exclusively applicable to healthcare-specific TT ventures. Similarly, the survey's geographic application area, shown in Section 6.4.1, represents a larger proportion of the SSA landscape when compared to the semi-structured interviews' focus area.

After the outcomes of the first and second levels of evaluation are applied to the conceptual framework developed in Section 5.4, the third level of framework evaluation is conducted. The final evaluation instrument calls for the consolidated framework to be retrospectively applied to multiple healthcare case studies. This enables the evaluation and improvement of the framework's applicability and versatility with respect to healthcare TT in SSA. As shown in Section 6.5.1, the case studies chosen all possess varying TT principles and geographic application areas. This allows evaluation of the framework's utility with regards to various facets of healthcare over a substantial region of SSA. After the completion of the evaluation procedure, a final consolidated conceptual framework is constructed and presented in Chapter 7.

It should be noted that the first and third levels of validation are qualitative research methods. This implies that their outcomes are subject to the interpretation of the researcher. As such, the use of a survey instrument serves an additional function by providing a quantitative empirical foundation to further strengthen the conceptual framework's validity. Thus, the evaluation of the conceptual framework is based on a combination of qualitative and quantitative research methods.

6.2 Research methodology: Chapter 6

The research methodology of Chapter 6 is structured to enable the completion of phase 6 and phase 7 of the Conceptual Framework Analysis guidelines, shown in Figure 2-7. The individual research methodologies of the three consecutive levels of evaluation instruments, as shown in Figure 6-2, are presented in Section 6.2.1, Section 6.2.2 and Section 6.2.3 respectively.

Various evaluation instruments are reviewed to appraise their applicability for the evaluation of the conceptual framework. When reviewing the methodology sections of the literature items utilised during the systematic conceptual literature review, refer to Chapter 3, four methods of scientific validation can be identified; (i) interviews with industry experts, (ii) the application to case studies, (iii) survey instruments, and (iv) framework implementation which are frequently employed by researchers (Sung *et al.*, 2000; Ansari *et al.*, 2001; Schuppan, 2009; Swamidass *et al.*, 2009; Mars, 2010; Shiferaw *et al.*, 2012; Jack *et al.*, 2015). Each evaluation instrument possesses individual strengths and weaknesses and implementing multiple validation instruments to improve the validity of research is often advocated (Passmore *et al.*, 2002; Bakar *et al.*, 2012).

Implementation presents the truest form of evaluation of the ease of use, practicality and applicability of any tool (Mouton, 2011). Implementation does however often require extensive time and monetary resources and must be repeated across multiple domains to ensure that all facets of the tool are evaluated (Mouton, 2011). For a healthcare TT framework, incorporating multiple stakeholders, countries, technologies and managerial principles, the use of framework implementation is considered an impractical approach. Furthermore, identifying multiple healthcare projects and attempting to convince primary stakeholders to implement an unproven framework severely limits the feasibility of this evaluation instrument.

In comparison, the use of interviews with industry experts represents a more practical evaluation instrument. Literature highlights that the use of structured telephone or electronic interviewing, structured self-administered questionnaires, free-attitude open interviews and semi-structured interviews all represent frequently utilised interview evaluation instruments (Bassioni *et al.*, 2005; Mouton, 2011). Semi-structured interviews are generally selected as they allow the researcher to ascertain the views, perceptions and experiences of industry experts through various open-ended questions (Longhurst, 2003; Mouton, 2011; Rabionet, 2011). This process allows the interviewee to either validate, modify or refute the individual components of the conceptual framework as presented by the interviewer (Mouton, 2011; Rabionet, 2011). In this study, semi-structured interviews are thus selected as the first evaluation instrument to be utilised on the conceptual framework and represents a qualitative research method.

In contrast, the use of a survey instrument represents a quantitative research method while still requiring respondents to evaluate the individual components of a framework or tool (Passmore *et al.*, 2002; Mouton, 2011). Literature highlights that the use of descriptive surveys, explanatory surveys, uni- and multidimensional surveys all represent frequently utilised survey validation instruments (Passmore *et al.*, 2002). As the conceptual framework for this study was constructed out of multiple interlinked nodes of the TT process, a multidimensional survey instrument is implemented. While survey instruments may be implemented in isolation, it is considered ideal for a survey to be derived from framework components that have already been previously evaluated by a different evaluation instrument (Passmore *et al.*, 2002; Mouton, 2011). Thus, when implementing the survey instrument as the second evaluation instrument, it greatly reduces the required scope of the survey's feedback, as the components of the framework, have already been refined by a previous evaluation instrument.

Finally, by applying the framework to an ex-post case study, inference can be drawn regarding the utility and relevance of the framework (Bassioni *et al.*, 2005; Zucker, 2009; Mouton, 2011). These conclusions are founded upon the similarities identified between practical solutions implemented in industry and the managerial best practices highlighted within the five phases of the conceptual framework. Additionally, case studies may validate a framework by highlighting that adherence to the framework's managerial best practices could have mitigated problems experience in industry (Zucker, 2009).

An in-depth case study provides researchers with a clear view of a very specific setting while multiple case studies allow researchers with contrasting data over multiple settings (Zucker, 2009). While multiple case studies do not provide as an in-depth exposition of a specific setting, they are deemed to be more conducive to the complexity of the conceptual framework. To this extent, three retrospective case studies are utilised in this study as the third evaluation instrument. As with the semi-structured interviews, case studies represent a qualitative research method.

6.2.1 Semi-structured interviews

After the completion of the preliminary conceptual framework development in Section 5.4, 16 semi-structured interviews with healthcare TT experts are conducted. The primary goal of the semi-structured interviews has been to extract industry experience from the interview candidates (Bassioni *et al.*, 2005; Sekaran *et al.*, 2016).

6.2.1.1 Identifying interview candidates

Interview candidates are identified via the LinkedIn[7] online social media platform provided by Microsoft. Searches within this online platform allow researchers to identify prospective candidates according to their specific industry fields as well as their geographic application areas.

In total, 16 potential interview candidates are identified and contacted via the online social media platform. Each candidate is provided with a high-level overview of the conceptual framework and the research objectives of this study, as stated in Section 1.4.

6.2.1.2 Interview candidate suitability criterion

The filters applied to the social media search platform ensures that each candidate contacted possesses an appropriate level of applicable industry experience with respect to this research study. However, as an additional precaution, and in accordance with the research methodology outlined for the semi-structured interviews in Section 2.6.1, exclusion criteria are constructed. The exclusion criteria are shown in Table 6-2, and are implemented to reinforce the suitability of the identified industry experts.

[7] Linkedin

Table 6-2 - Suitability criterion for semi-structured interview candidates

Criterion	Description
Geographic region	Interview candidates must have acquired industry experience in at least one SSA country.
TT experience	Interview candidates must have acquired industry experience in at least one or more of the following fields of TT: - Post technology transfer evaluation - Technology transfer offices - Licensing - Joint ventures - Foreign Direct Investments - Start-up or spin-off business development - Stakeholder integration - Public liaison - Transfer object development - Transfer object management - Technology transfer consultation - Market screening and evaluation - Transfer environment screening - Legal
Timeline	Interview candidates must have been working in a TT related industry in a SSA country after the year 2010.

Each of the 16 prospective interview candidates are evaluated using these suitability criteria and the information provided on their LinkedIn social media profiles to establish their suitability. To comply with this research study's primary data research ethical clearance grant, provided by Stellenbosch University's Research Ethics Committee (SUREC) and shown in Appendix G, it is important to state that only candidate information obtained in an open-source and freely listed manner is used for this evaluation process. After this process is completed, 16 individual interview sessions are scheduled with the industry experts.

6.2.1.3 Data capturing and deductive analysis

The semi-structured interviews are initiated by providing each industry expert with an overview of the framework, its components, structure and the overall intended goal of facilitating healthcare TT in SSA. The industry experts are then prompted to provide feedback surrounding general framework items such as the TT team, stakeholder co-creation, legal counsel, standardisation of components, implementation and evaluation procedures, adoption and sustainability and additional marketing. An advantage of the semi-structured interview process is that these responses are generally much more detailed than a simple "yes" or "no" (Sekaran *et al.*, 2016).

After the initial conversation, the interview candidate is guided through a predefined and standardized list of questions, as shown in Appendix E. Candidates are strongly encouraged to elaborate based on their individual responses to the standardised questions. Thus, it is important to note that the questions presented to the interview candidates only serve as starting points to gauge their individual knowledge. As a result, all interview candidates have been further questioned based on their initial responses to the questions shown in Appendix E.

Each interview is electronically documented using the program Skype for Business provided by Microsoft. These recordings are deductively analysed to extract industry experience relevant to individual phases of the conceptual framework. To identify the modifications required for the conceptual framework, this analysis focussed on categorising the candidates' responses into validation, additions and modifications groupings per phase. The high-level outcome of this analysis process is presented in Table 6-24 with a detailed overview of individual outcomes shown in Section 6.3.2.

It is noted that, in order to comply with this research study's primary data research ethical clearance grant, provided by SUREC, the primary data recordings, as well as the candidate names for all interviews, have been omitted from this document. However, a copy of the semi-structured interview questions, presented to all interview candidates, has been made available for review in Appendix E. Additionally, the descriptive statistics of the semi-structured interview candidates is presented in Section 6.3.1 to highlight the applicability of their experience surrounding healthcare TT in SSA.

6.2.2 Survey

This section provides an overview of the twelve steps performed during the construction of the survey instrument and subsequent data analysis. This survey instrument represents the second level of evaluation for the conceptual framework developed in Chapter 5 and as such is partly derived from the outcomes of the semi-structured interviews, shown in Section 6.3. These twelve steps are shown in Figure 6-3, derived from Figure 2-9, and outline the research methodology followed during the construction, administration and estimation of the survey instrument, shown in Section 6.2.2.1 to Section 6.2.2.11, with the final data results presented in Section 6.3.3.

Figure 6-3 - Steps completed for survey instrument

6.2.2.1 Step 1 – State the problem need

After the completion of the semi-structured interviews, multiple outcomes surrounding the validation, required modifications and potential additions to the conceptual framework had been outlined. However, as only 16 candidates were interviewed, these outcomes were derived from a small representative sample size which may create sample bias, an argument supported by various literature items (Passmore *et al.*, 2002; Whitty, 2013).

Furthermore, when reviewing the research aim, stated in Section 1.4, the conceptual framework has the requirement to facilitate healthcare TT across the entire region of SSA. When reviewing the knowledge and experience base of the semi-structured interview candidates, shown in Figure 6-15, their exclusive proclivity towards South Africa raises uncertainty regarding the validity of the interview outcomes with respect to the geographic focus area of this research study. Similarly, while to a lesser extent, Figure 6-14 also highlights potential uncertainty of the applicability of the first level of evaluation with respect to healthcare TT best practices versus ICT TT best practices in general.

Due to the potential for sample bias in the semi-structured interviews, accompanied by potentially unsubstantiated evaluation outcomes with respect to the geographic and healthcare focus areas, an additional level of evaluation is required to remove potential ambiguity from the conceptual framework. Thus, this second level of evaluation is the survey instrument and will aim to reinforce and/or improve the evaluation outcomes uncovered during the semi-structured interviews. It will also allow for the conceptual framework's utility and ease of use to be evaluated and refined with regards to healthcare TTs.

6.2.2.2 Step 2 – Plan the project

The survey's planning commenced with the construction of a research team responsible for the survey's construction, administration, data collection and the interpretation of the results. Six team members are included in this research team and are shown in Table 6-3 along with an overview of the individual tasks allocated to team members. The research team is divided into a primary and secondary research team. The primary research team will be directly responsible for the completion of the survey while the secondary team will participate only in an advisory capacity.

Table 6-3 - Survey instrument's research team

Team member		Role	Survey assignment
Primary	R. Marais	Primary researcher	The survey's construction, administration, data collection, data handling as well as incorporating the results into the conceptual framework.
	S.S. Grobbelaar	Research supervisor	Supervisory role on the survey's construction.
	I. de Kock	Research supervisor	Supervisory role on the survey's construction.
Secondary	SUREC	Ethical clearance	Review the ethical compliance of the survey in accordance with Stellenbosch University's internal compliance policies and South African law.
	Martin Kidd	Statistician	Aid the development of the survey's research questions and identify the required data. Provide guidance on the proposed model.
	D-Tree International	Third-party consultant	Aid with the construction and administration of the survey. Specific focus on aiding with data collection methods for healthcare surveys in SSA.

The primary research team includes a PhD candidate, an associate professor and a lecturer from Stellenbosch University. All steps required to complete the survey will be executed by the PhD candidate with the rest of the primary research team serving in advisory roles. Including a statistician from the commencement of the survey enabled additional input when outlining the survey's questions as well as identifying which data would be required to answer these particular questions (Passmore *et al.*, 2002; Bartels *et al.*, 2009).

The SUREC is included in the research team, as the survey instrument's testing and administration may not commence without first obtaining ethical clearance. As with the first level of evaluation, to comply with this research paper's survey instrument research ethical clearance grant, the names all of candidates approached to complete the survey have been omitted from this document. However, the SUREC permitted the publication of descriptive statistics surrounding the candidates' experience as well as any primary data collected. While obtaining ethical clearance for the survey instrument does not require any financial input, the research grant's expected timeline was included in the survey's planning.

Lastly, D-Tree International was included as a third party consultant due to their experience with healthcare initiatives and digital health strengthening in SSA (D-Tree International, 2018). Furthermore, this third-party industry consultant also has substantial experience creating and administering healthcare survey instruments and have existing protocols aimed at promoting a survey's response rate (D-Tree International, 2018).

Table 6-4 - Survey project plan

Task	Assigned team member(s)
Identify survey research methodology	
Review academic literature.	R. Marais
State the problem	
Review the semi-structured interview outcomes.	R. Marais
Highlight evaluation uncertainties.	Primary team members
Plan the project	
Identify the required research team.	R. Marais
Identify the survey's tasks and sub-tasks.	R. Marais
Assign team members to all survey sub-tasks.	Primary team members
Outline the survey tasks' expected timeline and cost.	R. Marais
Identify a target research journal for publication.	Primary team members
State the survey questions	
Outline the aim and research questions of the survey.	R. Marais; Statistician
Categorise questions into groupings.	R. Marais
Incorporate the outcomes from the semi-structured interviews.	R. Marais
Outline the survey's operational definition.	R. Marais
Review literature	
Highlight all surveys from literature reviews.	R. Marais
Evaluate the applicability of the survey instruments.	R. Marais
Develop/adapt survey items	
Select an existing survey instrument.	R. Marais
Select a measurement scale and format.	R. Marais; Statistician; D-Tree International
Define the constructs to be gathered and measured.	R. Marais
Define the constructs' measurement items.	R. Marais; Statistician
Outline how the data will be analysed.	R. Marais
Cross review the adapted survey instrument.	Primary team members; Statistician, D-Tree International
Construct the survey	
Synthesis the individual questions into a survey instrument.	R. Marais
Identify the potential candidate groups.	Primary team members
Finalise the survey's operational definition.	R. Marais
Obtain an ethical clearance grant.	R. Marais; SUREC
Pilot test the draft survey	
Pilot test one and revision.	R. Marais; D-Tree International
Pilot test two and revision.	R. Marais; D-Tree International
Administer the survey	
Finalise the candidates per candidate group.	Primary team members
Email the final survey instrument.	R. Marais
Follow up communications.	R. Marais
Analyse survey results	
Clean, filter and double enter all the data obtained.	R. Marais
Quantitative processing.	R. Marais; Statistician
Write-up final survey outcomes	
Summarise the final data outcomes.	R. Marais
Discuss the final outcomes.	R. Marais

6.2.2.3 Step 3 – State survey questions

The survey's aim is to evaluate and improve the conceptual framework's ease of use and utility for healthcare-specific TT over the geographic region of SSA. To this extent, the survey questions are divided into three primary categories; (i) descriptive statistics and industry experience of respondents (ii), healthcare TT principles, (iii) geographic application area of SSA. The research questions per category are outlined in Table 6-5.

Literature highlights that the applicability of the respondents' experience surrounding the primary research question should be evaluated (Kaushal *et al.*, 2008; Free *et al.*, 2013). Thus, predefined respondent exclusion criteria are recommended to promote the validity and usefulness of the survey's outcomes (Kaushal *et al.*, 2008; Free *et al.*, 2013). To this extent, the exclusion criteria, presented in Appendix F.2, aim to ensure respondents possess experience directly relevant to healthcare TT in one or multiple SSA countries. This process is also endorsed after revision by the third-party consultant.

To evaluate the experience of the survey respondents, the first category contains questions surrounding the respondent's descriptive statistics and industry experience. Additionally, the first category of the survey instrument provides respondents with a simple introduction which may promote the survey response rate (Passmore *et al.*, 2002).

The second category contains questions specifically addressing healthcare TT principles. The third category contains questions specifically addressing the geographic application area of SSA. Additionally, the survey's questions in the third category aim to uncover potential similarities or variances between the regions within SSA after multiple literature items highlighted the difference between these regions (Geissbuhler *et al.*, 2003; Bagayoko *et al.*, 2006; Mars, 2010; Anyanwu, 2012).

Literature suggests that incorporating the outcomes of an alternate evaluation instrument into the construction of the survey will both aid in its validity and applicability (Passmore *et al.*, 2002; Kaushal *et al.*, 2008). To this extent, the survey questions of both the second and third categories have been partly derived from the outcomes of the semi-structured interviews, shown in Section 6.3.

Step 3 is concluded by constructing the operational definition of the survey instrument, shown in Appendix F.1. The operational definition outlines the survey's technical definitions, data to be collected, measuring instrument and decision criteria while also providing a high-level overview of the survey's purpose within this research study. The operational definition is finalized during the final construction of the survey instrument and will be presented to all respondents before completing the survey.

Table 6-5 - Survey questions

Category 1	Descriptive statistics and industry experience of respondents
Survey question 1.1	What is the ratio of organisations working for profit versus not for profit?
Survey question 1.2	From which countries have the respondents gained their experience?
Survey question 1.3	In which areas of TT do the respondents have experience?
Survey question 1.4	In which fields of healthcare do the respondents have experience?
Survey question 1.5	What was the relative success of the respondent's technology transfer ventures?
Category 2	**Healthcare TT principles**
Survey question 2.1	What is the importance of stakeholder co-creation?
Survey question 2.2	What components determine a successful TT team?
Survey question 2.3	What is the perceived ease of use for the joint venture TT method?
Survey question 2.4	How do different training methods compare for TT ventures?
Survey question 2.5	What is the importance of legal considerations on a TT venture?
Category 3	**Geographic application area of SSA**
Survey question 3.1	How does Western Africa differ from SSA as a whole when executing the phases of TT?
Survey question 3.2	How does Central Africa differ from SSA as a whole when executing the phases of TT?
Survey question 3.3	How does Eastern Africa differ from SSA as a whole when executing the phases of TT?
Survey question 3.4	How does Southern Africa differ from SSA as a whole when executing the phases of TT?
Survey question 3.5	What is the perceived ease of use and usefulness of the framework over SSA as a whole?

6.2.2.4 Step 4 – Review literature of available survey instruments

Reviewing literature of applicable survey instruments ensures that researchers become familiar with existing published work, gaps in current literature and ensures that new work is being conducted (Passmore *et al.*, 2002). Furthermore, reviewing the applicable literature may provide the primary research team with an existing survey instrument that may be adapted for this survey instrument (Kitchenham *et al.*, 2002; Passmore *et al.*, 2002). Adapting an existing validated survey instrument reduces time and monetary effort of constructing and validating a new survey instrument (Kitchenham *et al.*, 2002; Passmore *et al.*, 2002).

While the primary purpose of the systematic comparative literature review is not to identify existing survey instruments, the literature reviewed during Chapter 4 is limited to healthcare and ICT TT case studies in SSA completed after the year 2000. Thus, the literature reviewed during the completion of Chapter 4 directly aligns with the research aim of the survey and will be utilised in its construction. The research methodology of the systematic comparative literature review's data collection and appraisal is shown in Section 4.2.

The 51 case studies identified during the systematic comparative literature review are re-examined and all literature items containing survey instruments are highlighted. A comparison of all the identified survey instruments is shown in Appendix F.4. Of the 51 case studies identified, 9 contained quantitative analysis using survey instruments. Questionnaires are the most frequently utilised survey instrument, with 6 out of the 9 case studies implementing questionnaires to gather primary data.

Further literature study highlighted that a questionnaire represents a well-tested survey instrument (Shields *et al.*, 2007; Schoen *et al.*, 2012; Free *et al.*, 2013; Hailey, 2014) provided that is it reinforced by peer-reviewed literature items (Kitchenham *et al.*, 2002; Whitty, 2013). Thus, due to its regularity and established validity in healthcare research (Kifle *et al.*, 2010; Karari *et al.*, 2011; Shiferaw *et al.*, 2012), adapting a questionnaire with standardised measurement scales represents an appropriate survey instrument for the conceptual framework's second level of evaluation.

The primary communication methods implemented in the identified survey instruments include hard copies, telephone calls, emails, site visits, online electronic surveys or a combination of these methods. Literature also suggests that in order to improve the survey's response rate, additional follow-up communication is advisable (Shields *et al.*, 2007; Whitty, 2013).

Lastly, as shown in Table F-3 in Appendix F, the response format of the 9 identified survey instruments are evaluated. Likert scales and open-ended responses are frequently implemented with one survey utilising a satisfaction scale. However, literature highlights that the response format must be directly applicable to the survey's individual research questions and implementing a single response format improves the overall clarity of a survey instrument (Kitchenham *et al.*, 2002; Passmore *et al.*, 2002).

6.2.2.5 Step 5 – Adapt existing survey items

Step 5 of the survey's research methodology requires the research team to either develop a new survey instrument or adapt a survey instrument by modifying one or more existing survey instruments (Passmore *et al.*, 2002). After reviewing the applicable literature in Step 4, a survey instrument from two existing and well-validated survey instrument items is adapted (Ssewanyana *et al.*, 2007; Kifle *et al.*, 2010). However, it is important to note that the development is directly supplemented by the outcomes of the semi-structured interviews in addition to the two existing survey instruments.

The adapted survey instrument utilises a five-point Likert item scale for all the survey's measurement items, except for the demographic questions. Respondent responses may range between 1 (strongly disagree) and 5 (strongly agree). A five-point Likert item scale is selected on its prevalence in the survey instruments outlined in F.4. The Likert item scale also has a proclivity to standardised quantitative data processing (Kitchenham *et al.*, 2002; Passmore *et al.*, 2002).

The previously validated survey instruments (Ssewanyana *et al.*, 2007; Kifle *et al.*, 2010) are adapted to modify their geographic and TT focus. To this extent, the geographic application area is altered from Uganda and Ethiopia to SSA and the TT principles from ICT and telemedicine TT to healthcare TT. This ensures that the adapted survey instrument aligns with the survey's questions, outlined in Table 6-5.

Finally, when using general measurement scales it enables researchers to easily compare results with other studies of a similar nature (Kitchenham *et al.*, 2002; Passmore *et al.*, 2002). To this extent, the adapted survey instrument's measurement constructs comprised of perceived ease of use and usefulness. Table 6-6 outlines the adapted survey instrument's measurement scales, definitions, as well as highlighting examples of each measurement scale's area of focus.

Table 6-6 - The survey's measurement scales (adapted from Ssewanyana & Busler, 2007; Kifle et al., 2010)

Construct	Definition	Measurement item's focus areas
Perceived ease of use	The degree to which a person believes that using a system would be free of effort.	If I were to use a standardised framework that guides technology transfer…. It would be easier for me to use than my current methods. It would be easier to identify the required stakeholders for the technology transfer. It would be easier for me to assign and execute stakeholder roles. It would be easy for me to promote co-creation amongst technology transfer stakeholders.
Usefulness	The degree to which a person believes that using a system would enhance their job performance.	Using a standardised framework that guides technology transfer would improve the success rate of my technology transfer ventures. Using a standardised framework that guides technology transfer would shorten the technology transfer's timeline. Using a standardised framework that guides technology transfer would reduce the technology transfer's budget. If I were to use a standardised framework that guides technology transfer, I would find it useful in my job.

It is argued that researchers should review the measurement scales and items to increase the instrument's validity regardless of if the survey instrument is newly constructed or has been adapted (Kitchenham *et al.*, 2002; Shields *et al.*, 2007; Schoen *et al.*, 2012; Free *et al.*, 2013). Several literature items further recommend that the revision of the measurement items should be completed before, and not during, the survey instrument's pilot test as this revision should be conducted by parties with relevant academic or industry experience rather than potential survey respondents (Passmore *et al.*, 2002; Kifle *et al.*, 2010).

Finally, this revision process is also encouraged by the authors of the two existing survey instruments being adapted (Ssewanyana *et al.*, 2007; Kifle *et al.*, 2010) as well as by the research team's third-party consultant.

Thus, a revision panel is established to critique the validity of the adapted survey instrument's measurement items. Additionally, the revision panel evaluated the suitability of the format, vocabulary and operational definition, presented in Appendix F.1, of the survey instrument. The revision panel comprised of the primary research team, D-Tree International and the SUREC.

While the primary research team oversaw the revision process, the contributions of the industry expert are prioritised due to their experience in conducting surveys in SSA in the field of healthcare (D-Tree International, 2018). Lastly, the SUREC is included in the revision panel to ensure ethical compliance of the survey's measurement scales and measurement items. All the revisions identified for the survey instrument's measurement scales, measurement items and operational definition are incorporated into the survey's construction during Step 6.

6.2.2.6 Step 6 – Technology transfer literature summation and hypotheses

As stated in Section 6.2.2.1, the primary goal of the survey is to build upon the outcomes of the semi-structured interviews while refining the conceptual framework's practicality and usefulness. To this extent, critical literature components uncovered during the systematic conceptual and comparative literature reviews, refer to Chapter 3 and Chapter 4, are restated during step 6 of survey's construction to improve the readability of this research study.

These critical literature components serve as the foundation for the construction of hypotheses which are utilized during the survey instruments subsequent steps. The literature summation is presented from two primary key perspectives: (i) measures of TT performance and (ii) determinants influencing the performance of a TT venture.

i. Measures of technology transfer performance

The fundamental purpose of a TT venture is to enable the adoption of a transfer object for a determined faction of end-users (Teece, 1977; Schwartz, 2004; Bozeman *et al.*, 2015). The motivation behind end-user adoption may greatly vary as different stakeholders initiate TT ventures for varying reasons such as economic returns, expansion of market area or improving the social welfare of end-users (Bozeman, 2000; Golob, 2006; Hoekman *et al.*, 2006). Regardless of the motivation however, end-user adoption of the transfer object remains a primary measure of TT performance.

When additional end-users, not included in the predetermined faction, are also exposed to the transfer object, technology diffusion occurs (Hoekman et al., 2006). As the diffusion of the transfer object acts as an extension of the original end-user adoption, it can also be regarded as a primary measure of TT performance (Bozeman, 2000; Golob, 2006). The final measure of performance identified is the satisfaction level of the TT team when conducting a TT venture. (Bozeman, 2000; Becerra-Fernandez *et al.*, 2003; Bassioni *et al.*, 2005). Lastly, it is important to note that adoption, diffusion and satisfaction are only the crowning goals measuring the relative success of a TT venture, and all three are dependent on a variety of individual TT determinants.

ii. Determinants influencing the performance of a TT venture.

In total, nine major groups of determinants are identified as critical to the success of a TT venture, namely: (i) The TT team; (ii) Stakeholder Co-creation; (iii) Legal Considerations for Project Components; (iv) Standardization of Project Components; (v) Project Implementation Methods; (vi) Project Evaluation Procedures; (vii) Training Methods for the Technology; (viii) Adoption and Sustainability; and (xi) Marketing. A detailed literature overview of each determinant is shown in Appendix F.6.

These determinants have previously been utilized as the foundations for the best practises developed during the conceptual framework's construction in Section 5.3. As before, the determinants will be subject to the perceived ease of use and usefulness measurement scales outlined in Table 6-6. This, along with the measures of performance leads to the primary set of hypotheses for this survey:

(H1:) There will be a positive association between the ease of use of the best practices in the first phase of the conceptual framework and the relative success of a technology transfer venture

(H2:) There will be a positive association between the ease of use of the best practices in the second phase of the conceptual framework and the relative success of a technology transfer venture

(H3:) There will be a positive association between the ease of use of the best practices in the third phase of the conceptual framework and the relative success of a technology transfer venture

(H4:) There will be a positive association between the ease of use of the best practices in the fourth phase of the conceptual framework and the relative success of a technology transfer venture

(H5:) There will be a positive association between the ease of use of the best practices in the fifth phase of the conceptual framework and the relative success of a technology transfer venture

(H6:) There will be a positive association between the usefulness of the best practices in the first phase of the conceptual framework and the relative success of a technology transfer venture

(H7:) There will be a positive association between the usefulness of the best practices in the second phase of the conceptual framework and the relative success of a technology transfer venture

(H8:) There will be a positive association between the usefulness of the best practices in the third phase of the conceptual framework and the relative success of a technology transfer venture

(H9:) There will be a positive association between the usefulness of the best practices in the fourth phase of the conceptual framework and the relative success of a technology transfer venture

(H10:) There will be a positive association between the usefulness of the best practices in the fifth phase of the conceptual framework and the relative success of a technology transfer venture

6.2.2.7 Step 7 – Construct survey

Step 7 illustrates how the final survey instrument is constructed. An example of the final survey instrument is shown in Appendix F.10. Please note that the survey instrument shown in Appendix F.10 represents the final version distributed to respondents and, as such, contains additional refinements derived from the outcomes of the pilot surveys, completed in Step 8. The survey instrument is constructed by conflating the following elements:

i. The content and structure of the preliminary conceptual framework, shown in Section 5.4;
ii. The outcomes of the semi-structured interviews, shown in Table 6-24;
iii. The survey questions, shown in Table 6-5; and
iv. The adapted survey measurement scales, shown in Table 6-6.

The survey instrument is split into three separate sections as the measurement items of these categories differ substantially. The first section contains questions regarding the respondents' demographics and has been derived from category 1 of the survey instrument's research questions. The measurement scales, and subsequent items are tailored to each individual demographic question. The outline of the demographic questions, along with their individual measurement scales, is shown in Table 6-7. The individual measurement items of the demographic questions are presented in the final survey instrument, shown in Appendix F.10. Table 6-7 also highlights which individual survey questions the demographic questions have been derived from.

Table 6-7 - Outline of the survey instrument's demographic questions and measurement scales

Demographic questions	Question (Refer to Table 6-5)	Measurement scale
What is your official title within this organisation?	1.3; 1.4	Open-ended
In what year was your organisation's health initiative initiated?	1.2 - 1.5	Year scale
What was the motivation for the healthcare initiative	1.2 - 1.5	Commercial-scale
Which sub-Saharan countries, if any, does your organisation most frequently conduct operations in?	1.2	Geographic scale
Which technology management markets, if any, does your organisation most frequently conduct operations in?	1.1 - 1.4	List of technology management markets
Which fields of technology transfer, if any, does your organisation conduct operations in?	1.3	List of technology transfer components
Which fields of healthcare, if any, does your organisation conduct operations in?	1.4	List of healthcare fields

The second section of the survey contains three questions, shown in Table 6-8, aimed at evaluating the relative success or failure of the TT ventures that survey respondents are in the process of completing or have already concluded. While these three questions may be categorised as demographic questions, they have been placed in a separate section of the survey instrument's research methodology due to their increased importance in the data processing step of the survey.

The outline of the evaluation questions and their applicable measurement scales are shown in Table 6-8. Table 6-8 also highlights which individual survey research questions the evaluation questions are derived from, shown in Table 6-9.

These three evaluation questions will allow for a variance and regression analysis pertaining to the various levels of TT success and the individual actions of the TT team, captured in the third section of this survey instrument. This variance and regression analysis are completed in Section 6.3.3. These three evaluation questions are constructed based jointly on the outcomes of the semi-structured interviews, the recommendation of the third-party consultant as well as both systematic literature reviews.

Table 6-8 - Outline of the survey instrument's evaluation questions and measurement scales

Evaluation questions	Question (Refer to Table 6-5)	Measurement scale
To what extent did the end-user adopt the technology?	1.5	Adoption scale
What was the extent of the transfer object's diffusion after the transfer?	1.5	Diffusion scale
What has been your organisation's satisfaction level regarding the technology transfer considering time and monetary input?	1.5	Satisfaction scale

Although the measurement scales for each evaluation question is different, they have all been based on a five-point Likert scale to enable standardized and simplified computations. The individual measurement items of the evaluation questions are presented in Table 6-9 as well as in the final survey instrument, shown in Appendix F.10.

Table 6-9 - Outline of the measurement items for the measurement scales implemented in the evaluation questions

Measurement scales	Measurement items				
Adoption scale	Technology was not adopted at all	Technology was poorly adopted	Technology was marginally adopted	Technology was generally adopted	Technology was wholly adopted
Diffusion scale	Technology did not experience any diffusion	Technology's diffusion was limited	Technology experienced marginal diffusion	Technology experienced diffusion	Technology was widely diffused
Satisfaction scale	Completely unsatisfied	Unsatisfied	Somewhat satisfied	Satisfied	Completely satisfied

The survey's third section contains multiple action statements and represents the primary data to be gathered by this survey instrument. This section has been constructed upon the adapted survey measurement scales shown in Table 6-6. As such, perceived ease of use and usefulness are utilised for the measurement scales for all action statements within the third section of the survey instrument. The measurement items for these two measurement scales are shown in Table 6-10.

Table 6-10 - Outline of the measurement items for the measurement scales implemented in the action statements

Measurement scales	Measurement items				
Perceived ease of use	Impossible to implement	Difficult to implement	Routine to implement	Easy to implement	Trivial to implement
Usefulness	Not useful at all	Negligible utility added	Moderately useful	Useful	Extremely useful

The actions statements of the third category are outlined in Table 6-11. These actions statements have been categorised according to the five phases of the developed preliminary conceptual framework namely; (i) technology development, (ii) technology analysis, (iii) transfer method application, (iv) change management, and (v) commercialisation. This aims to ensure that respondents can provide feedback about the utility of specific nodes within the framework. However, to simplify the survey's structure and flow for respondents, these actions statements are grouped into the various foundations of the conceptual framework. These foundations consist of the TT team, stakeholder co-creation, legal considerations for project components, standardisation of project components, project implementation methods, project evaluation procedures, training methods, adoption and sustainability and marketing as outlined in Appendix F.6.

Table 6-11 also highlights the individual survey research questions from which the action statements are derived. Action statements with additional references have been partly constructed from the outcomes of the semi-structured interviews. While not shown in Table 6-11, the measurement items shown in Table 6-10 will be applied to every action statement presented in Table 6-11. It is important to note that the wording of some action statements presented in Table 6-11 differs from those presented to respondents in the final survey instrument. These wording changes resulted from the outcomes of the pilot test completed in Section 6.2.2.8 and aimed to ensure ease of understanding amongst respondents by eliminating academic jargon. A summary of these changes is shown in Appendix F.3.

Table 6-11 - Outline of the survey instrument's primary action statements per phase of the conceptual framework

Action statements	Survey question (Refer to Table 6-5)
Phase I: Technology development	
A universal starting point (M.1 - Table 6-24)	
- Creating a universal technology transfer starting point regardless of the initiator.	2.4; 3.5
Relationship between transferor and transferee	
- Conducting preliminary screening of the primary stakeholders' abilities to allocate initial technology transfer tasks.	2.1 - 2.4; 3.1 - 3.5
Constructing a detailed co-creation tool	
- Constructing a dedicated technology transfer team from members of both primary stakeholders.	2.3; 3.5
- Implementing a managerial hierarchy within this team, i.e. where all team members, except one, is supervised and directly managed by another.	2.1; 2.3; 3.5
- Implementing a tangible or intangible incentive scheme for team members.	2.1; 2.3; 3.5
- Defining the technology transfer as a profitable business venture or a strategic alliance.	2.5
Legally binding stakeholders (A.1 - Table 6-24)	
- Legally binding the transferor to the technology transfer over its entire lifecycle.	2.3; 2.5; 3.1 - 3.5
Phase II: Technology analysis	
Establishing a standardised stakeholder tool (A.2 - Table 6-24)	
- Assigning standardised, not case-specific, roles or responsibilities to individual stakeholders.	2.2; 2.4; 2.5; 3.5
Incorporating additional stakeholders into a co-creation tool	
- Constructing a dedicated technology transfer team from both primary and additional stakeholders.	2.3; 3.5
- Implementing a managerial hierarchy within this team, i.e. where all team members, except one, is supervised and directly managed by another.	2.1; 3.5
- Outlining a tangible or intangible incentive scheme for team members.	2.1; 2.3; 3.5
- Defining the technology transfer as a profitable business venture or a strategic alliance.	2.5; 3.5
Screening the transfer environment	
- Screening the transfer environment's infrastructure components and categorising available and missing components.	2.5; 3.2; 3.1 - 3.5
- Selecting infrastructure mitigation practices from a standardised technology transfer list for case-specific technology transfers.	3.2; 3.1 - 3.5
- Identifying tailored-made solutions for missing infrastructure components.	3.5
Incorporating legal counsel	
- Incorporating legal advice into the transfer object's design.	2.2; 2.3; 3.5
- Incorporating legal advice into the completed technology transfer strategy.	2.2; 2.3; 3.5
Phase III: Transfer method application	
Selecting a transfer method	
- Implementing a joint venture technology transfer method in favour of other methods.	2.3; 3.1 - 3.5
Internal revision procedures (A.4 - Table 6-24)	
- Evaluating an individual technology transfer using standardised criteria.	2.4; 3.1 - 3.5
Promoting future adoption (A.1, A.2, A.3 - Table 6-24)	
- Constructing a prototype of the transfer object.	2.3; 3.5
- Incorporating and incentivising early adopters into the technology transfer team.	2.3; 3.5
Phase IV: Change management	
Improving the technology transfer team's outreach	
- Routinely identifying and removing stakeholders with limited future utility regarding the technology transfer.	2.1; 2.3; 3.1 - 3.5
- Identifying and recruiting ground-level stakeholders to champion the transfer object.	2.1 - 2.3; 3.5

Training ground level users (A.1, A.2, A.4, M.1 - Table 6-24)	
- Constructing training methods based on the user's existing internal training policies.	2.3; 2.5; 3.1 - 3.5
- Implementing on-site transfer object training.	2.2; 2.3; 3.5
- Training end-users to train future users of the transfer object.	2.3; 3.5
- Identifying end-users' capabilities and constructing training programs accordingly.	2.3; 2.5; 3.1 - 3.5
Ensuring sustainable communication	
- Implementing and maintaining a standardised and continual communication channel between the transferor and transferee after the technology transfer has occurred.	2.3; 3.5
Phase V: Commercialisation	
Reviewing the completed technology transfer	
- Compiling revision feedback from multiple stakeholder perspectives into a standardised table.	2.4; 2.5; 3.5
- Using standardised and pre-defined evaluation criteria for the revision process.	2.4; 3.5
- Allowing future technology transfers access to revision documents of completed technology transfers.	2.5; 3.1 - 3.5
Promoting sustainability (A.4 - Table 6-24)	
- Marketing the transfer object to additional public-sector stakeholders, not in the original transfer team.	3.1 - 3.5
- Marketing the transfer object to additional private sector stakeholders, not in the original transfer team.	3.1 - 3.5
Codification standards (A.2, M.2 - Table 6-24)	
- Implementing and maintaining a standardised and continual form of communication between all stakeholders throughout the technology transfer.	2.3; 2.4; 3.5
- Documenting all outcomes throughout the technology transfer into standardised tables.	2.4; 3.5
- Allowing future technology transfers to access documentation of completed technology transfers.	2.5; 3.1 - 3.5

6.2.2.8 Step 8 – Conduct pilot tests

The pilot tests are implemented to ensure that the survey instrument is free of language errors and simple to understand. The pilot tests also ensure that the individual questions within the survey instruments are clear, unambiguous and are relevant to the survey instrument's research questions as outlined in Table 6-5.

The survey instrument was subject to three independent pilot tests. The preliminary pilot test was completed by inviting the survey instrument's research team to complete the survey and provide feedback.

This feedback primarily consisted of language editing and general sentence construction. It is noted that the original survey instrument included an additional third measurement item, "compatibility", to further evaluate the action statements shown in Table 6-11. This third measurement item attempted to quantify the compatibility of the conceptual framework with existing company and government protocols. After evaluating the feedback of the first pilot test, this measurement item was wholly removed from the survey instrument as it partly overlaps with perceived ease of use. Additionally, removing the compatibility measurement scale greatly reduces the total survey completion time, thus improving the potential response rate of the final survey instrument (Passmore *et al.*, 2002).

The second and third pilot tests incorporate the experience of individuals employed at the South African Council for Scientific and Industrial Research (CSIR) and Broadreach Healthcare (PTY) Ltd respectively. Broadreach Healthcare is a private South African based company with multiple healthcare initiatives across the African continent (Broadreach Healthcare, 2018). While the names of the individuals involved in the pilot testing have been omitted for anonymity as per SUREC requirements, the individuals are selected due to their direct industry experience in TT and healthcare initiatives while remaining independent from one another.

A predefined testing protocol is implemented for the second and third pilot tests and is outlined in Figure 6-4. Each pilot test candidate was invited to complete the survey instrument after which the individual is electronically interviewed to acquire feedback on the various characteristics of the survey instrument.

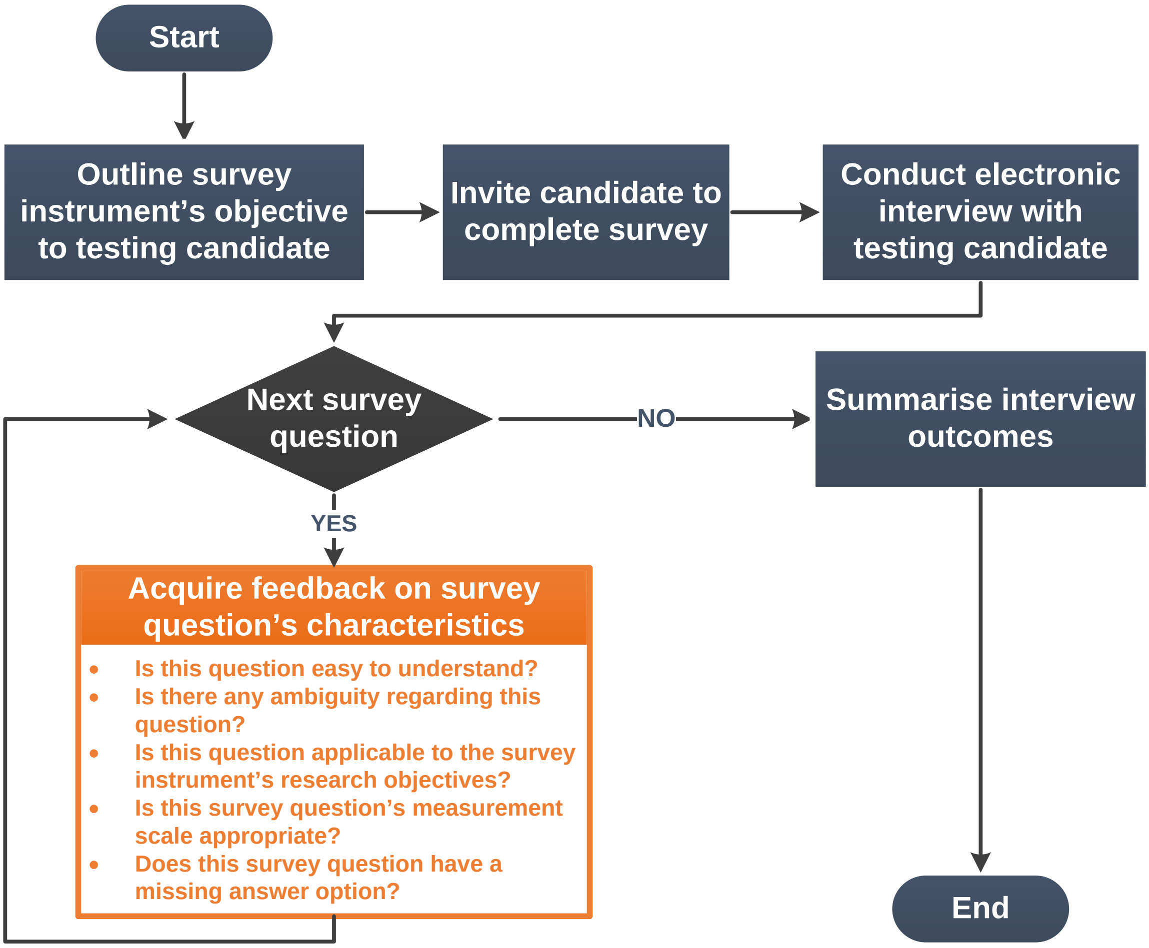

Figure 6-4 - Pilot testing protocol for survey instrument

The feedback of the second and third pilot test mainly focussed on improving the survey's clarity and removing ambiguity from several questions. Several additions to the predefined answers options are also implemented based on the outcomes of the second and third pilot tests

A complete summary of the three pilot test is outlined in Appendix F.5. This summary highlights the individual testing industries of the three pilot tests, the identified potential problem questions and recommendations for general question enhancement.

6.2.2.9 Step 9 – Administer the survey

The administration of the survey instrument was wholly governed by the SUREC to ensure that this study remained within the compliance parameters set forth within the ethical research grant (SUREC case number: ING-2018-7493, refer to Appendix G). To this extent, the research team implemented The Center for Health Market Innovations (CHMI) and the Global Digital Health Network (GBHN) to act as gatekeepers between the research team and potential respondents.

These two administrative institutions provide access to their internally developed medical project databases and project members. While these medical project databases are internally developed, the information within is kept within an open domain and use was not subject to any additional legal or ethical compliance regulations.

Before the survey could be distributed to potential respondents, both the CHMI and the GBHN received a gatekeeper request form, provided by the SUREC, to be signed and returned for review. After the survey instrument's research team received both institutions' signed forms, a final revision was conducted, led by the SUREC.

After the completion of this review, the survey could be distributed to potential respondents through the CHMI and GBHN online contact forms. Additional electronic and telephonic correspondences are granted for projects and project leaders with contact information listed on the CHMI and GBHN project databases, provided it was listed in the public domain. The final method of survey distribution granted by the SUREC is a forwarding mechanism built into the survey instrument allowing respondents to forward the survey to additional potential respondents.

Projects within both databases were alphabetically sorted and reviewed to ensure that projects and project leaders are not subject to the survey's exclusion criteria listed in Appendix F.2. The remaining projects are categorized into clusters based on their geographic application area. Projects implemented over multiple countries are categorized according to their primary country of application or divided into multiple sub-projects in instances where projects had different project leaders for each country. Lastly, these clusters are formatted to ensure that no project was listed in both CHMI and GDHN databases, resulting in inadvertent duplication. Out of the 50 SSA countries, 44 clusters possessed at least one project or more.

The CHMI provided 492 individual healthcare projects and the GDHN provided 71 individual healthcare projects resulting in a total of 563 potential survey respondents. The survey instrument was electronically distributed via the CHMI and GDHN online contact forms with a standardised invitation message provided for review in Appendix F.6. All 563 project leaders are contacted via these online contact forms. Emails, containing the same invitation message, are distributed in conjunction with the online contact forms for instances where email contact information is freely listed on the CHMI and GDHN websites.

Lastly, projects with freely listed contact numbers are phoned directly to inquire about the respondent's availability and willingness to complete the online survey instrument. In total, 184 projects are contacted via telephone. For four of these phone calls, respondents informed the research team of their willingness to complete the survey but inability due to their current environment's lacking digital infrastructure. All four of these respondents are contacted in a follow-up session where the survey was administered to them telephonically. This process required a primary researcher to read the online survey to the respondent and capture the respondent's answer in real-time on a blank survey form on their personal computer. No personal interviews are conducted during the survey instrument's administration. The complete outline of the survey administration respondent data is provided in Appendix F.8.

6.2.2.10 Step 10 – Model creation

Before any quantitative data processing can commence there is an inherent need to define the data set (Kitchenham et al., 2002; Passmore et al., 2002). This subsequently allows the creation of a model (Coltman et al., 2008; Edwards, 2011). As applying a model to an incompatible data set will produce results that are statically void, it is important to understand the characteristics of the chosen model and compare it to the survey instruments' perceived ease of use and usefulness data sets (Coltman et al., 2008; Collier et al., 2009). In order to provide statistical evidence to either support or reject the hyptoheses, shown in Section 6.2.2.6, a structural equation model, with a mixed formative-reflective measurement model, is implemented for the regression and correlation data analyses of the survey.

i. Structural equation modelling

In order to process the data results captured by the survey in a systematic and scientifically sound manner, an appropriate measurement model and structural model are required. By incorporating both measurement and structural models it provides researchers with a method to model the relationship between variables while still maintain a substantial degree of flexibility (Hoyle *et al.*, 1994). This will subsequently provide conclusions pertaining to the survey's research questions as well as the hypotheses testing, outlined in Section 6.2.2.3 and Section 6.2.2.6.

The primary purpose of a measurement model is to describe the causal relationships between the latent variable, also referred to as a construct, and its indicators, also referred to as measured variables, items, estimators and measures (Anderson *et al.*, 1988; Hoyle *et al.*, 1994; Pribeanu, 2012). A path diagram of a basic measurement model is shown in the orange demarcated area within Figure 6-5 with η representing the latent variable, χ representing the indicators and ε representing the variability or error unique to the individual indicator. It is noted that it is desirable to have a latent variable described by at least three or more indicators (Hoyle *et al.*, 1994). In terms of measurement models, structural equation modelling differentiates between two distinct models, namely reflective and formative (Edwards *et al.*, 2000; Howell *et al.*, 2007; Pribeanu, 2012; Fattore *et al.*, 2018).

The structural model differs from the measurement model as it attempts to describe the relationships between dependent and independent variables which may either be observed or latent (Hoyle *et al.*, 1994; Diamantopoulos *et al.*, 2008; Pribeanu, 2012). Perhaps the most basic structural model is depicted by the simple linear regression equation. A path diagram of a basic structural model is shown in the dark blue demarcated area within Figure 6-5 with η representing the latent variable or independent variable, Z representing mediating variable, ψ representing the dependent variable the indicators and ε representing the variability or error unique to the individual indicator. In this instance ζ represents the disturbance term. The disturbance term represents a summation of all possible causes which are not captured or correlated to the individual indicators of the latent variables.

When combining the measurement model and structural model, represented by the collective whole of Figure 6-5, a general structural equation model is created. The curved line connecting η_1 with η_2 represents an advantage of structural equation modelling as the model places no restriction on the relationship between the latent variables. This is as expected when implementing multiple regression analysis but is different from analysis of variance (Hoyle *et al.*, 1994; Peng *et al.*, 2002; Blanca *et al.*, 2018), yet this does not restrict a research of implementing either of these analyses within individual sections of the model (Hoyle *et al.*, 1994). A second benefit is shown by the curved line connecting ψ_1 with ψ_2 as structural models allow from a directional relationship between the dependent variables (Hoyle *et al.*, 1994). The final major advantage is shown by Z, as structural equation modelling simultaneously regards the mediator variable as both a predictor and an outcome. Thus, the mediator variable is both a dependent and independent variable (Hoyle *et al.*, 1994).

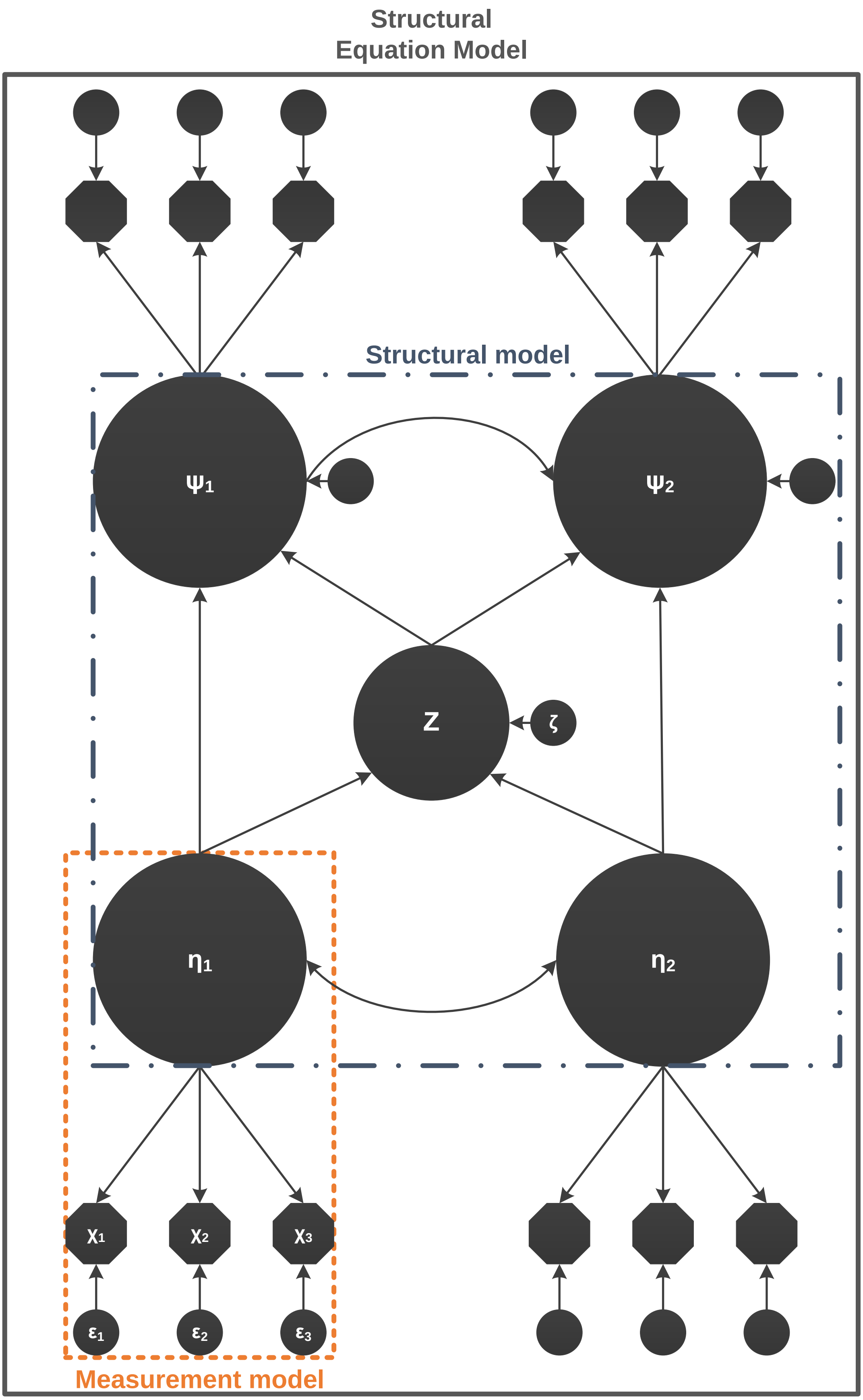

Figure 6-5 - Example of a structural equation model

Considering these model advantages in conjunction with the aim of the survey, the use of structural equation modelling is implemented for this research study. It is a flexible and wide-ranging model drawing on the strengths of multiple well-defined statistical analysis techniques such as multiple regression, rank order regression, factor analysis and analysis of variance (Hoyle *et al.*, 1994; Bagozzi, 2007; Diamantopoulos *et al.*, 2008; Chang *et al.*, 2016; Fattore *et al.*, 2018).

ii. Reflective and formative measurement models

As previously stated, two distinct measurement models may be implemented within structural equation modelling. Choosing an appropriate measurement model is primarily dependent on the relationship between the latent variable and their individual indicators (Coltman *et al.*, 2008; Diamantopoulos *et al.*, 2008; Pribeanu, 2012). While both measurement models share multiple similarities, it will be imperative that researcher select the correct measurement model as misspecification may lead to results that are scientifically void (Diamantopoulos *et al.*, 2008; Hardin *et al.*, 2008). Model misspecification and the resulting outcomes are further addressed in Section 6.2.2.10.

Reflective measurement models have a comparatively long stature is social sciences and precede formative measurement models by several decades. Reflective measurement models are derived from classical test theory with one of the initial characterizations dating back to 1968 (Lord *et al.*, 2008). Within this measurement model, indicators denote the manifestations of their latent variable (Coltman *et al.*, 2008; Diamantopoulos *et al.*, 2008; Lord *et al.*, 2008). The causality of the latent variable to indicators has subsequently led to reflective indicators being labelled manifest variables (Pribeanu, 2012). A path diagram for a basic reflective measurement model is shown in Figure 6-6.

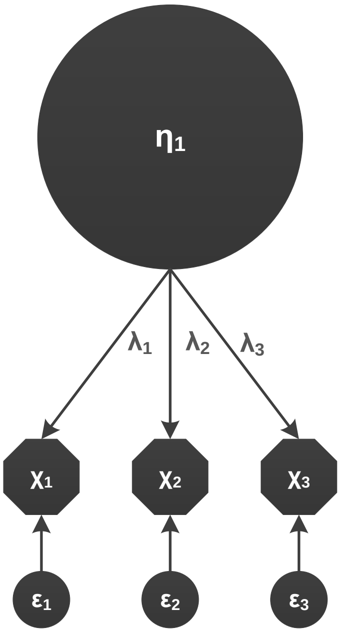

Figure 6-6 - Example of a basic reflective measurement model

The latent variable, represented by η_1, serves as the linkage for indicators, represented by χ_i. From Figure 6-6 the general equation for a reflective measurement model indicator can be derived and is shown in Equation 6-1.

$$\boldsymbol{\chi}_{\boldsymbol{i}} = \boldsymbol{\lambda}_{\boldsymbol{i}} + \boldsymbol{\varepsilon}_{\boldsymbol{i}}$$

$$\text{With } \boldsymbol{cov}(\varepsilon_i, \varepsilon_j) = 0 \quad for\ i \neq j$$

$$\text{And } \boldsymbol{cov}(\eta, \varepsilon_i) = 0 \quad for\ all\ i$$

Equation 6-1 - General equation for a reflective measurement model

The reflective indicator is represented by a linear function of the parent latent variable plus a measurement error where χ_i represents the *i*th indicator of the latent variable, λ_i represents the loading of the *i*th indicator on the latent variable and ε_i represents the measurement error of the corresponding indicator (Howell *et al.*, 2007; Diamantopoulos *et al.*, 2008; Lord *et al.*, 2008). The variable ε_i may also be used to represent the uniqueness of the corresponding indicator (Howell *et al.*, 2007).

For reflective measurement models, a change in the latent variable will simultaneously be observed in changes to the corresponding reflective indicators and thus reflective indicators are characterized as being interchangeable (Howell *et al.*, 2007; Coltman *et al.*, 2008; Pribeanu, 2012). Finally, measurement errors are assumed to be wholly independent of one another as well as from the latent variable (Howell *et al.*, 2007; Diamantopoulos *et al.*, 2008; Lord *et al.*, 2008).

Unlike reflective measurement models, the implementation of formative measurement models in structural equation modelling is a much more recent occurrence with one of the first characterizations dating back to 1988 (Anderson *et al.*, 1988). However, the wide-spread implementation of formative measurement models has only started to occur within the last two decades and despite this, use of reflective measurement models within scientific communities still largely outweigh formative measurement models (Bagozzi, 2007; Diamantopoulos *et al.*, 2008; Fattore *et al.*, 2018).

The rise in the implementation of formative measurement models stems from the differences to traditional reflective measurement models. While reflective measurement models are focused on how a latent variable is perceived, formative measurement models are focused on how a latent variable is truly measured (Pribeanu, 2012). Thus, within the formative measurement model, latent variables denote the manifestations of their indicators (Bagozzi, 2007; Diamantopoulos *et al.*, 2008; Pribeanu, 2012). Another major difference between reflective and formative measurement models is that no assumptions are made regarding the internal consistency among the formative indicators (Howell et al., 2007). A path diagram for a basic formative measurement model is shown in Figure 6-7.

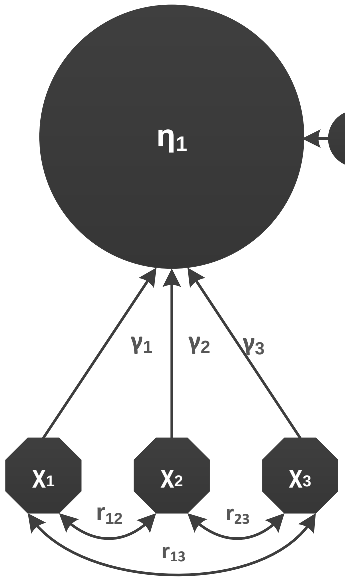

Figure 6-7 - Example of a basic formative measurement model

In contrast to a reflective measurement model, the latent variable, represented by η_1, is the dependent variable and the formative indicators, represented by χ_i. are the independent variables. This is reflected in the general equation for a formative measurement model and is shown in Equation 6-2.

$$\eta = \chi_1\gamma_1 \times \chi_2\gamma_2 \times \chi_3\gamma_3 \times \dots \times \chi_n\gamma_n + \zeta$$

Equation 6-2 - General equation for a formative measurement model

This can, in turn, be simplified to

$$\eta = \sum_{i=1}^{n} \chi_i\gamma_i + \zeta$$

$$\boldsymbol{cov}(\chi_i, \zeta) = 0 \quad for\ all\ i$$

Equation 6-3 - Conduced general equation for a formative measurement model

Here, the latent variable is viewed as a function of the formative indicators plus a disturbance term where χ_i represents the *i*th indicator of the latent variable, γ_i represents the loading of the *i*th indicator on the latent variable and ζ represents the disturbance term (Howell *et al.*, 2007; Coltman *et al.*, 2008; Diamantopoulos *et al.*, 2008). Upon further review, keen observers will note that Equation 6-3 represents a multiple regression equation (Diamantopoulos *et al.*, 2008). The disturbance term contains all the outstanding causes that are not contained within the formative indicators which results in the disturbance term being wholly independent of the indicators (Howell *et al.*, 2007; Diamantopoulos *et al.*, 2008).

While the disturbance term is not always required (Bollen, 2011), a study into the usefulness of the disturbance term found that there was a decrease in model fit when it was omitted (Pribeanu, 2012). From a conceptual perspective, this outcome aligns with the notion that researchers would struggle to identify and subsequently measure each formative indicator of a latent variable which is the primary function of the disturbance term. This is one of the major advantages that a formative measurement model possesses over the reflective measurement model alternative (Diamantopoulos *et al.*, 2008).

In summation, four primary differentiations are noted between reflective and formative measurement models. First, formative indicators denote a specific aspect of the latent variable and as such are not interchangeable (Howell *et al.*, 2007; Diamantopoulos *et al.*, 2008; Pribeanu, 2012). Furthermore, the elimination of a formative indicator will have an undetermined effect on the latent variable which does not hold true for reflective indicators (Pribeanu, 2012).

Second, unlike reflective indicators, formative indicators have no individual error-terms. Instead, the formative measurement model introduces the error term at the latent variable's level in the form of a disturbance term (Hoyle *et al.*, 1994; Howell *et al.*, 2007; Diamantopoulos *et al.*, 2008; Pribeanu, 2012). Thus, formative indicators attempt to minimize the disturbance term, or residuals (Howell *et al.*, 2007; Hardin *et al.*, 2008).

Third, there are no predefined expectations or assumptions regarding the intercorrelations between the formative indicators both with regards to strength and direction. In contrast, reflective indicators are expected to exhibit high degrees of intercorrelations (Howell *et al.*, 2007; Diamantopoulos *et al.*, 2008).

Finally, and perhaps most crucially, an unedited formative measurement model in isolation is assumed to be poorly identified and thus can potentially not be estimated (Diamantopoulos *et al.*, 2008). In contrast, reflective measurement models with three or more indicators are considered to be identified and can thus be estimated (Hoyle *et al.*, 1994). The complete procedure for the survey's model identification is shown in a subsequent section.

It is highly advisable that the number of redundant elements in the covariance-matrix of the formative indicators to be greater than the number of unknown parameters in the formative measurement model (Hoyle *et al.*, 1994; Pugesek *et al.*, 2003; Diamantopoulos *et al.*, 2008).

An additional step that should be completed in formative measurement models is the scaling of the latent variables. This is more commonly known as the Scaling Rule and may be completed by fixing the path from a formative indicator to the latent variable or standardizing the latent variable by fixing its variance to unity (Edwards *et al.*, 2000; Pugesek *et al.*, 2003; Diamantopoulos *et al.*, 2008; Chang *et al.*, 2016).

The final step that can be undertaken to ensure that a formative measurement model is not under-identified is to not treat the measurement model as a formative model in isolation (Diamantopoulos *et al.*, 2008). This is done by implementing a mixed measurement model, containing both formative and reflective indicators (Diamantopoulos *et al.*, 2008; Fattore *et al.*, 2018). It is noted however that simply inserting reflective indicators into a measurement model to ensure model identification may raise substantial doubt on the theoretical specification and appropriateness of the model (Diamantopoulos *et al.*, 2008). Thus, reflective indicators should only be incorporated into a predominately formative model if the reflective indicators also explicitly pertain to the research in question.

Researchers are advised to evaluate the advantages and disadvantages when using formative or reflective indicators and to ensure they understand the specific purpose of each model (Edwards *et al.*, 2000; Bagozzi, 2007). Formative indicators should be implemented when the aim is to understand the unobserved variance as the latent variable level, while reflective indicators should be implemented when the aim is to understand the variance at the indicator level (Hardin *et al.*, 2008).

iii. Measurement model misspecifications and implications

It is a frequent occurrence for researchers who utilize a measurement model to automatically assume that their indicators are reflective indicators, also referred to as effect indicators (Bagozzi, 2007; Diamantopoulos *et al.*, 2008; Pribeanu, 2012). Formative indicators, also referred to as cause indicators, are often overlooked even when they may be more suitability for many applications. (Diamantopoulos *et al.*, 2008)

This oversight is argued to be partly down to a general unawareness among researchers regarding the suitability formative indicators for certain latent variables (Edwards *et al.*, 2000; Diamantopoulos *et al.*, 2008). Similarly, a general lack of knowledge among researchers regarding the correct implementation of formative measurement models within a structural equation model may also explain a hesitance to utilize formative indicators (Diamantopoulos *et al.*, 2008).

This may often lead to model misspecification where reflective indicators are utilized despite formative indicators being more suitable when considering the specific latent variable. Such an instance would constitute a Type I error. Conversely, although far less frequent, is when formative indicators are utilized when reflective indicators are appropriate. Such an instance would constitute a Type II error (Diamantopoulos *et al.*, 2008).

The difference between the result errors stems from the foundations of the two measurement models. The standard procedures reflective measurement models have been refined over a much longer period, yet reflective measurement models are still relatively new in the social sciences research community. (Hoyle *et al.*, 1994; Diamantopoulos *et al.*, 2008; Lord *et al.*, 2008).

Given the various documented instances of measurement model misspecification (Bagozzi, 2007; Howell *et al.*, 2007; Diamantopoulos *et al.*, 2008; Bollen, 2011; Edwards, 2011), attention must be drawn to the potentially detrimental effects of such an occurrence. Any bias in the estimates may both affect the relationships between the latent variables and thus the theoretical validity of the conclusions drawn from the research.

The main effect stems from the difference in the intercorrelations among formative and reflective indicators. As shown in Equation 6-1, reflective indicators are assumed to have high degrees of intercorrelations as there are no predefined variances between the dependent variables (Coltman *et al.*, 2008). However, following a similar approach in a formative model would quickly lead to an unfeasibly large number of additional parameters as researchers would be forced to include the covariances between the indicators, between the indicators and their latent variable as well as between the dependent variable and the latent variables (Coltman *et al.*, 2008; Diamantopoulos *et al.*, 2008).

Lastly, it is important to note several studies highlighting that structural equation modelling may present different results depending on the measurement model implemented (Howell *et al.*, 2007; Chang *et al.*, 2016). This holds true even when the measurement models as drawn from the same observed data sets. As such, the decision to implemented formative or reflective indicators should be made prior to any statistical computations as the theoretical foundations of each model are not compatible (Edwards *et al.*, 2000; Howell *et al.*, 2007; Coltman *et al.*, 2008; Diamantopoulos *et al.*, 2008; Hardin *et al.*, 2008).

iv. Implications on this study

The purpose of the survey instrument is to evaluate the conceptual framework's ease of use, usefulness and the subsequent theoretical effects the framework may impart on the adoption of the transfer object. Additionally, the framework aims to evaluate the potential differences, if any, between the regions of SSA for the various components of the conceptual framework.

Keeping the purpose of the survey instrument in view, it is important to comprehend that the survey questions may be regarded as variables within a larger model (Collier *et al.*, 2009). Thus, the relationships between the responses to the survey, the indicators, and the latent variables, which these responses are intended to measure must be outlined (Coltman *et al.*, 2008; Edwards, 2011). This will be accomplished by implementing structural equation modelling on the data sets and, as stated before, requires either formative and reflective measurement models to be utilized (Coltman *et al.*, 2008; Collier *et al.*, 2009; Edwards, 2011). A decision must be made as to which measurement model is correct to implemented.

When reviewing the survey instrument shown in Appendix F.10, the first latent variable pertains to the Phase I of the conceptual framework and subsequent best practices. Best practices captured by the survey instrument pertaining to this latent variable have been restated in Figure 6-8 with the Phase I representing the latent variable and X_1 through X_7 representing indicators. These variables are all tested for perceived ease of use and usefulness during the survey's administration step. This is also the case for the five other latent variables shown in Appendix F.10.

Phase I	
X_1	Conduct preliminary screening of the transferee's and transferor's abilities in order to allocate initial project tasks.
X_2	Construct a dedicated project team from the transferee, transferor and additional stakeholders.
X_3	Implement a mangerial hierarchy for the project team.
X_4	Outline a tangible incentive scheme for team members.
X_5	Outline an intangible incentive scheme for team members.
X_6	Legally bind the technology donor to the technology transfer over its entire life-cycle.
X_7	Create a universal project starting point regardless of the initiator.

Figure 6-8 - Phase I latent variable and indicators

When reviewing the variables within the Phase I latent variable, it is apparent that the most appropriate statistical model is a formative measurement model as there is no apparent correlation between the variables. The indicators pertain to multiple foundations with no direct link between each individual indicator. Additionally, the respondent's attitude towards Phase I will have no impact on the scores assigned to the variables within the latent yet the indicator scores determine the overall score of the latent variable. Lastly, an improvement in the score of each individual indicator will also lead to an increase in the latent variable's score, indicating that the latent variable is the more important.

A major reason to implement a formative measurement model stems from the requirement to explain the variance between the various regions of SSA. This requires the unobserved variance of the latent variable to be estimated which is predominately done with formative indicators (Edwards *et al.*, 2000; Howell *et al.*, 2007; Diamantopoulos *et al.*, 2008; Hardin *et al.*, 2008). Another argument for the use of formative indicators is the apparent randomness of the intercorrelation between the indicators, ranging from -0.03 to 0.838, which does not coincide with the expected high level of intercorrelations typically expected of reflective indicators.

However, as stated previously in this section, certain steps must be taken into consideration regarding model identification when working with formative indicators. As such, both the T-Rule (Hoyle *et al.*, 1994; Pugesek *et al.*, 2003; Diamantopoulos *et al.*, 2008) and the Scaling

Rule (Edwards *et al.*, 2000; Pugesek *et al.*, 2003; Diamantopoulos *et al.*, 2008; Chang *et al.*, 2016) are implemented and are further discussed in the following section.

Lastly, the inclusion of a set of reflective indicators is considered a necessity to ensure the model is not under-identified (Diamantopoulos *et al.*, 2008). The latent variable, relative success, is included with three reflective indicators. The reflective indicators are shown in Figure 6-9 and represent the adoption and diffusion score of the survey respondent's respective transfer objects as well as the overall satisfaction levels of the survey respondent's technology transfer ventures. Thus, these reflective indicators are not merely included to boost model identification, but rather form a significant portion of the theory being investigated by this structural equation model.

Relative success of the technology transfer venture - latent variable	
Y_1	End-user adoption of the transfer object.
Y_2	Additional transfer object diffusion past the intended set of original end-users.
Y_3	Satisfaction levels of the TT team regrding the TT venture as a whole.

Figure 6-9 - Relative success of the technology transfer venture

The final structural equation model for the survey instrument is shown in Figure 6-10. Latent variables are represented by η, with η_1 to η_5 representing the five phases of the conceptual framework and η_6 representing the relative success of technology transfer. The disturbance terms for each latent variable are represented by ζ_1 through ζ_6 respectively. Similarly, the variance for each latent variable is represented by σ_1 through σ_6 respectively. All formative indicators are represented by X and all reflective indicators are represented by Y. For individual descriptions of each formative indicator please refer to Appendix F.11, with the descriptions for the three reflective indicators shown in Figure 6-9. These three reflective indicators all have associated residual terms which are represented by ε_1 to ε_3 respectively.

It is noted that the final structural equation model for the survey instrument is reused for both the perceived ease of use and usefulness measurement items for the formative indicators, represented by X_1 through X_{35} in Figure 6-10. The suffix $_{\text{ease of use}}$ and $_{\text{usefulness}}$ will be implemented to differentiate between the two measurement items in the results section of the survey, for example, $X_{1\ \text{ease of use}}$ refers to the formative indicator X_1 with the perceived ease of use data set. This is not applicable for the model identification, shown in the following section as the structural equation model will remain constant regardless whether perceived ease of use or usefulness indicators are implemented. However, for the model fit and validity section this differentiation is included as model fit methods such as Chi-Square will require computations with the individual sets of data.

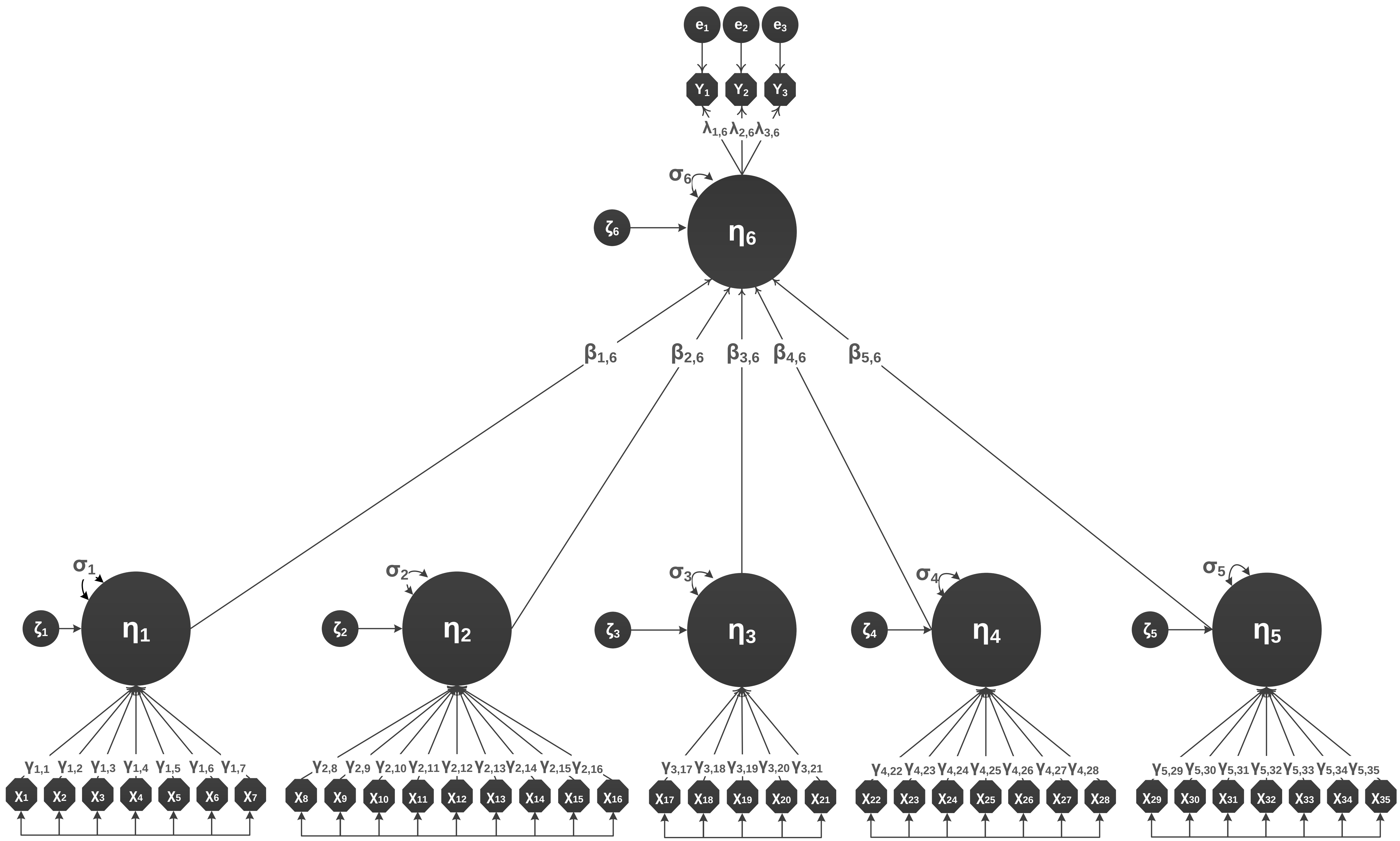

Figure 6-10 - Path diagram of the structural equation model for the survey

v. Model identification

As an introduction to model identification, the three potential outcomes of model identification are briefly discussed, namely under-identification, over-identification and perfect identification (Bollen *et al.*, 2009). Under-identification refers to a model where there is insufficient data available to compute the unobserved parameters in the model (Bollen, 2011; Edwards, 2011). In contrast, a model is over-identified if the known parameters outweigh the unknown parameters (Diamantopoulos *et al.*, 2008; Bollen, 2011). In simpler terms, over-identified models have more than one route to estimate an unknown parameter. Over-identified models always have at least one degree of freedom which is preferred in structural equation modelling as it allows researchers will greater flexibility when computing unobserved parameters (Bollen *et al.*, 2009). Perfect identification, also known as just identification, refers to when the observed parameters in a model point to the existence of a single, unsurpassable, value for each unobserved parameter within the model (Bollen *et al.*, 2009). For perfectly identified models a model fit test is arbitrary as it inherently represents a perfect fit. Such models have zero degrees of freedom.

In general, a model is identifiable if its parameters are uniquely ascertained (Diamantopoulos *et al.*, 2008; Bollen *et al.*, 2009). To ensure the structural equation model for this survey, shown in Figure 6-10, is identifiable the Scaling Rule, the T Rule, the 3+ Indicator Rule, and the Exogenous X Rule are applied (Diamantopoulos *et al.*, 2008; Bollen *et al.*, 2009; Bollen, 2011; Edwards, 2011; Chang *et al.*, 2016).

For the first step in model identification, it is important to scale the latent variables of the structural equation model for this survey. As the scale of the latent variables are undetermined, researchers may either impose a constraint on the variance of the latent variables, referred to as the standardized approach, or on the loading of one of the formative indicators of each latent variable, referred to as the unstandardized approach (Diamantopoulos *et al.*, 2008; Chang *et al.*, 2016). For both approaches, the constraint results in scaling the parameter to unity which is known as the Scaling Rule (Chang *et al.*, 2016).

However, several studies cite that unit loading identification, constraining a formative loading to 1.0, is consistently less powerful than constraining the latent variable's variance to 1.0 (Diamantopoulos *et al.*, 2008; Chang *et al.*, 2016). This is as a result of the standardized approach performing substantially better both in terms of model fit and the statistical significance of computed unobserved model parameters (Chang *et al.*, 2016). With this in mind, the variance of the latent variables, represented by σ_1 through σ_6 of the structural equation model will be constrained to the unity.

As discussed earlier, it is prudent that the number of observed parameters outweigh the number of unobserved parameters, also known as the T Rule (Hoyle *et al.*, 1994; Pugesek *et al.*, 2003; Diamantopoulos *et al.*, 2008). If this holds true, then the covariance matrix can be uniquely derived as a function of the structural equation model's parameters. The equation for the T Rule is shown in Equation 6-4 (Diamantopoulos *et al.*, 2008).

$$t \leq \frac{\chi_n(\chi_n + 1)}{2}$$

Equation 6-4 - T Rule formula

For this equation, χ_n represents the number of independent and dependent indicators and t the number of unknown parameters. After the Scaling Rule is applied, parameters constrained to unity are no longer considered as unknown parameters (Pugesek *et al.*, 2003), thus the variances of the latent variables are not included in this calculation. When evaluating the structural equation model for this survey, shown in Figure 6-10, 35 formative loadings, 3 reflective loadings, 5 beta loadings, 3 reflective indicator residuals, 6 latent variables, 6 disturbance terms and 114 intercorrelation terms between the formative indicators are evaluated.

$$35 + 3 + 5 + 3 + 6 + 6 + 114 \leq \frac{(35 + 3)((35 + 3) + 1)}{2}$$

$$172 \leq 741$$

Thus, the T Rule holds for this model and seems to suggest that the model is over-identified, although at this point such a claim is not yet proven. It is noted that, while the T-Rule and Scaling Rule are not strictly required for the model identification of a reflective measurement model, it is widely regarded as good scientific practice to do so regardless of which measurement model is being implemented (Hoyle et al., 1994; Diamantopoulos et al., 2008).

Additionally, while the T Rule is deemed as necessary in model identification it is not sufficient in isolation (Diamantopoulos *et al.*, 2008). To this extent, the next rule applied for model identification is the 3+ Indicator Rule which requires each latent variable to be associated with at least three indicators. When reviewing the structural equation model for this survey, it is apparent that η_6, the latent variable representing the relative success of the TT venture, is associated with three reflective indicators. This holds true for the latent variables represented by formative indicators as well. However, as mentioned in a previous section, this rule is designed for reflective indicators rather than formative indicators (Hoyle *et al.*, 1994).

The final model identification rule applied is the Exogenous X rule which is deemed a sufficient condition for the identification of structural equation models with multiple latent variables

(Bollen *et al.*, 2009). There are four conditions to meet the Exogenous X Rule, the first of which requires each latent variable to have an indicator that is unique to it. The second condition requires each latent variable to have a minimum of two observed indicators, uniquely or otherwise. The third condition requires each latent variable to have an identified structure or equation. The fourth and final condition requires the conformable coefficient matrix to have full rank. If this fourth condition is met, then the model is assumed to be over-identified (Bollen *et al.*, 2009).

As shown by the structural equation model for this survey, shown in Figure 6-10, each latent variable has an indicator unique to it and the second condition for the Exogenous X rule has already been met by the 3+ Indicator Rule (Hoyle *et al.*, 1994). From Figure 6-10, it is also clear that each latent variable has a structured equation defining it, as first shown in Equation 6-1 and Equation 6-3, thus condition three is also met. Condition three is considered to be met when the structural equation model can be displayed in a path diagram and solved using a stastical computer package (Bollen *et al.*, 2009).

In order to meet the fourth condition, regarding the full row rank of the conformable coefficient matrix, every row of the matrix must be proven to be linearly independent of one another. A simple check that can be done to establish this is to first review the number of latent variables and number of indicators with the equation, shown in Equation 6-5, where χ_n represents the number of independent and dependent indicators and *m* the number of latent variables.

$$\chi_n \geq 2m + 1$$

Equation 6-5 - Full row rank test

If the number of indictors is more than double the number of latent variables, a non-square matrix will result and will automatically be full row rank (Bollen *et al.*, 2009). As there are 38 indicators and only 6 latent variables within the structural equation model for this survey the fourth condition is met and also shows that the model is over-identified.

6.2.2.11 Step 11 - Establishing model validity

After ensuring the structural equation model for this survey is over-identified, and therefor all the unobserved parameters can be solved, the next step is to establish the validity of the model. Establishing model validity is important as it highlights the degree to which a study is deemed to be free of bias and thus scientifically replicable and useful (Hoyle *et al.*, 1994; Coltman *et al.*, 2008; Diamantopoulos *et al.*, 2008; Bollen, 2011).

“All models are wrong,

some are useful”

- *George Edward Box*[8]

To this extent, a validity assessment will be implemented which allows researchers to review the model validity of structural equation models containing both formative and reflective indicators.

It is important to note that traditional reliability analyses such as the Cronbach Alpha coefficient test cannot be applied to the survey instrument as this measures the internal consistency of the variables (Edwards, 2011). As per definition, the variables within a formative measurement model may present negative, positive or no correlation among each other and do not represent a single sub-dimension. This also results in factor analysis being inapplicable to formative measurement model analyses. Thus, no internal reliability analysis is conducted as it is considered redundant for a formative model (Coltman et al., 2008; Collier et al., 2009; Edwards, 2011). Instead, model validity must be established by different means. However, the use of means, variance and regression analyses may still be implemented for a formative model and is further discussed in the following section (Hoyle et al., 1994).

The validity assessment is completed in four steps, with the four validity checks and their description shown in Table 6-12 (Hoyle *et al.*, 1994; Coltman *et al.*, 2008; Diamantopoulos *et al.*, 2008; Bollen, 2011; Edwards, 2011; Pribeanu, 2012; Chang *et al.*, 2016). These four steps are a combination of quantitative and theory-based checks to incorporate the use of both formative and reflective indicators.

Table 6-12 - Validity procedure for the structural equation model

Validity evaluation	Evaluation focus	Expected outcomes
Content validity	Latent variables	Substantial coverage of the latent variables by their indicators
Overall model fit	Model fit operations	Acceptable values for various model fit operations
Validity coefficients	Loading coefficients λ and γ	Correct sign, substance and statistical significance
Multicollinearity between indicators	Variance inflation factor	Values indicating absence of multicollinearity

i. Content validity

The first step in establishing the validity of the structural equation model pertains to the creation of the indicators and how accurately and completely these indicators describe their parent variables (Hardin *et al.*, 2008; Bollen, 2011). This content validity step has been

[8]George Edward Pelham Box was an English statistician and scholar, who specialized in quality control, time-series analysis, design of experiments, and Bayesian inference. He is widely regarded as one of the most influential modern statisticians.

completed in the systematic conceptual literature review, the systematic comparative literature review and the conceptual framework development shown in Chapter 3, Chapter 4 and Chapter 5 respectively.

Apart from the conceptual framework evaluation, shown in Chapter 6, these three chapters form the majority of this research study and documents a comprehensive systematic approach to establishing the content of the individual phases of the conceptual framework. Thus, to avoid a major duplication within this document a brief summary, of the major components of each latent variable, representing each phase, along with the relevant observed indicators is provided in Appendix F.12. This summary is derived from the determinants influencing the performance of a TT venture, shown in Appendix F.6

ii. Overall model fit

The next step in the validity evaluation is to assess whether the structural equation model for this survey, shown in Figure 6-10, fits the data, also referred to as model fit. While most literature items state the need for model fit operations, there appears to be great argument as to which operations are required and valid (Bagozzi, 2007; Howell *et al.*, 2007; Hooper *et al.*, 2008; Pribeanu, 2012; Fattore *et al.*, 2018). The most frequently implemented model fit test is the Chi-Square test, also referred to as the χ^2 test, and evaluates how closely the observed data matches the expected data in the fitted model (Howell *et al.*, 2007). For the χ^2 test the model is interpreted as "fitting" the data when the p-statistic is greater than 0.05 (Hooper *et al.*, 2008). This is as a value of less than 0.05 points to a statically significant variation between the expected and observed indicator values, for one or more data points.

Using Statistica (TIBCO Inc., 2019) to evaluate the structural equation model, shown in Figure 6-10, results in a $\chi^2_{\text{usefulness}}$ statistic of 564.307 and $\chi^2_{\text{ease of use}}$ statistic of 582.552. In order to interpret these values, they need to be compared with the Chi-square distribution tables which in turn requires the degrees of freedom to be calculated. The degrees of freedom in a structural equation model can be calculated using Equation 6-6, where *df* represents the degrees of freedom, *k* represents the total number of observed model parameters and *t* represents the number of unobserved parameters (Cortina *et al.*, 2016).

$$df = \frac{k^2 - k}{2} - t$$

Equation 6-6 - Degrees of freedom formula for structural equation models (Cortina *et al.*, 2016)

Using the same values determined for the T-Rule test, shown in Section 6.2.2.10, and the reflective and formative indicators as the observed model parameters, the equation results in the following

$$df = \frac{(35+3)^2 - (35+3)}{2} - 172$$

$$df = df_{usefulness} = df_{ease\ of\ use} = 531$$

Using the χ^2 test statistic and the degrees of freedom results in a $p_{usefulness}$ value of 0.153 and a $p_{ease\ of\ use}$ value of 0.060. Thus, based on a Chi-Square goodness of fit test the structural equation model is deemed a good fit when the model is used to evaluate the usefulness data set and the perceived ease of use data set.

However, while most literature items include the Chi-Square goodness of fit test, most state that it can not be implemented in isolation to measure the fit of a model as it is severely flawed in multiple perspectives (Hoyle *et al.*, 1994; Hooper *et al.*, 2008; Bollen, 2011; Pribeanu, 2012; Cortina *et al.*, 2016). The first issue is that the test assumes multivariate normality, thus any substantial deviations may result in a model being rejected even when the model is correctly specified (Hooper *et al.*, 2008). Another issue, although not pertinent to this study, is that the test is very sensitive to large sample sizes and will almost always reject models with samples sizes of more than 400 (Hooper *et al.*, 2008; Cortina *et al.*, 2016). Additionally, for a small sample size, the Chi-Square goodness of fit test lacks power and thus may not be the best choice for differentiating between a good and ill fitting model (Hooper *et al.*, 2008).

Keeping the limitations of the Chi-Square goodness of fit test in view, further investigation into model fit will be done with the χ^2/df ratio, the Root Mean Square Error of Approximation (RMSEA) and the standardised root mean square residual (SRMR).

The χ^2/df ratio statistic provides a good alternative as it minimizes the effect of the sample size when compared with the traditional χ^2 statistic. For the χ^2/df ratio test, the equation is explanatory and results in values of 1.063 for usefulness and 1.097 for perceived ease of use. Models with ratios below 3 are deemed to have "a good fit" and a value of 1.0 represents a perfect fit (Hoyle *et al.*, 1994; Hooper *et al.*, 2008). Thus, for the χ^2/df ratio test both the usefulness and perceived ease of use data sets within the structural equation models are deemed to display good fit.

The RMSEA is utilized when researchers are evaluating how well a structural equation model would fit the population covariance matrix (Diamantopoulos *et al.*, 2008). It is widely regarded as a critical model fit indicator due to the statistic's sensitivity to the number of estimated, or unobserved, model parameters (Bagozzi, 2007; Howell *et al.*, 2007; Diamantopoulos *et al.*, 2008; Hooper *et al.*, 2008; Chang *et al.*, 2016). It could thus be argued that the RMSEA test favours parsimony as it will always favour models with fewer unknowns (Diamantopoulos *et al.*, 2008). With respect to acceptable values for the RMSEA statistic, there is still some debate, however models with RMSEA statistics of 0.01, 0.05 and 0.08 are deemed excellent, good and average (Diamantopoulos *et al.*, 2008; Hooper *et al.*, 2008). Values of 0.08 and higher indicate the model does not fit.

Perhaps the greatest advantage of the RMSEA statistic is that researcher may also provide the confidence intervals around the statistic value (Hooper *et al.*, 2008). This in turn, allows researchers to more accurately test model fit. The equation for the RMSEA statistic is shown in Equation 6-7, where χ^2 is the traditional Chi-square statistic, *df* is the degrees of freedom and *N* is the sample size (Hooper *et al.*, 2008).

$$RMSEA = \sqrt{\frac{\chi^2 - df}{df \times (N-1)}}$$

Equation 6-7 - Root mean square error of approximation formula

For the structural equation model, shown in Figure 6-10, this equation becomes

$$RMSEA_{usefulness} = \sqrt{\frac{564.307-531}{531\ x\ (89-1)}} = 0.027 \text{ (at 90\% confidence interval)}$$

and

$$RMSEA_{\ ease\ of\ use} = \sqrt{\frac{582.552-531}{531\ x\ (89-1)}} = 0.033 \text{ (at 90\% confidence interval)}$$

Thus, for both perceived ease of use and usefulness data sets the structural equation model's fit is deemed to display a good model fit. The final model fit statistic that will be calculated is the SRMR which measures the difference between the residuals of the observed and expected covariance matrix (Bagozzi, 2007; Pribeanu, 2012). Values for SRMR range from 0 to 1, with values closer to 0 indicating a good model fit. In general, a model with and SRMR value of 0.08 and less is deemed to display a good model fit (Hooper *et al.*, 2008).

Using Statistica (TIBCO Inc., 2019) to evaluate the structural equation model, shown in Figure 6-10, results in SRMR value of 0.085 and 0.075 for usefulness and perceived ease of use respectively. Thus, while both are on the boundary line, the SRMR statistics indicates that the model fits for the perceived ease of use data set but not for the usefulness data set. An explanation for both statistic values may be attributed to the sample size of this study as the SRMR is sensitive to sample size with model based on larger sample sizes returning lower SRMR values (Hooper *et al.*, 2008).

A summary of all the model fit tests is shown in Table 6-13. For the usefulness data set, the returned SRMR value did not indicated a good fitting model. However, considering that this SRMR value is extremely close to the border, and the positive model fit statistics shown by the χ^2 test, the χ^2/df ratio and the RMSEA the structural equation model is deemed to adequately fit for the purpose of this study.

Table 6-13 - Summary of model fit evaluation

Model fit test	Ease of use outcome	Usefulness outcome	Outcome indicating acceptable model fit
Chi-square goodness of fit	0.060	0.153	p values greater than 0.05
χ^2/df ratio	1.118	1.083	Ratio less than 3
RMSEA	0.037	0.031	Value less than 0.05
SRMR	0.075	0.085	Value less than 0.08

iii. Validity coefficients

After the model fit is established the next step in establishing the structural equation model's validity is to evaluate the factor loadings between the indicators and the latent variables (Bollen, 2011). For the structural equation model, shown in Figure 6-10, these loadings in question would be $\gamma_{1,1}$ to $\gamma_{5,35}$ and $\lambda_{1,6}$ to $\lambda_{3,6}$.

For the indicator loadings it is important to ensure that values all have the correct sign and display the expected degree of statistical significance and substance (Diamantopoulos *et al.*, 2008; Bollen, 2011; Pribeanu, 2012). Indicator loadings are expected to all display a positive sign as, per definition of a formative loading, the latent variable is dependent of the formative indicator (Pribeanu, 2012). Additionally, with the context of this study, the latent variables are all expected to increase as their indicator scores increase. For the indicators, a loading smaller than 0.6 will require further scrutinization to determine if it is justified to keep such indicators within the model (Bollen, 2011). The structural equation model is modelled using Statistica (TIBCO Inc., 2019) and the various indicator loadings are summarized in Table 6-14.

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Table 6-14 - Indicator loadings and significance for perceived ease of use and usefulness data sets

Indicator coefficient	Ease of use outcome		Usefulness outcome	
	Loading	Significance (p-value)	Loading	Significance (p-value)
$\gamma_{1,1}$	0.672	0.002	0.810	<0.001
$\gamma_{1,2}$	0.903	<0.001	**0.547**	**0.25**
$\gamma_{1,3}$	0.793	<0.001	0.709	<0.001
$\gamma_{1,4}$	0.813	<0.001	0.722	<0.001
$\gamma_{1,5}$	0.788	<0.001	0.737	<0.001
$\gamma_{1,6}$	0.730	<0.001	0.680	<0.001
$\gamma_{1,7}$	0.792	<0.001	0.674	<0.001
$\gamma_{2,8}$	0.805	<0.001	0.811	<0.001
$\gamma_{2,9}$	0.746	0.002	0.736	<0.001
$\gamma_{2,10}$	**0.385**	**0.159**	**0.575**	**0.05**
$\gamma_{2,11}$	0.649	0.006	0.635	<0.001
$\gamma_{2,12}$	0.767	0.001	0.741	<0.001
$\gamma_{2,13}$	0.827	<0.001	0.801	<0.001
$\gamma_{2,14}$	0.676	0.007	0.720	<0.001
$\gamma_{2,15}$	0.794	<0.001	0.761	0.02
$\gamma_{2,16}$	0.829	0.002	0.789	<0.001
$\gamma_{3,17}$	0.802	<0.001	0.711	<0.001
$\gamma_{3,18}$	0.820	<0.001	0.848	<0.001
$\gamma_{3,19}$	0.709	0.004	0.662	0.01
$\gamma_{3,20}$	0.818	<0.001	0.681	<0.001
$\gamma_{3,21}$	0.738	<0.001	0.735	0.01
$\gamma_{4,22}$	0.609	<0.001	**0.531**	<0.001
$\gamma_{4,23}$	0.745	<0.001	0.754	<0.001
$\gamma_{4,24}$	0.807	<0.001	0.817	<0.001
$\gamma_{4,25}$	0.712	<0.001	0.842	<0.001
$\gamma_{4,26}$	0.803	<0.001	0.757	<0.001
$\gamma_{4,27}$	0.730	<0.001	0.810	<0.001
$\gamma_{4,28}$	0.715	<0.001	0.675	0.01
$\gamma_{5,29}$	0.821	0.002	0.870	<0.001
$\gamma_{5,30}$	0.834	<0.001	0.759	<0.001
$\gamma_{5,31}$	0.743	<0.001	0.713	<0.001
$\gamma_{5,32}$	0.874	<0.001	0.636	**0.06**
$\gamma_{5,33}$	0.616	0.012	**0.582**	0.02
$\gamma_{5,34}$	0.631	0.007	0.820	<0.001
$\gamma_{5,35}$	**0.579**	0.023	0.812	0.01
$\lambda_{1,6}$	0.825	<0.001	0.931	<0.001
$\lambda_{2,6}$	0.808	<0.001	0.669	<0.001
$\lambda_{3,6}$	0.790	<0.001	0.740	<0.001

For all values computed and displayed in Table 6-14, p-values are calculated with a two-tailed test with a significance level fixed to 0.05 (α = 0.05). A pleasing aspect is that all indicators, both for perceived ease of use and usefulness data sets, display a positive sign which is in accordance with the theory behind formative latent variables and the theoretical foundations of the latent variables themselves within this research paper, refer to Appendix F.6 and F.12.

For the perceived ease of use data set all indicator loadings, apart from $\gamma_{2,10 \text{ ease of use}}$, are statistically significant. However, for the usefulness data set, the indicators $\gamma_{1,2 \text{ usefulness}}$, $\gamma_{2,10 \text{ usefulness}}$, and $\gamma_{5,32 \text{ usefulness}}$ returned p-values which require further investigation. For $\gamma_{1,2 \text{ usefulness}}$, the p-value is well above the cut-off point but both $\gamma_{2,10 \text{ usefulness}}$, and $\gamma_{5,32 \text{ usefulness}}$ are borderline, with $\gamma_{2,10 \text{ usefulness}}$ still within the significance level, albeit just.

While it could be argued that p-values of $\gamma_{2,10 \text{ usefulness}}$, and $\gamma_{5,32 \text{ usefulness}}$ are marginal and thus could be retained within the structural equation model, this research study has been founded upon a systematic approach and as such hard cut-offs will be enforced. This should also reduce any subjective bias which often plagues quantitative results. To this extent the formative indicators $X_{10 \text{ usefulness}}$ and $X_{32 \text{ usefulness}}$ will be removed from the structural equation model to maintain a systematic research approach. The formative indicators $X_{10 \text{ ease of use}}$ and $X_{2 \text{ usefulness}}$ are also excluded for any further computations as they likely do not explain the variance of their respective latent variables.

As to the p-values, a hard cut-off will be implemented with the loadings to reduce any subjective bias regardless of the marginality of individual cases. Thus, $X_{35 \text{ ease of use}}$, $X_{22 \text{ usefulness}}$, and $X_{33 \text{ usefulness}}$ are also eliminated.

When reviewing these indicators in Table 6-14, a summary can be created to indicate which variables will no longer be included for further computation of the structural equation model. This summary is presented in Table 6-15. Removing 4 of 38 observed variables for the usefulness data set appears in line with what is stated in multiple literature items considering the strict elimination criteria imposed on this structural equation model (Diamantopoulos *et al.*, 2008; Bollen, 2011). This percentage is even less, 2 of 38, for the perceived ease of use data set.

Table 6-15 - Summary of eliminated formative indicators

Variable	Description	Loading	Significance (p-value)
$X_{10 \text{ ease of use}}$	Sharing existing knowledge and experience with other project team members.	**0.385**	**0.159**
$X_{35 \text{ ease of use}}$	Allowing future projects to access documentation of completed projects.	**0.579**	0.023
$X_{2 \text{ usefulness}}$	constructing a dedicated project team from the transferee, transferor and additional stakeholders.	**0.547**	**0.25**
$X_{10 \text{ usefulness}}$	Sharing existing knowledge and experience with other project team members.	**0.575**	**0.05**

X_{22} usefulness	Routinely evaluating team members and removing members with limited future use for the project.	**0.531**	<0.001
X_{32} usefulness	Marketing the project to additional public-sector stakeholders not in the original team.	0.636	**0.06**
X_{33} usefulness	Marketing the project to additional private sector stakeholders not in the original team.	**0.582**	0.02

iv. Multicollinearity between indicators

Multicollinearity may occur when the formative indicators of a latent variable are highly correlated (Cenfetelli *et al.*, 2009; Bollen, 2011; Pribeanu, 2012). This is an undesirable feature as it will result in difficulties in the estimation of the structural equation model (Diamantopoulos *et al.*, 2008; Cenfetelli *et al.*, 2009). If multicollinearity exists within the formative indicators of a latent variable, the formative indicators are highly correlated with one another (Bollen, 2011).

This calls into question the specification of the indicators as formative, as formative indicators inherently compete with one another to describe the latent variable (Cenfetelli *et al.*, 2009). Multicollinearity may thus provide evidence that one or more of the formative indicators of a latent variable are redundant or overlapping (Diamantopoulos *et al.*, 2008; Cenfetelli *et al.*, 2009; Bollen, 2011).

It thus becomes increasingly difficult to estimate the unique effects of the individual formative indicators and multicollinearity increases (Bollen, 2011). This difficulty stems from the increase in the standard errors of the formative loading coefficients experienced when multicollinearity is present (Diamantopoulos *et al.*, 2008; Bollen, 2011). Furthermore, multicollinearity can have a significant negative impact on the stability of the formative indicator loadings as the estimation is completed using multiple regression as shown in Equation 6-3 (Diamantopoulos *et al.*, 2008; Hardin *et al.*, 2008). This also highlights another substantial difference between formative and reflective measurement models as reflective indicators are expected to display covariance with one another. Multicollinearity is not of interest here as reflective loadings are estimated with simple regression rather than multiple regression (Hoyle *et al.*, 1994; Edwards *et al.*, 2000; Hardin *et al.*, 2008).

Another effect of multicollinearity among formative indicators is that it may result in a substantial percentage of the indicators having non-significant loadings (Bollen, 2011). However, based on the results shown in Table 6-14, this is not expected to be an issue for this survey's structural equation model. Regardless, multiple literature items outline that collinearity should always be evaluated when implementing formative indicators (Diamantopoulos *et al.*, 2008; Hardin *et al.*, 2008; Cenfetelli *et al.*, 2009; Bollen, 2011; Pribeanu, 2012).

One of the most frequent tests employed pertaining to the collinearity of formative indicators is the variance inflation factor (Diamantopoulos *et al.*, 2008; Cenfetelli *et al.*, 2009; Bollen, 2011). The variance inflation factors provides an estimation on the effect, or inflation, of the latent variable's standard error due to the present multicollinearity in the structural equation model (Bollen, 2011). The equation for the variance inflation factor is shown in Equation 6-8 with R_i^2 representing the coefficient of determination for the formative indicator *i*.

$$VIF = \frac{1}{1 - R_i^2}$$

Equation 6-8 - Variance inflation factor formula

A returned variance inflation factor of 1 represented an uncorrelated formative indicator. As with model fit indexes, there is still some debate regarding an appropriate cut-off value for the variance inflation index with suggested values as high as 10 (Diamantopoulos *et al.*, 2008). For this structural equation model a value of 3.33 will be implemented as it represents a more conservative approach less prone to subjective bias (Diamantopoulos *et al.*, 2008; Bollen, 2011). The variance inflation factors of the formative indicators are shown in Table 6-16.

Table 6-16 - Variance inflation factors for formative indicators both for perceived ease of use and usefulness data sets

Indicator	Variance inflation factor		Indicator	Variance inflation factor	
	Ease of use	Usefulness		Ease of use	Usefulness
X_1	1.79	1.53	X_{19}	1.88	1.63
X_2	**3.60**	-	X_{20}	1.76	1.60
X_3	2.29	1.54	X_{21}	1.76	1.59
X_4	2.62	1.85	X_{22}	1.35	-
X_5	1.98	1.92	X_{23}	1.76	1.83
X_6	1.98	1.59	X_{24}	2.65	2.08
X_7	2.56	1.78	X_{25}	2.08	3.04
X_8	2.13	2.26	X_{26}	2.47	1.98
X_9	1.93	1.81	X_{27}	1.97	2.61
X_{10}	-	-	X_{28}	1.93	1.52
X_{11}	1.87	1.47	X_{29}	1.88	2.25
X_{12}	2.91	1.86	X_{30}	2.30	1.70
X_{13}	2.87	2.44	X_{31}	2.06	1.54
X_{14}	1.45	2.15	X_{32}	2.63	-
X_{15}	**4.16**	**4.06**	X_{33}	1.96	-
X_{16}	**4.62**	**4.31**	X_{34}	1.74	2.94
X_{17}	2.46	1.63	X_{35}	-	2.92
X_{18}	2.40	1.70	-	-	-

From the variance inflation factors it is clear that the formative indicators $X_{2\text{ ease of use}}$, $X_{15\text{ ease of use}}$, $X_{16\text{ ease of use}}$, $X_{15\text{ usefulness}}$ and $X_{16\text{ usefulness}}$ are likely to have some degree of correlation between the other formative indicators within their parent latent variable. However, as X_{15} and X_{16} are linked to the same parent latent variable, Phase II, when $X_{16\text{ ease of use}}$ and $X_{16\text{ usefulness}}$ are eliminated from the model, the variance inflation factors for $X_{15\text{ ease of use}}$, and $X_{15\text{ usefulness}}$ drop to 2.08 and 2.06 respectively, both of which are below 3.33. In summation $X_{2\text{ ease of use}}$, $X_{16\text{ ease of use}}$, and $X_{16\text{ usefulness}}$ are eliminated from the structural equation model to ensure low levels of multicollinearity are present.

6.2.2.12 Step 12 - Model estimation

Based on the implementation of the structural equation model, the survey questions and hypothesies, six different statistical methods are implemented for the survey's data analysis including frequency, mean, variance, regression and correlation analyses as well as descriptive statistic analysis. These six analyses, and the survey questions and hypotheses they aim to answer are shown in Figure 6-11.

Frequency and mean analysis are conducted to determine the perceived ease of use and usefulness of each observed indicator and subsequent latent variable. Variance analysis is conducted to determine whether any differences are presented between the perceived ease of use or usefulness of the individual framework phases. Variance analysis is also implemented to determine the difference among the four regions of SSA. Lastly, regression and correlation analyses are implemented, in conjunction with the structural equation model, to determine the relationships between the perceived ease of use or usefulness of each phase and the relative success of a TT venture. Thus, the structural equation model, shown in Figure 6-10, will provide evidence to either support or reject the hypotheses of this survey.

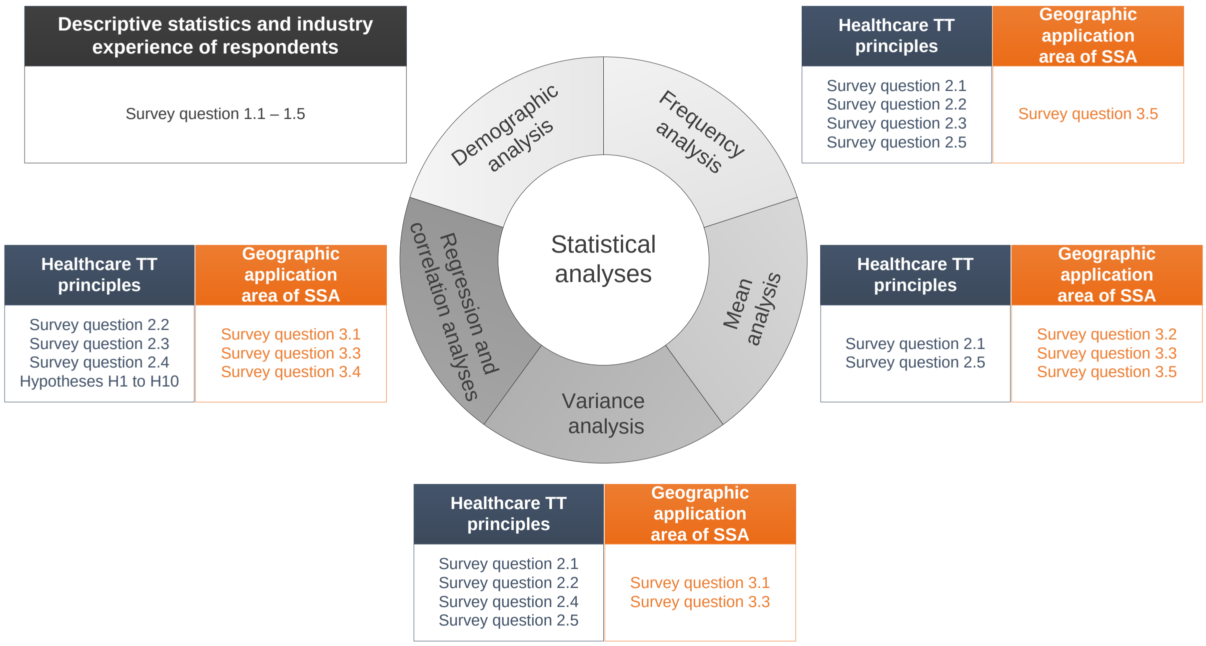


Figure 6-11 - Outline of statistical methods utilised to answer survey's research questions and hypotheses

i. Frequency analysis

Frequency analysis serves as a useful starting point for the survey as, in conjunction with the descriptive statistics, it provides a basic overview of the outcomes of the survey (Link *et al.*, 2016; Research Optimus, 2018). Literature further argues that frequency information allows researchers to highlight the similarities, variances and strength of the relationships between the variables obtained during data capturing (Carley, 1993; Paret *et al.*, 2018; Research Optimus, 2018)

While the strength of the relationship between variables may simply be portrayed as the numbers of times or frequency, a specific variable is captured, the strength and direction of such relationships are better identified by other statistical methods such as variance and regression analyses (Carley, 1993; Miller Jr, 1997; Laerd, 2013). Thus, for the survey's frequency analysis emphasis is placed on ranking the relative foundation constituents and identifying the percentile values of the survey's outcomes pertaining to the nine foundations of the conceptual framework. Frequency distribution graphs are presented for the individual foundations as well as a summary comparing all nine foundations. These frequency distribution graphs are repeated for both the perceived ease of use and usefulness measurement items.

Microsoft Excel is utilised for the calculations completed during the frequency analysis of the survey's data. The final results of the frequency analysis are shown in Section 6.4.2.1 and Section 6.4.3.1.

ii. Mean analysis

It is important to state that the mean analysis implemented in the data analyses of the survey does not refer to the statistical method analysis of means, also referred to as ANOM. As ANOM is a direct alternative to the analysis of variance, also referred to as ANOVA, it provides no additional utility as ANOVA is already utilised during the variance analysis step of the survey.

Instead, the mean analysis intends to act as a basic revision of the individual components of the preliminary conceptual framework outlined in Section 5.4 and recommended alterations outlined during the first step of the framework evaluation. This allows the research team to enforce the relevance and utility of framework best practices with quantitative data. Similar evaluations are implemented for the phases and foundations of the conceptual framework. A revision protocol is implemented to flag any individual research question, foundation or phase with an arithmetic mean indicating it is difficult to implement or not useful during a TT venture. Thus for the mean analysis step, no data analysis is done to investigate any relationships between questions or phases.

The mean evaluation calculates the arithmetic mean for each question presented to respondents during Section 3 of the survey instrument, as outlined in Appendix F.10. This is done for both the perceived ease of use and usefulness measurement scales. The resulting arithmetic means for each question are categorised according to their corresponding phase and subsequently their corresponding foundation. An arithmetic mean for each phase and foundation is calculated using the arithmetic means of their applicable research questions. The relationship between the phases, foundations and individual research questions are shown in Table 6-11 and subsequently in Table F-6 and Table F-7. Lastly, a grand mean is calculated for both measurement items across the entire conceptual framework.

Microsoft Excel is utilised for the calculations completed during the mean analysis of the survey's data. The final results of the mean analysis are shown in Section 6.4.2.2 and Section 6.4.3.2.

iii. Variance analysis

To further investigate the constituents of the conceptual framework as well as how these constituents are interlinked, the statistical method of ANOVA is implemented in addition to the initial mean analysis. ANOVA is a statistical method implemented to determine if there is a difference between the means of independent variables and is a well-established quantitative research method (Miller Jr, 1997).

ANOVA implements a confidence interval which is defined as a range of values with a specified probability that the value of a variable lies within this range. Thus, the confidence interval represents the uncertainty of the variance analysis. As an example, a 95% confidence interval, a common value used in ANOVA, would indicate the mean for the whole population would be in this range. Thus, as the sample size increases, the smaller this range becomes as the probability of the measurement items representing the true mean becomes larger (Miller Jr, 1997).

The ANOVA implemented utilised the measurement items of perceived ease of use, usefulness and the evaluation items of adoption, diffusion, and satisfaction to determine how the success of TT ventures is influenced by the conceptual framework.

Additionally, Fischer's Least Significant Difference (LSD) is implemented to determine how the components of the framework differ among the four major regions of SSA. The LSD allows researchers to calculate the smallest difference between two means, which is still considered statistically significant. Thus, it allows researchers to draw comparisons between these two means, rather than the collective group (Williams *et al.*, 2010). As respondents could select multiple geographic regions the LSD calculation will allow for variances to be determined between specific regions of SSA and the rest of SSA.

For all variance analysis calculation, a significance level of 0.05 is implemented as in accoradnace with quantitative data analyses in similar studies (Philip F. Musa *et al.*, 2005; Kifle *et al.*, 2010). As the ANOVA calculations are more complex than the initial the mean evaluation, all ANOVA calculations are completed on the processing software Stastica provided by TIBCO. The final results of the variance analysis are shown in Section 6.4.2.3 and Section 6.4.3.3.

iv. Regression and correlation analyses

The final quantitative analysis techniques applied to the data results of the survey instrument are regression and correlation analyses. Regression analyses aim to identify the association between variables by evaluating the relative impact of a variable on another (Zou *et al.*, 2003; Armstrong, 2012).

Regression analysis is often implemented in social science evaluation procedures as it provides researchers with a systematic method for data analysis (Armstrong, 2012). The outcomes based on regression analysis are typically less subject to bias and thus logistic regression is favoured when evaluating hypotheses between one outcome variable and one or more continuous predictor variables (Peng et al., 2002; Armstrong, 2012). For the structural equation model, shown in Figure 6-10, this outcome variable is represented by the Relative Success latent variable and the predictor variables are represented by the Phase I through Phase V latent variables.

As there are five predictor variables, also known as independent variables, and one outcome variable, also known as a dependent variable, multiple regression analysis will be implemented for this survey. The multiple regression analysis will be completed using standardized data, for both the perceived ease of use and usefulness data sets to simplify the interpretation of results. Thus, the regression coefficients shown in Section 6.4.2.4 and Section 6.4.3.4 represent standardized regression coefficients.

Multiple regression analysis produces several different statistics, with the standardized regression coefficients, R-squared and the F-value representing the primary statistics of interest for this survey (Zou *et al.*, 2003). The significance of these statistics will also be of importance (Armstrong, 2012). The outcomes of the multiple regression analyses will also allow conclusions to be drawn regarding the hypotheses, *H3* to *H12*, first outlined in Section 6.2.2.6.

The first statistic that will be examined is the F-value as well as the significance level of the F-value. If the F-value is statically significant ($p < 0.05$), then the structural equation model explains a significant portion of the variance in the outcome variable, represented by the relative success of a TT venture (Peng *et al.*, 2002).

The R-squared statistic, also referred to as the coefficient of determination, represents the percentage of the variance of the outcome variable that is explained by the predictor variables (Peng *et al.*, 2002; Zou *et al.*, 2003). Thus, for this survey, the R-squared value will represent how much of the variance around the means of the observed data is explained by the structural equation model for the perceived ease of use and usefulness data sets (Zou *et al.*, 2003). A higher R-squared value is often preferred, yet it is necessary to compare the R-squared statistic against previous studies to make a useful conclusion (Boateng *et al.*, 2002; Zou *et al.*, 2003; Philip F Musa *et al.*, 2005; Hardin *et al.*, 2008). Previous studies of a similar nature have returned R-squared values of 0.25 and 0.4 for perceived ease of use and usefulness respectively (Boateng *et al.*, 2002; Philip F Musa *et al.*, 2005). These values will be utilized as the baseline to compare the outcomes of the multiple regression analysis for this survey. If the computed R-squared value is less than the expected statistic, it will be important for researchers to further explore and explain this discrepancy (Zou *et al.*, 2003).

While the R-squared statistic shows the strength of the association between the predictor variables and the outcome variable it can not be used for formal hypothesis testing. The F-value determines the statistical significance of this association (Peng *et al.*, 2002; Zou *et al.*, 2003).

If the F-value is statistically significant and the R-squared value are in accordance with what has been observed in previous studies of a similar nature, the standardized regression coefficients should be evaluated (Boateng *et al.*, 2002; Peng *et al.*, 2002; Hardin *et al.*, 2008). Standardized regression coefficients represent the degree of change in the outcome variable for every unit of change in the predictor variable, assuming all other predictor variables are held constant (Boateng *et al.*, 2002). As an example, if a predictor variable has a positive standardized regression coefficient of 0.5, it is assumed that an increase of one unit in the predictor variable will result in an increase of 0.5 in the outcome variable. This example assumes that all other predictor variables remain constant and that the standardized regression coefficient is statistically significant (Peng *et al.*, 2002; Hardin *et al.*, 2008).

The significance of the individual regression coefficients is evaluated with a t-test and the resulting p-value. If the coefficient is not statistically significant ($p > 0.05$) the predictor variable does not significantly predict the outcome variable and it should be disregarded (Peng *et al.*, 2002).

If the standardized regression coefficient is statistically significant, the sign of the value should next be evaluated (Boateng *et al.*, 2002; Peng *et al.*, 2002). These coefficients can have both positive and negative values. For the hypotheses *H3* to *H12*, all pertain to the presence of a *positive association* between the predictor and outcome variables, and as such positive standardized regression coefficients are expected for both the perceived ease of use and usefulness data sets. This is in accordance with the theory upon which the structural equation model is founded, as shown in Appendix F.6 and F.12.

Correlation analysis will be implemented after the completion of the multiple regression analysis and aims to identify the strength of a direction of the relationship between two continuous random variables (Zou *et al.*, 2003; Armstrong, 2012). These variables may either be linear or nonlinear and correlation analysis is often referred to as linear association (Zou *et al.*, 2003).

It is also noted that correlation analysis does not prove causation. Two variables that are highly correlated are not proof of causation as several other unidentified factors may have occurred (Zou *et al.*, 2003; Armstrong, 2012). Proving causation will not form part of the scope of this research document.

When correlation analysis is implemented in research, two correlation coefficients are frequently implemented when determining the relationship two variables namely, Pearson's product-moment correlation and Spearman's rank-order correlation (Yamane, 1973; Gauthier, 2001; Zou *et al.*, 2003; Benesty *et al.*, 2009; Laerd, 2013). Pearson's product-moment correlation coefficient measures the linear relationship and is implemented when the data set represents parametric statistics and thus the data set is required to fit a normal distribution (Yamane, 1973; Zou *et al.*, 2003; Benesty *et al.*, 2009). In contrast, Spearman's rank-order correlation measures the general association between variables and represents non-parametric statistics and the data set is not required to fit a normal distribution (Yamane, 1973; Zou *et al.*, 2003; Laerd, 2013).

Spearman's rank-order correlation is more applicable when a researcher is investigating the strength and direction of a monotonic relationship between variables. Pearson's product-moment correlation also measures the strength and direction but only for a linear relationship between variables (Yamane, 1973; Benesty *et al.*, 2009; Laerd, 2013; Chatterjee *et al.*, 2015). For monotonic relationships, changes in the independent variable result in similar changes in the dependent variable's direction but not necessarily at a constant rate in terms of strength. Linear relationships also exhibit a similar relationship for direction, however, the change in strength always occurs at a constant rate (Gauthier, 2001).

If the observed data of a research study produces scatterplots that show a linear relationship, the Pearson product-moment correlation test[9] is appropriate. Alternatively, if the scatterplots show a monotonic relationship, the Spearman rank-order correlation test[10] should be implemented (Yamane, 1973; Gauthier, 2001; Zou *et al.*, 2003; Benesty *et al.*, 2009; Laerd, 2013). As data produced by the survey is primarily ordinal, and not continuous, it is relatively closely clustered with few outliers and displays monotonic relationships between variables. It is concluded that for the correlation analysis Spearman rank-order correlation coefficient is to be implemented.

This correlation coefficient is represented by the Greek letter Rho (ρ) and will be used to highlight the strength and direction of the correlation between variables. A graphical summary of the strength of ranging Rho values is shown in Figure 6-12.

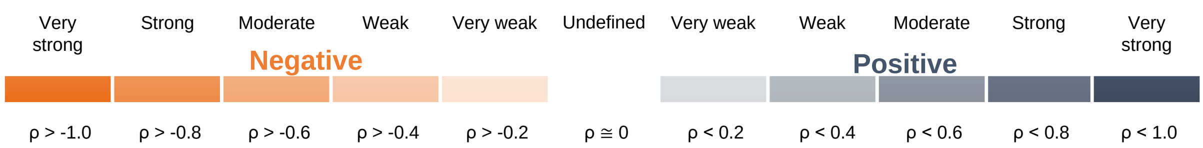


Figure 6-12 - Summary of Rho values for Spearman rank-order correlation coefficients

[9] The Pearson product-moment correlation coefficient is used in statistics to measure the strength and direction of the linear relationship between two variables. It can range between -1 and 1.

[10] Spearman's rank correlation coefficient is used in statistics as a nonparametric measure of rank correlation and assesses how well the relationship between two variables can be described using a monotonic function. It can range between -1 and 1.

The results of the regression and correlation analyses are shown in Section 6.4.2.4 and Section 6.4.3.4. These analyses utilised the evaluation items scores captured during the survey instrument at the dependent variables and the measurement items scores as the independent variables. As with the ANOVA calculations, all regression analyses calculations are completed on the processing software Statistica provided by TIBCO[11].

6.2.3 Case studies

A case study represents a systematic procedure with which a researcher may classify and categorize an event or an interlinked set of events (Zucker, 2009). Alternatively, it may be described as an "empirical inquiry" which investigates a particular phenomenon within an existing real-world situation (Yin, 2017). It is important to note that case studies inherently do not attempt to uncover a universal pattern or cause and effect linkages but rather focus on exploration of the subject or event in question (California State University, 2015; Yin, 2017). Thus, the use of multiple case studies will allow the exposition of the conceptual framework recommended managerial best practices within these case studies. In addition, a case study allows a complete comprehension of a set of events by implementing inductive logic. This further strengthens the overall evaluation procedure as it provides a contrasting thought process when compared to the qualitative evaluation instrument of semi-structured interviews (Mouton, 2011).

This section outlines the research methodology employed during the completion of the three case studies. These case studies represent the third and final level of validation of the conceptual framework. The outcomes of the case studies are shown in Section 6.5.

6.2.3.1 Case study approach

A brief overview of case study related literature highlighted that four different types of case studies are most frequently implemented by researchers during validation procedures. These include cumulative, pilot, critical instances and illustrative (Zucker, 2009; California State University, 2015).

Each case study type may further be categorized as prospective or retrospective. Prospective case studies are novel and often groundbreaking as they facilitate the study of a new event or set of events (Zucker, 2009). Prospective case studies do, however, present ambiguous results as the field of study is comparably unsubstantiated. Additionally, prospective case studies require substantial time effort and timelines are often outside the control of the

[11]TIBCO Software Inc. provides integration, analytics and event-processing software such as Statistica aimed at automating large statistical computations (TIBCO Inc., 2019).

researcher (California State University, 2015). To this extent, retrospective case studies are implemented as they are considered relevant to the specific subject matter, allowing for more unambiguous outcomes. Thus, for the third level of conceptual framework validation, three retrospective illustrative case studies will be utilised.

6.2.3.2 Case study suitability criterion

To ensure the relevance of the case studies with respect to the framework's geographic application area and healthcare TT principles, multiple suitability criteria are implemented. Each case study must wholly adhere to the suitability criteria, shown in Table 6-17, before being retrospectively applied to the conceptual framework.

Table 6-17 - Case study suitability criteria

Criterion	Description
Geographic region	The case study must have been completed within at least one SSA country.
Healthcare application	The case study must be founded upon healthcare TT procedures.
Stakeholder involvement	The case study must involve multiple stakeholders from different organisations either public or private.
Timeline	The case study must have been initiated after 01 January 2010.
Social impact	The case study must either be for social improvement or a combination of social improvement and commercial gain.
Co-creation presence	The case study must involve facets of stakeholder co-creation.
Independence	The multiple case studies must be independent of one another.

The suitability critera are constructed to align with the rationale of the conceptual framework's overall evaluation. To this extent, items such as geographic region and healthcare application are evaluated along with co-creation. Case studies initiated before 2010 are excluded as project leaders may no longer be present at the relevant parent organisation or may be unable to recall detailed project events from the past. Additional criteria such as stakeholder involvement and social impact motivation are also included based on these items' prevalence in the outcomes of the survey instrument, as shown in Section 6.3.3. The identification of each case study and subsequent evaluation against these suitability criteria is shown in Section 6.2.3.3.

6.2.3.3 Case study identification and evaluation

For the conceptual framework's third level of validation, three case studies are identified and screened utilising the suitability criteria shown in Table 6-17. A detailed exposition of each individual case study is presented in Section 6.5.1.

The case studies identified are (i) Safer deliveries by D-Tree International, (ii) Mobile Phone Microscopy Diagnosis by the University Health Network, and (iii) Chipatala cha pa Foni by VillageReach. Each case study is evaluated by applying the suitability criterion to ensure their individual applicability. All three case studies are considered to sufficiently adhere to the evaluation criterion with a summary of the evaluation results shown in Table 6-18. While not shown in Table 6-18, independence is considered sufficiently met as all three case studies are completed in different geographic and healthcare areas and by varying independent organisations, as first noted in the rationale of the conceptual framework's evaluation procedure shown in Figure 6-2.

Table 6-18 - Case study suitability evaluation summary

		Case study 1	Case study 2	Case study 3
	Parent organisation	**D-Tree International**	**University Health Network**	**VillageReach**
	Project	**Safer deliveries program**	**Mobile Phone Microscopy Diagnosis**	**Chipatala cha pa Foni**
Suitability criterion	Geographic region	The project was implemented in Tanzania in Eastern Africa.	The project was implemented in Ivory Coast, Laos, Ghana and Tanzania in Western and Eastern Africa.	The project was implemented in Malawi in Eastern Africa.
Suitability criterion	Healthcare application	The project is categorised as a mobile healthcare application in the field of e-Health and telemedicine.	The project is categorised as a mobile medical device with e-Health and telemedicine applications.	The project was categorised as a mobile messaging service in the fields of telemedicine and improving patient reach.
Suitability criterion	Stakeholder involvement	The project stakeholders included D-Tree International, the Tanzanian Ministry of Health and local community leaders.	The project stakeholders included the University Health Network and local healthcare champions.	The project stakeholders included VillageReach, USAID, Airtel and the Malawian ministry of health.
Suitability criterion	Timeline	The project was initiated in 2011 and is currently still active.	The project was initiated in 2013 and is currently still active.	The project was initiated in 2011 and is currently still active.
Suitability criterion	Social impact	The project is motivated by social impact drive motivator.	The project is motivated by social impact drive motivator.	The project was motivated by social impact drive motivator.
Suitability criterion	Co-creation presence	The project focussed on knowledge creation and sharing between stakeholders, joint implementation between D-Tree International and the Ministry of Health as well as knowledge evolution for future projects completed by D-Tree International.	The project is very dependent on the relationship within the University Health Network, with multiple healthcare practitioners, engineers and project managers responsible for the transfer object's development and implementation.	The project focussed on knowledge creation and sharing between VillageReach and the Malawian Ministry of Health. These two stakeholders are responsible for the technology's development and implementation as well as additional expansion operations.

6.2.3.4 Conceptual framework case study application

To highlight the conceptual framework's potential applicability to healthcare TT case studies in SSA, the framework is systematically applied to each individual case study. A detailed analysis of each case study is conducted by reviewing the parent organisation's development and implementation procedure. Additional emphasis is placed on identifying outcomes which presented as problematic during the completion of the case study as well as management's reactions to these problem areas.

Multiple in-depth interviews with project leaders from each case study are conducted to complete this analysis. During these interviews, project leaders are questioned about various facets of their case study throughout its lifecycle. These facets are directly aligned with the individual nodes within the conceptual framework and pertain to the TT stakeholders and their interactions, the development and implementation of the transfer object, the transfer environment, infrastructure considerations, project evaluation procedures, change management and the sustainability of the project.

It must be noted that, as with the first and second levels of the evaluation procedure, the individual names of the project leaders are omitted for anonymity purposes. This is done partly to ensure compliance with this study's research ethics grant provided by the SUREC. Additionally, anonymity is enforced to promote honest case study feedback while not deterring project leaders to share case sensitive, yet applicable case study information. The final applicability outcomes of each case study are presented in Section 6.5.

6.3 Results: Semi-structured interviews

The results of the first level of the conceptual framework's validation are outlined by presenting both the descriptive statistics and outcomes of the semi-structured interviews. The descriptive statistics provide an overview of the interview candidates and their field of experience to lead authority to the outcomes gained from the semi-structured interviews. The collective outcomes of all interviews are then categorised per individual phase of the conceptual framework. This enables the identification of nodes and linkages which may require additions or modifications as well as framework components which align with the recommendations of the industry experts. This allows for the conceptual framework to be consolidated with the outcomes of the semi-structured interviews.

6.3.1 Descriptive statistics of the semi-structured interviews

Figure 6-13 outlines the divide between academics and practitioners among the interview candidates. It is important to note that multiple academic interview candidates claimed to have substantial experience working in industry. While all 16 interview candidates possessed direct TT experience, Figure 6-14 highlights the split between candidates with universal versus healthcare-specific TT experience. Figure 6-15 outlines that the primary experience of all 16 candidates is based on the South African landscape. Figure 6-16 provides a detailed overview of the individual fields that the 16 candidates stated to have the most experience in.

Figure 6-13 - Outline of interview candidate's profession

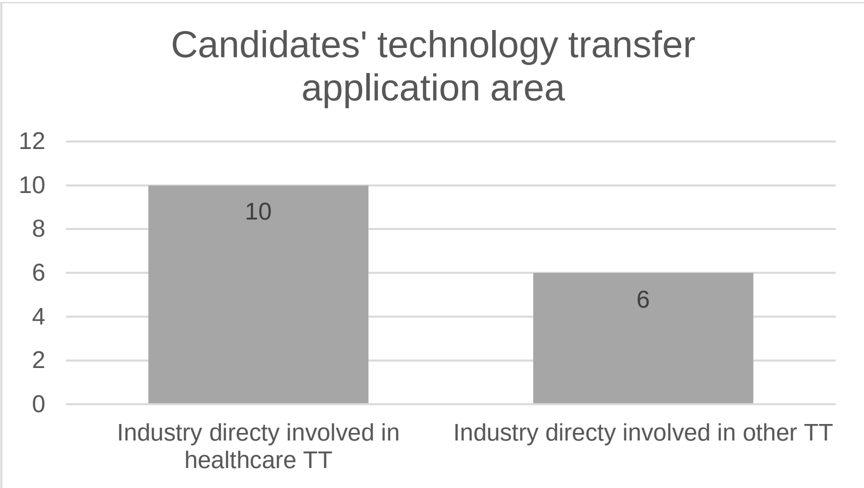


Figure 6-14 - Outline of candidates TT application area

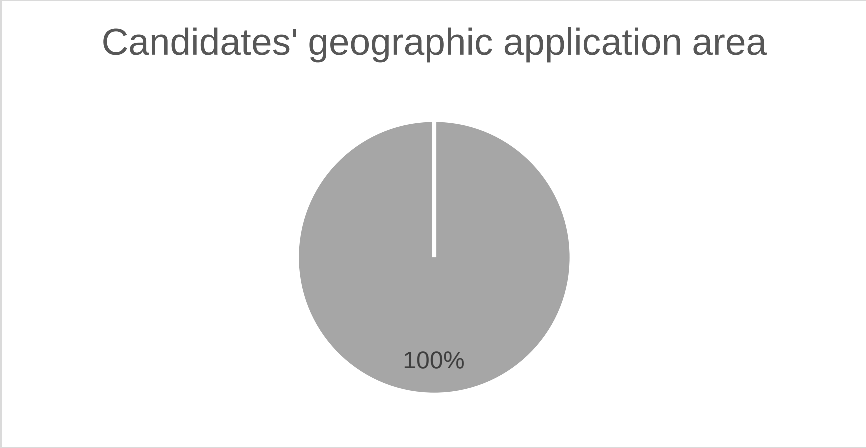


Figure 6-15 - Outline of candidates' geographic application area

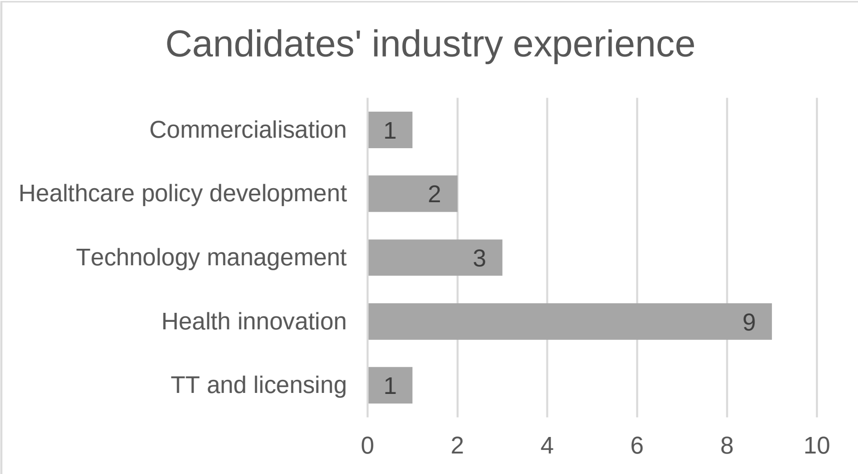


Figure 6-16 - Detailed outline of interview candidates' individual field of practise or study

6.3.2 Outcomes of the semi-structured interviews

The outcomes of the semi-structured interviews have been divided into three sub-categories. The first category highlights where candidate's expertise directly aligned with the preliminary conceptual framework's contents, shown in Section 5.4. The second category contains all the additions which the interview candidates deemed necessary to a successful TT venture. The third category summarises where interview candidate responses highlighted inadequate features within the preliminary conceptual framework which required modifications.

These three sub-categories are shown in Table 6-19 to Table 6-23 and represent the individual outcomes of the semi-structured interviews for the five phases of the preliminary conceptual framework. Within Table 6-19 to Table 6-23 the three sub-categories are noted as A.1 - A.6 for nodes and relationships requiring additions, M.1 - M.3 for nodes and relationships requiring modifications, and V.1 - V.5 for nodes and relationships deemed applicable to real-world healthcare TT ventures.

Table 6-19 - Interview outcomes regarding the contents of Phase I of the conceptual framework

Interview outcomes pertaining to Phase I	
Validations	V.1 It will be important for the transferee and transferor to be involved with each other from the initiation of the TT. V.2 Pre-defined communication, operational and documentation standards must be established at the initiation of the TT. V.3 The first three phases of the conceptual framework must be completed concurrently and not sequentially. This should be enforced rather than allowing it to be optional. V.4 The stakeholder relationship tool, shown in Figure 5-12 must be implemented and revised throughout the entire TT venture. V.5 Ensure that all transferee characteristics, requirements and capacities have been identified and documented at the commencement of the TT.
Additions	A.1 The transferor must be legally tied to the TT. This will ensure continued involvement and support throughout and beyond the TT process. A.2 Investigate as to what the transferee does not want from the transfer object. This will also aid in ensuring stakeholder involvement and adoption efforts. A.3 For healthcare, consider the difference between the personnel using the transfer object and the administrators who commissioned it.
Modifications	M.1 A preliminary analysis of the transfer object's proposed market may serve as a universal starting point across all TT ventures. M.2 Standardisation can cripple young TT ventures. Differing standards may cause a TT to be abandoned.

Table 6-20 - Interview outcomes regarding the contents of Phase II of the conceptual framework

Interview outcomes pertaining to Phase II	
Validations	V.1 No technologically complex transfer object will survive in an infrastructure scarce environment. Thus, it is important to ensure infrastructure mitigation practices have been identified and implemented. V.2 The TT must be championed in a collaborative manner. V.3 While collaborative effort will be required, efforts should be made to ensure that all individual roles have been assigned so that all facets of the TT receive the required attention. V.4 Digital literacy will always remain a substantial issue in rural areas. If not checked, these digital literacy barriers will result in the transfer object becoming a burden rather than an asset. V.5 The incorporation of a TTO removes pressure from the transfer team while simultaneously providing logistical and legal expertise.
Additions	A.1 The transfer team should construct a hard infrastructure level chart which allows for various future upgrades to the transfer object depending on available future infrastructure. A.2 The transfer team must maintain continual stakeholder communication to account for shifting stakeholder requirements and expectations. A.3 When implementing a new technology into the transfer environment, patient reactions must be considered. While uncommon, patients may refuse being subjected to a new health technology. A.4 The transfer team should consult their legal team, as the legal team's expertise and design input may simplify future licensing, IP and transfer object marketability.

Table 6-21 - Interview outcomes regarding the contents of Phase III of the conceptual framework

Interview outcomes pertaining to Phase III	
Validations	V.1 The creation of a dedicated team which solely focuses on the transfer object's suitability will improve the adoption and commercialisation of the TT in the subsequent phases. V.2 The joint venture TT method has been condoned as the template for a co-creation health-related TT and should be considered for the primary method in all potential TT ventures. V.3 Implementing a stage-gate feature will be invaluable to any TT venture as it facilitates both risk management and quality control.
Additions	A.1 The primary stakeholders should attempt to produce a functioning prototype of the transfer object as soon as possible. This will allow for a degree of transfer object modification to occur before the TT progresses to Phase IV. Including the prototyping into the stage-gate feature would also be beneficial for quality control purposes. A.2 The prototyping process should be augmented by incorporating early adopters of the transfer object. This will streamline the subsequent adoption process and allow for revision of the transfer object at an early stage. However, early adopters must not be approached too soon as an incomplete transfer object may act as a deterrent and hinder adoption in the subsequent phases. A.3 Early adopters must be incentivised by providing either tangible and intangible rewards. Highlighting how the transfer object will solve a client's problem may be more influential than offering monetary compensation when approaching a potential early adopter. A.4 Ensuring ethical compliant primary stakeholders must be the collaborative organisation's first goal. Healthcare TTs, especially joint ventures with the public sector, will be severely delayed if stakeholders do not operate according to ethical compliance standards.
Modifications	M.1 When attempting to ensure the suitability of the transfer object, attempts must solely focus on altering the transfer object to function in its transfer environment. Alterations to the transfer environment must thus be avoided as they often deplete the time and monetary resources of a TT venture. M.2 When implementing supplementary TT methods, an attempt must be made to avoid licensing option whenever the TT's commercialisation strategy permits. Open source transfer objects greatly increase the rate of technological diffusion and may also introduce the transfer object into different environments than for which it was designed. Thus, the balance between IP and open-source access should be carefully evaluated. M.3 Various project managers lamented the implementation of a stage-gate due to time and monetary constraints which accompany a stage-gate. As such, the dual stage-gates should be combined into a single process to both maintain quality control and risk management but reduce time and monetary constraints imposed by multiple stage-gates.

Table 6-22 - Interview outcomes regarding the contents of Phase IV of the conceptual framework

Interview outcomes pertaining to Phase IV	
Validations	V.1 The transferor must assign a dedicated team of personnel responsible for end-user training. This team should also motivate end-users by marketing why the transfer object will be beneficial. V.2 Transfer object related training must be conducted on-site and in-process. Removing the end-user from his environment will be detrimental to the adoption rate of the TT. V.3 Implementing a "training to train" methodology will be feasible. However, care should be taken not to over commit resources.
Additions	A.1 Identify end-user levels. Training end-users beyond their individual capabilities only results in wasted resources. Similarly, allowing an end-user access to sensitive healthcare information or data should only be sanctioned after the end-user's level has been authorised to receive the information. A.2 Universal adoption policies cannot be implemented in isolation. Tailored adoption policies will always be required in conjunction with universal policies. A.3 Training an end-user how to maintain or troubleshoot a transfer object should automatically follow the end-user's basic transfer object operations training. A.4 Co-creation training policies should be founded upon the end-user's existing internal training policies and protocols. Implementing training structures familiar to the end-users will greatly improve the TT's rate of adoption. A.5 The best way an end-user can be motivated to adopt a particular transfer object will be by illustrating how the transfer object will solve their current problems.
Modifications	M.1 Continual stakeholder involvement will be an impossibility. This becomes more prevalent when trying to continually involve high-level stakeholders. The change management strategy must thus account for disappearing stakeholders and ensure that the required output has been extracted before stakeholders disband from the transfer team. M.2 Adoption will be simplified if an end-user, not the client, has aided in the development of the transfer object. M.3 It will be imperative to ensure that ground-level stakeholders and end-users retain authority. Often when new high-level stakeholders enter the TT, ground-level users get frozen out which ultimately damages the transfer object's adoption.

Table 6-23 - Interview outcomes regarding the contents of Phase V of the conceptual framework

Interview outcomes pertaining to Phase V	
Validations	V.1 Standardising knowledge codification practices must be enforced throughout the TT. Additionally, these practices aid in obtaining certification and ensuring compliance. V.2 Successful commercialisation will be promoted by incorporating the end-user and the client as TT stakeholders. In turn, these stakeholders will receive direct remuneration for personal efforts toward the commercialisation of the transfer object. V.3 Healthcare TT will typically be evaluated utilising the public value criterion. While economic profit remains important, increasing public value will typically offset monetary shortfalls. V.4 Health technologies typically utilise either a free-to-use or licensing business strategy depending on the available stakeholders. V.5 The overall scope of the TT and transfer team must be acknowledged during the commercialisation phase. Commercialisation will largely fall outside of the scope of the initial transfer team.
Additions	A.1 When evaluating a completed TT, evaluating the client's capacity to disseminate the transfer object should be the primary evaluation criteria. A successful TT requires the client to have taken ownership of the transfer object. While the transfer team will be involved to a lesser degree, continual support channels should be instigated. A.2 The TT's knowledge documentation and standardisation procedures and protocols warrants its own department within the transfer team. A.3 The transfer object's usage and continual usage should be measured to evaluate both the success of the initial TT as well as its sustainability. A.4 Driving the TT for the sake of technology itself will typically not be sustainable. Thus, the transfer team must ensure that value has been created for the business or public value entity utilising the transfer object. A.5 For SSA, the most prevalent bottleneck towards commercialisation has been the lack of manufacturers and a supply chain. SSA countries often only possess distributors and thus the time and cost implications of importing health technologies must be investigated and documented in the commercialisation strategy. A.6 The transfer team should lobby the public healthcare sector or corresponding branch of government to construct universal standards that can be utilised to regulate and simplify the TT's operational and documentation compliance.
Modifications	M.1 Generic evaluation criteria will be uncommon. The transfer team should utilise pre-defined and case-specific criterion when evaluating the TT. M.2 Regulating and enforcing too much standardisation may potentially cripple young ventures as differing standards between stakeholder may result in the TT to be abandoned. Thus, codification and operational standards must be evolved as the TT progresses.

6.3.3 Discussion of the semi-structured interviews' outcomes

A summary of the validations, additions and modification implemented to the individual nodes and relationship flows within the preliminary conceptual framework is shown Table 6-24. In addition, multiple industry experts have also suggested two primary structural alterations to the preliminary conceptual framework. These structural alterations entail the stage-gates in Phase II and Phase III as well as the progression through Phase I, Phase II and Phase III.

Table 6-24 - Summarised outcomes of the semi-structure interviews

		Phase I Refer to Table 6-19	Phase II Refer to Table 6-20	Phase III Refer to Table 6-21	Phase IV Refer to Table 6-22	Phase V Refer to Table 6-23
Validations	V.1	Co-creation relationship	Infrastructure mitigation	Collaborative organisation	Dedicated training personnel	Standardisation of knowledge codification
	V.2	Standards	TT champion	Joint venture for co-creation	On-site and in-process training	End-user integration
	V.3	Concurrent phases	Assigning stakeholder roles	Stage-gate usage	Training to train	Healthcare public value
	V.4	Stakeholder levels instrument	Digital literacy barriers			Business strategies
	V.5	Transferee exposition	Incorporation of a TTO			The scope of TT
Additions	A.1	Legally binding the transferor	Hard infrastructure levels	Constructing a prototype	End-user training levels	End user’s capacity
	A.2	End-user aversions	Stakeholder levels	Incorporating early adopters	Tailored training protocols	Product documentation division
	A.3	End-user vs client	Patient perceptions	Incentivising early adopters	Maintenance training	Usage evaluation criteria
	A.4		Incorporating legal expertise	Ethical compliance	Incorporating existing internal policies	Value creation for businesses
	A.5				Motivation	Supply chain analysis
	A.6					Government interaction
Modifications	M.1	The initiation point		Transfer environment modification	Stakeholder levels instrument	Tailored evaluation criteria
	M.2			An open-source transfer object	Creating inherent motivation	Limiting standardisation
	M.3			Dual stage-gates	Decentralising authority	

The implementation of a stage-gate process to TT was supported by most of the industry experts. However, several project managers involved in TT operations opposed the implementation of two stage-gates due to the monetary and time pressures added by these revision points. To mitigate these pressures, the dual stage-gates have been conflated into a single revision node, placed at the conclusion of Phase III. The content of the stage-gates has not been modified but rather compiled into a single revision node and as such will entail all the revision outcomes of the stage-gates in the preliminary conceptual framework, shown by Figure 5-15 and Figure 5-19 in Section 5.4.

The second structural alteration surrounds the general flow of the first three framework phases and has been partly addressed in the preliminary conceptual framework by conflating the first three stages into a single transfer method application strategy as shown by Figure 5-18. All the interview candidates stated that the first three phases of a TT venture must be conducted in parallel. Several interview candidates lamented TT ventures that run in a linear fashion and strongly advocated for this process to be collapsed to ensure that these phases will not be completed in isolation from one another.

While Figure 5-18 and Phase III of the framework does highlight the need to incorporate the outcomes of Phase I and Phase II into the overall transfer method application strategy, further additions have been installed to ensure the first three phases will be completed concurrently rather than sequentially. To accomplish this, the transfer application strategy node has been included in Phase I and Phase II which strengthens the linkage between the TT's analysis, development and application. Furthermore, additional feedback loops have been incorporated to ensure the first three phases will be completed in parallel.

While the interview process highlighted linkages between Phase IV and Phase V, most interview candidates concluded that these phases should be completed in a sequential fashion. This stems from the uncorrelated stakeholders typically involved in either phase. A summary of the required flow of the conceptual framework's phases has been provided in Figure 6-17 and will be implemented in the final framework, shown in Chapter 7.

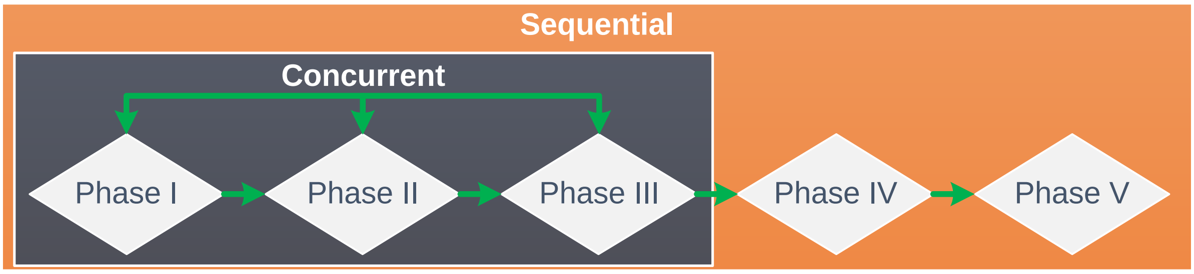


Figure 6-17 - Required progressions through the conceptual framework's phases

It is noted, that per the rationale of the conceptual framework evaluation, all additions and modifications outlined by the outcomes of the semi-structured interviews are incorporated into the preliminary conceptual framework before commencing with the second level of evaluation, as represented by the survey instrument.

6.4 Results: Survey

The results of the second level of the conceptual framework's evaluation are shown in this section. The descriptive statistics, rank of perceived ease of use and rank of usefulness are outlined in Section 6.4.1, Section 6.4.2 and Section 6.4.3 respectively.

The descriptive statistics provide an overview of various demographic features of the survey respondents and aims to strengthen the authority of the survey's results with respect to the conceptual framework's geographic application area and healthcare TT principles. The outcomes of the survey instrument are structured to illustrate the perceived ease of use and utility of individual components and phases of the conceptual framework. To this extent, both these measurement items are investigated using frequency, mean, variance and regression analyses. Lastly, the various outcomes of the survey's data results are discussed and consolidated into the conceptual framework, which is subsequently displayed in Chapter 7.

6.4.1 Descriptive statistics of the survey instrument

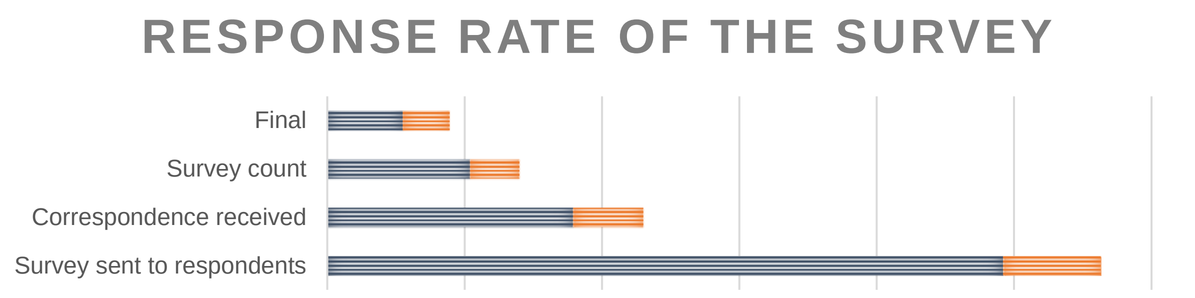
Section 6.4.1 serves as an introduction for the survey's data results by highlighting the survey respondent's fields of healthcare, technology management and TT experience as well as the primary geographic application area of their experience. Data summaries pertaining to the survey's questions outlined in category 1, refer to Table 6-5, are also provided. While no statistical research methods are employed during the presentation of the descriptive statistics, the data results shown in Section 6.4.1 provide credence to the subsequent statistic research methods and conclusions by confirming the applicability of the survey's data with respect to the focus areas of the conceptual framework.

As highlighted in Section 6.2.2.9, a total of 563 survey invitations were distributed to healthcare technology managers listed within the CHMI and GHDN databases. In total, 230 different healthcare managers responded to the initial invitation by either indicating a willingness to complete the survey instrument or requesting additional information. The online link directing respondents to the survey is kept open for a 60-day period after the final invitation is distributed.

Once the online link expired, the survey had collected 140 responses, 51 of which are incomplete and subsequently discarded. Thus, a final total of 89 responses are utilised for the data results of the survey instrument. While the final sample size does not represent an exhaustive reflection of the entire population, the descriptive statistics do also provide a snapshot of the composition of the healthcare technology management field in SSA.

Figure 6-18 presents a comparison of the survey's response rate for respondents identified via the CHMI and GDHN databases. The higher response rate of respondents from the GDHN, 47,89%, in comparison to respondents from the CHMI, 11,18%, is wholly attributed to the additional contact information listed on the GDHN database. Nearly all respondents within the GDHN network could be directly contacted via email and telephone whereas respondents from the CHMI could only be contacted via an online contact form.

Figure 6-18 - Survey instrument's response rate outline



	Survey sent to respondents	Correspondence received	Survey count	Final
CHMI	492	179	104	55
GDHN	71	51	36	34
Total	563	230	140	89

During the initial interview conducted with the statistician, a survey response count of 200 was recommended as ideal as from a statistical perspective, as a sample size of two hundred approximates a normal distribution. This notion is also reinforced by multiple literature items (AUTM, 2000; Kitchenham *et al.*, 2002; Passmore *et al.*, 2002). However, after the completion of the pilot tests, the third-party consultant stated that previous healthcare survey's conducted in conceptual healthcare across SSA rarely obtain more than 50 completed survey responses.

> *"There are a very small number of healthcare technology managers in Africa when you compare us with Europe or the [United] States. One project manager working at [a large aid organisation such as] USAID often leads more than 20 different projects in a region." "They are mostly courteous enough to share their experiences on one of the main projects but very rarely more than one."*

- D-Tree International correspondent

This issue is subsequently raised with the statistician, citing a response count of 89, and after reviewing the data, the statistician concluded that the sample size is sufficient to enable valid statistical conclusions to be made using quantitative data analysis.

Figure 6-19 highlights the year of commencement for each survey respondent's healthcare TT venture. Of the 89 projects captured by the survey responses, 73 commenced after 2000 with more than a third starting between 2011 and 2015. While not in the scope of this research study, Figure 6-19 may also serve as the foundation for future research investigating how different healthcare and TT components have evolved in SSA over a 40-year period.

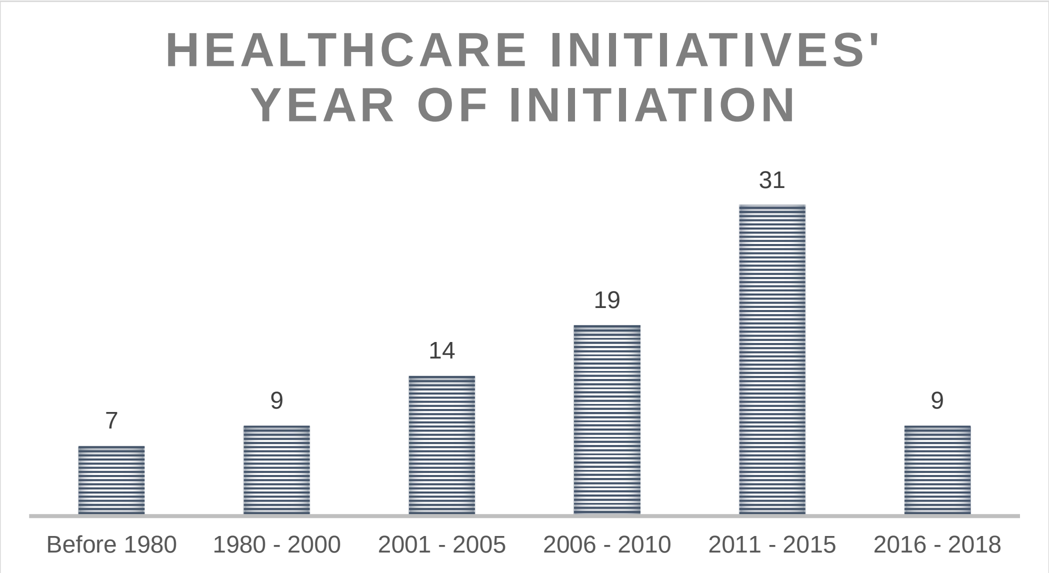


Figure 6-19 - Outline of projects' initiation year

A recurring theme evident throughout the conceptual framework is stakeholder co-creation and the relationship between the primary TT stakeholders. The driving forces behind the development and implementation of healthcare TT in SSA are directly linked with the facilitation of stakeholder co-creation. To this extent, the survey aims to identify the primary motivation behind healthcare TT ventures. A summary of the driving forces for the healthcare transfer object is shown in Figure 6-20. This outline serves to answer question 1.1 as well as partly answer question 2.1, refer to Table 6-5, of the survey.

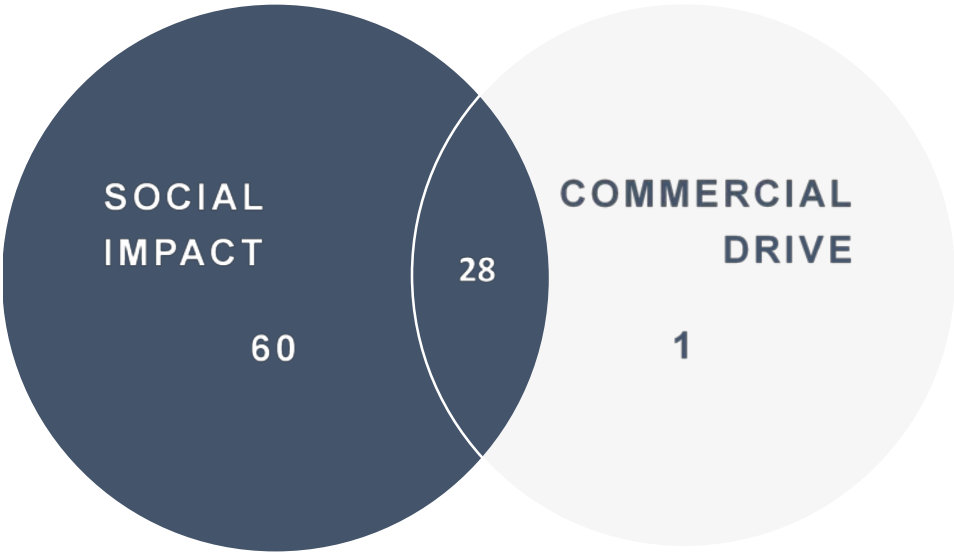


Figure 6-20 - Balance of the driving force behind projects

Figure 6-20 provides a clear indication that healthcare TT ventures in SSA are seldom initiated for commercial drive or to increase the market reach of the parent organisation. While some projects contained elements of both commercial drive and social impact, the survey's data results highlight the need to ensure that Phase I of the conceptual framework does not emphasise the commercialisation of the transfer object. Thus, Phase I should almost exclusively focus on constructing a relationship between the primary stakeholders based on the transfer object's potential community impact.

As discussed in Section 6.2.2.1, the survey is undertaken to investigate the conceptual framework's applicability to the entire SSA region. The need to expand the geographic application area of the second level of evaluation stems from the limited experience of the semi-structured interviews candidates in countries other than South Africa. To this extent, survey respondents are asked to indicate the country in which their transfer object is implemented as well as countries in which they had previously implemented healthcare technologies. A heatmap of SSA is shown in Figure 6-21, highlighting the various countries in which respondents had directly implemented healthcare technologies. Kenya, with 31 responses, represents the country with the highest concentration of implemented healthcare technologies. While not imperative, a pleasing aspect of the survey's data is that every SSA country contained at least one response claiming to have direct experience in that country.

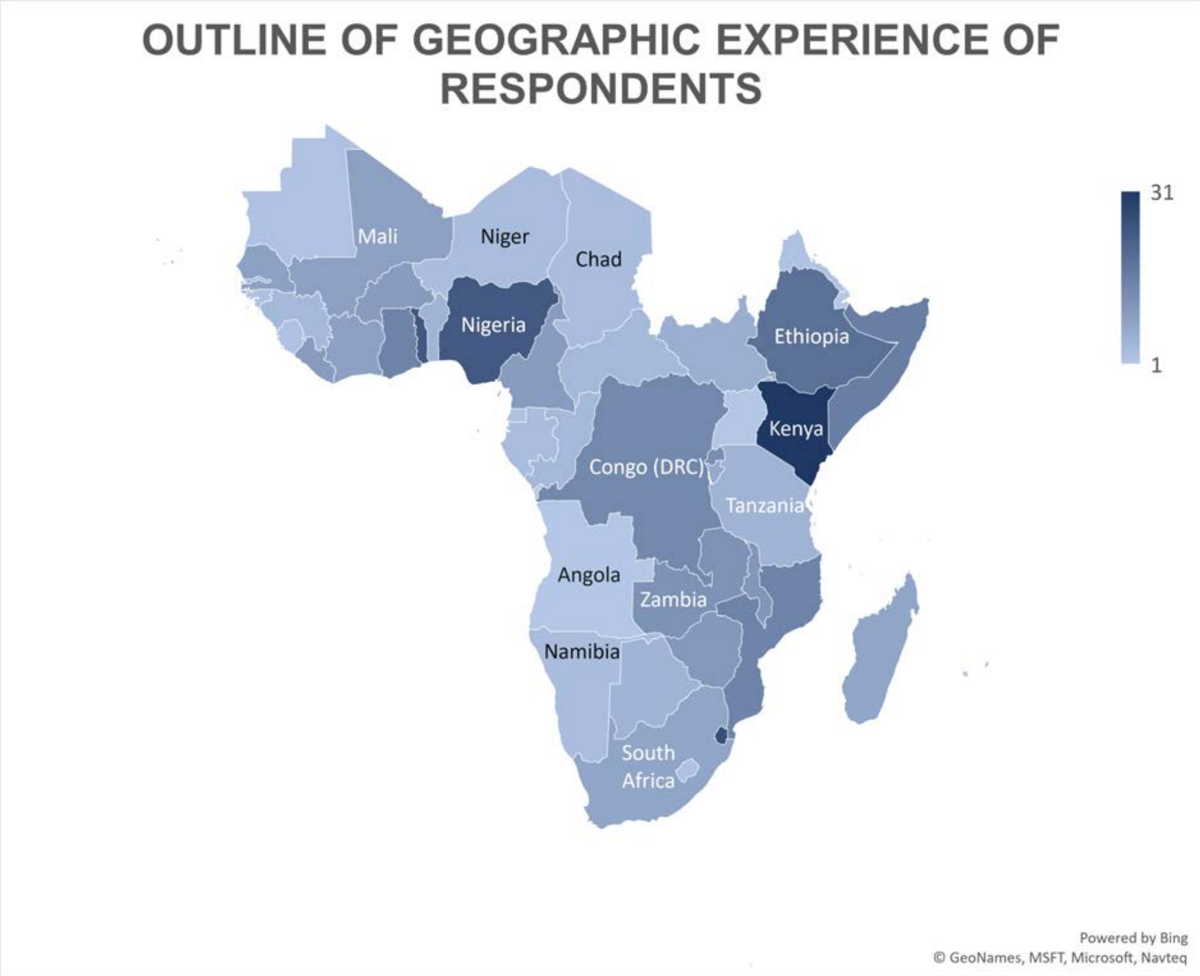


Figure 6-21 - Summary of geographic application areas of projects per country

When reviewing Figure 6-21, higher concentrations are observed in Western and Eastern Africa with Central and Southern Africa depicting a lower concentration. This is reinforced by Figure 6-22, outlining the regional experience of the respondents. Out of the 89 complete survey responses, 68 respondents indicated that they possess experience with healthcare technology implementation in one or more of the four regions of SSA. Eastern Africa represents the most healthcare TT experience with 24 respondents while Western, Central and Southern Africa received 19, 12 and 13 responses respectively. Figure 6-21 and Figure 6-22 serve to answer question 2.2, refer to Table 6-5, of the survey. Figure 6-22 also serves as the foundation for the variance analysis conducted to answer all the questions in category 3 of the survey.

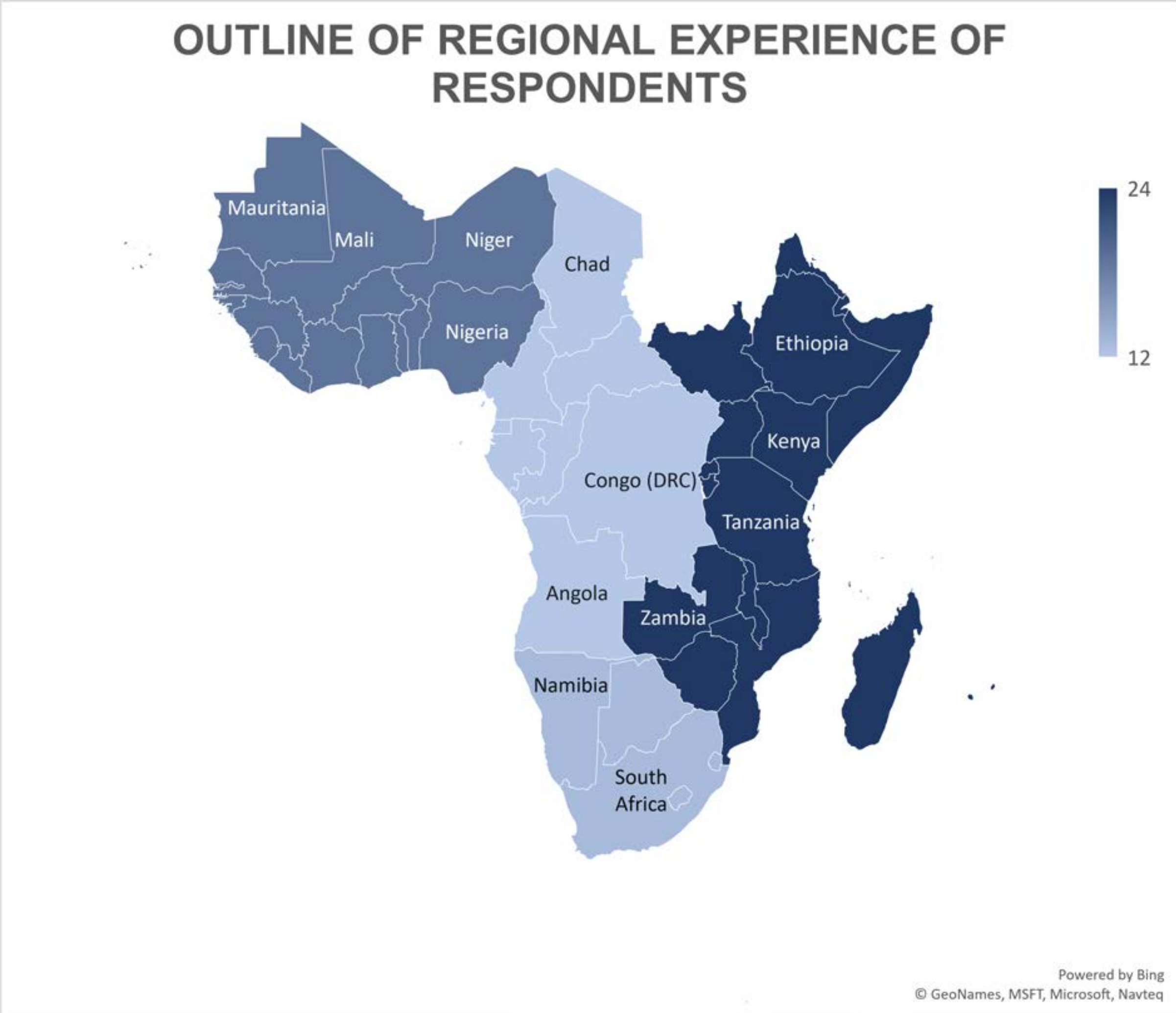


Figure 6-22 - Summary of geographic application areas of projects per region

Figure 6-23 summarises the level of career experience of the survey's respondents. As healthcare technology implementations are mostly overseen by managing or country directors, executive and senior-mid management positions account for the majority of the survey's respondents. Several responses are also captured from interns and junior personnel. After follow-up communications, these lower-tiered respondents are identified to be the personnel designated with the knowledge capture of the transfer object's development and implementation for subsequent internal revisions.

Figure 6-23 also reinforces the statement provided by the third-party consultant surrounding the quantity of the available healthcare respondents in SSA, as executive and management level personnel represent 76% of the respondents. Thus, the data required by the survey can primarily only be provided by the project managers, directors or country leaders of healthcare TT ventures which account for a small proportion of the overall healthcare workforce conducting operations in SSA.

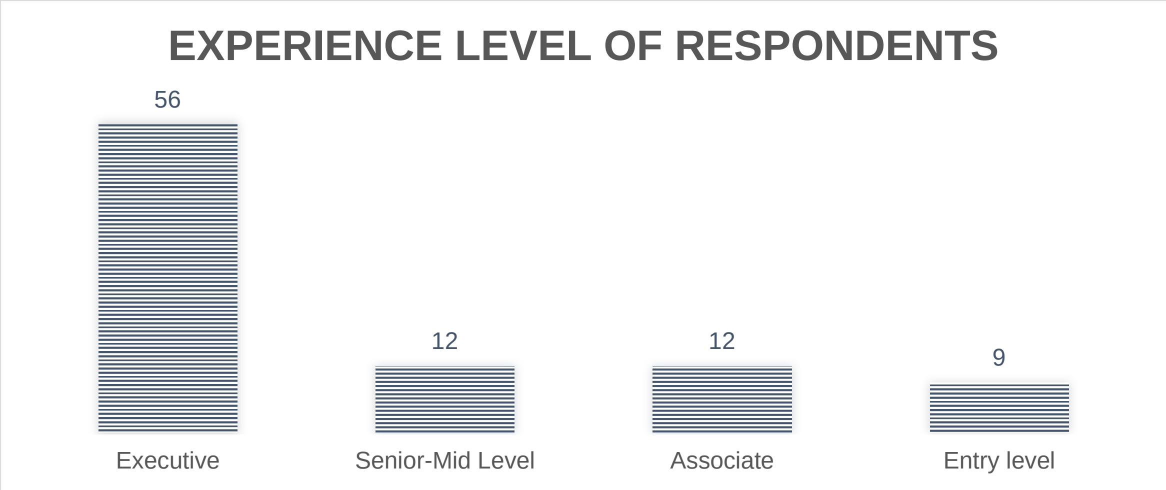


Figure 6-23 - Summary of survey respondents' levels of experience

To comply with the ethical research grant provided for this survey by the SUREC, individual candidate names are not captured during the completion of the survey. However, the parent organisations of each respondent are listed for review in Appendix F.9. Each parent organisation is crossed referenced with those listed in the survey's administration step, presented in Appendix F.8. This check is done to ensure that all response gathered are from parent organisations that adhere to the survey instrument's exclusion criteria shown in Appendix F.2. This also check also ensures that no duplicates are accidentally included in the final data set.

It is noted that the survey question pertaining to the parent organisation utilised an open-ended text response so that no respondent would be forced to list their parent organisation if they did not wish to do so. As a result, two respondents declined to list their parent organisations as is highlighted in Appendix F.9.

Figure 6-24, Figure 6-25 and Figure 6-26 highlight the applicability of the survey respondents' experience with respect to the fields of healthcare, technology management and TT. For all the demographic questions pertaining to the respondents' experience, respondents are not limited to a single entry but rather multiple checkboxes. Thus, an individual respondent could select multiple options based on their individual industry experience.

Figure 6-24 summarises the fields of healthcare in which respondents accumulated industry experience and serves to answer question 1.4 of the survey. At least 40 or more respondents indicated that they possessed direct industry experience in healthcare services, HIS, e-Health, and patient care. Figure 6-24 also highlights that experience surrounding physical medical devices is restricted to 18% of the respondents while healthcare services, e-Health, HIS, supply chain improvements all received more than twice this. This reinforces an important healthcare TT characteristic, first uncovered in Section 3.3.5 of the systematic conceptual literature review, in that the transfer object is much more likely to encapsulate an entire system or service than an individual physical artefact.

All the 89 respondents indicated that they possessed industry experience in at least 2 or more fields of healthcare with respondents selecting 4 on average. Respondents selecting "other" almost exclusively stated healthcare education when promoted to elaborate. This indicates a missing response option for the fields of healthcare question within the survey. This also shows the relative importance of healthcare education and training in healthcare technology management in SSA.

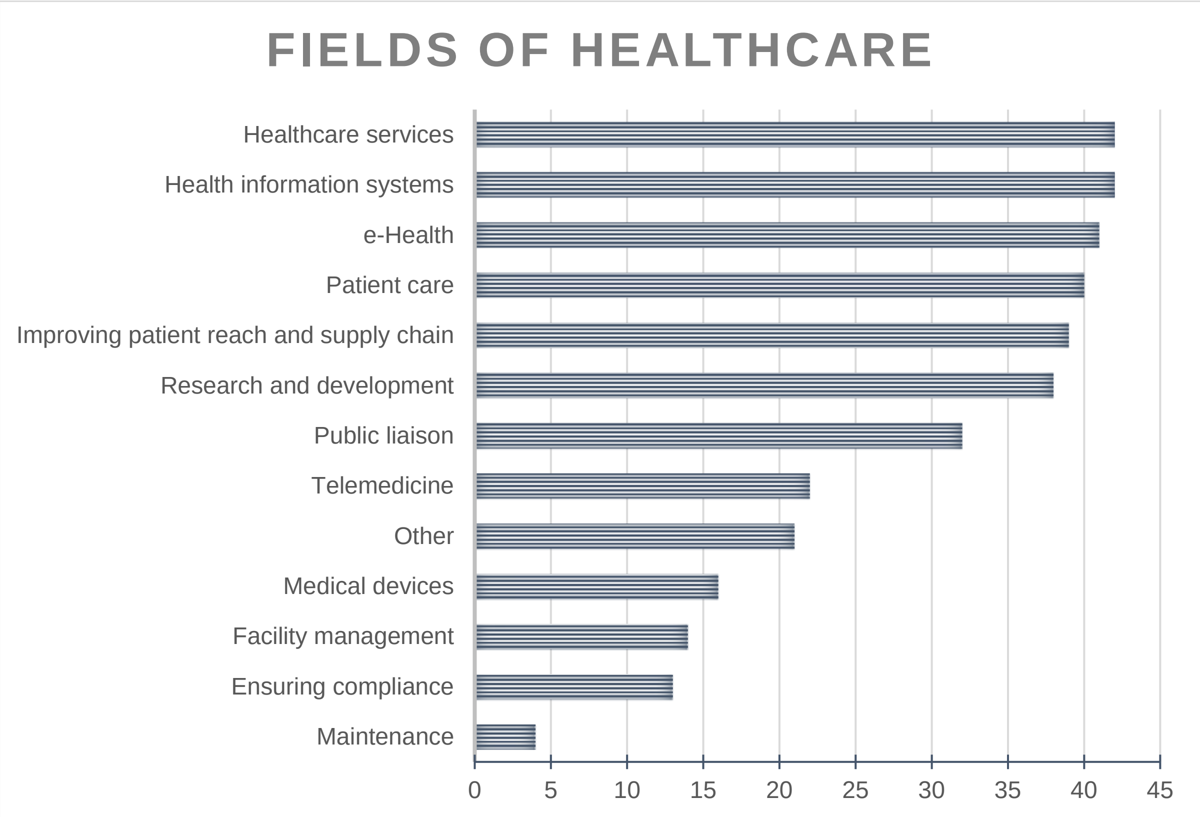


Figure 6-24 - Summary of respondents' healthcare application experience

Figure 6-25 summarises the fields of technology management in which respondents accumulated industry experience. Of the 89 respondents who completed the entire survey, 76 indicated they possess industry experience in project execution, representing just over 85% of the sample set. Phase I to Phase III of the conceptual framework run concurrently and pertain to the project execution of a TT, a notion reinforced by the outcomes of the first level of the conceptual framework's evaluation, as shown in Figure 6-17. As project execution is predicated on every node within Phase I through Phase III, Figure 6-25 clearly highlights that the majority of the survey respondents possess direct experience with respect to the conceptual framework's TT healthcare principles.

All the 89 respondents indicated that they possessed industry experience in at least 1 or more fields of technology management with respondents selecting between 3 and 4 on average. While present in the response options, no respondent selected the "other" option for technology management fields.

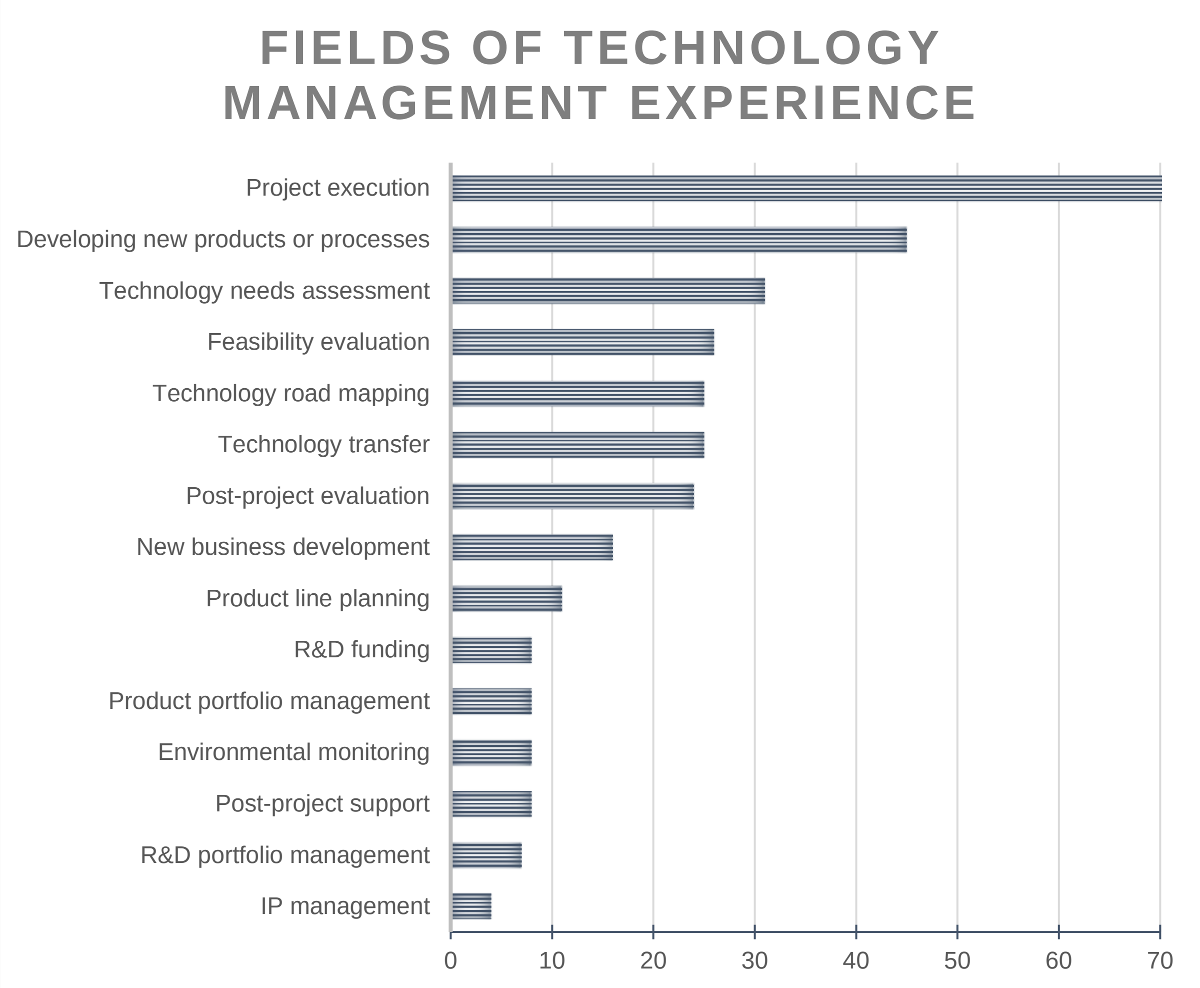


Figure 6-25 - Summary of respondents' technology management experience

Figure 6-26 summarises the fields of TT in which respondents accumulated industry experience and serves to answer question 1.3 of the survey. An interesting anomaly is identified when comparing the respondents' data from Figure 6-25 and Figure 6-26. Only 25 of the 89 respondents indicated they possess TT experience as a subset of technology management, yet no respondents indicated they do not possess experience in any subset of TT even when presented with the response option. A possible explanation may be that technology managers do not fully understand the categorisation of TT components and simply view them as additional fields of technology management.

When reviewing components related to stakeholder co-creation, 39 respondents indicated they possess experience for both the transfer object's development and stakeholder integration while public liaison, training and joint ventures received 27, 21 and 17 responses respectively. All the 89 respondents indicated that they possessed industry experience in at least 1 or more fields of technology management with respondents selecting 3 on average. Only 5 respondents selected “other” yet three of these did not elaborate when prompted.

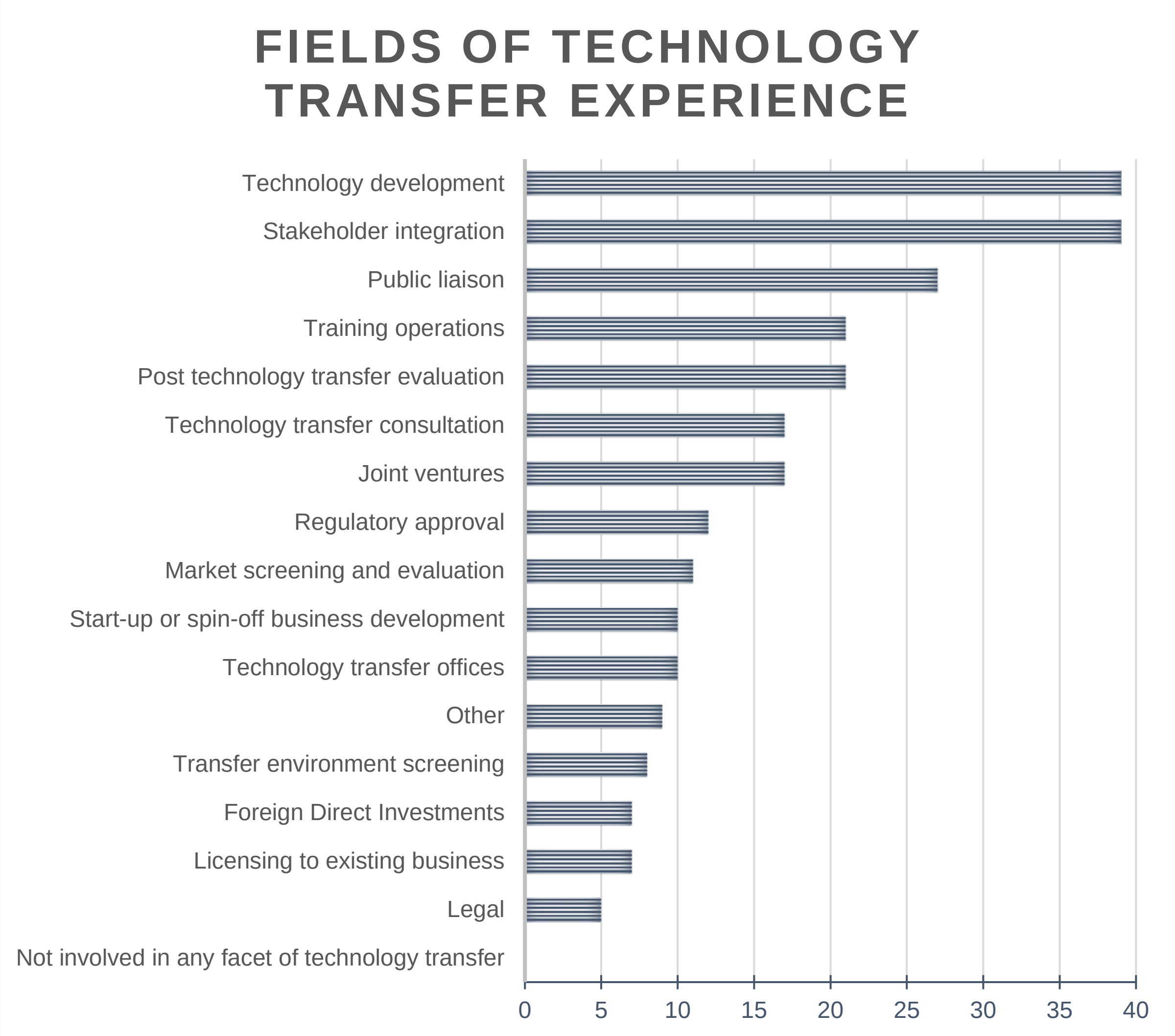


Figure 6-26 - Summary of respondents' technology transfer experience

As outlined during the construction of the survey instrument in Section 6.2.2.6, three evaluation questions are presented to each respondent requiring each respondent to rank the end-user adoption, additional diffusion of the transfer object and overall satisfaction level of the healthcare initiative for which they are completing the survey. While all three questions implemented a 5-point Likert scale, a not yet certain option is also included for the additional diffusion question. Figure 6-27 summarises the responses for all three of these evaluation questions and serves to answer question 1.5 of the survey.

The data presented in Figure 6-27 is subsequently utilised during the variance and regression analyses, shown in Section 6.4.2 and Section 6.4.3. As such, it is important to note that all three evaluation question responses are not normally distributed, and care is taken not to implement statistical methods requiring such data sets. Additionally, 7 respondents indicated that they are “not yet certain” about the diffusion of their transfer object. Thus, for all future diffusion related calculations shown in Section 6.3.3, the sample size is reduced from 89 to 82.

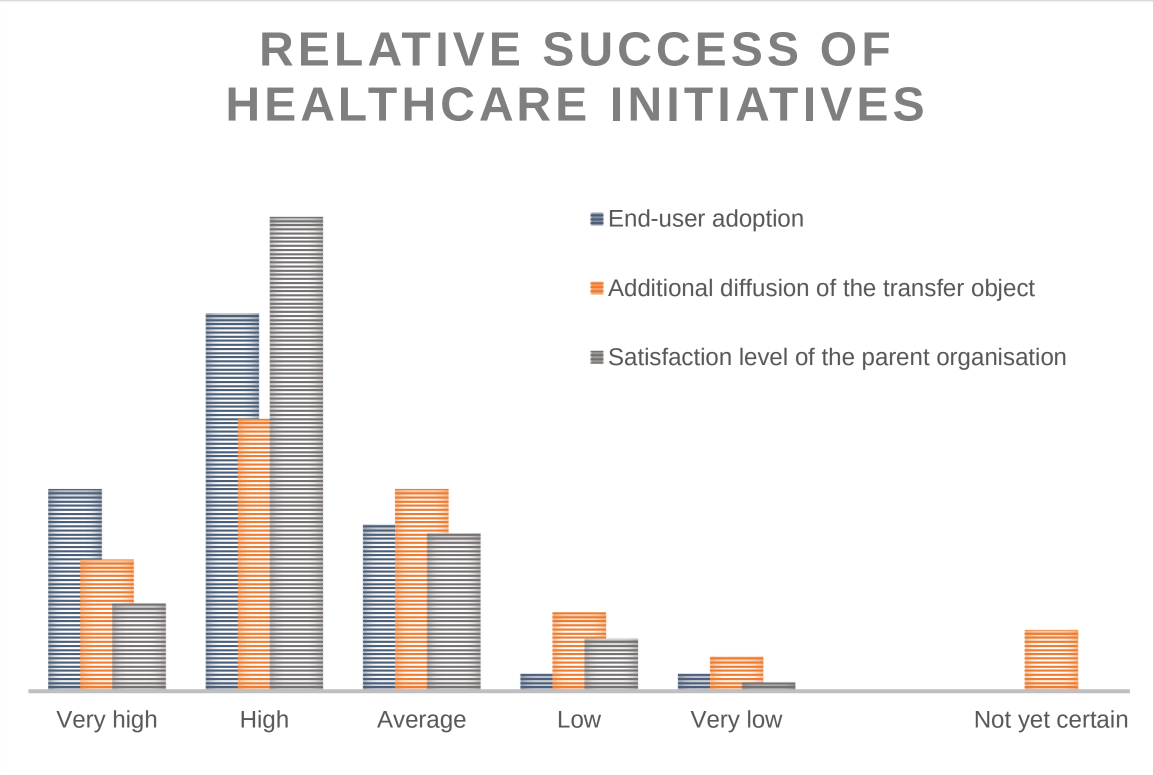


Figure 6-27 - Relative success of the survey's healthcare initiatives

6.4.2 Rank of perceived ease of use

Section 6.4.2 presents the results of the data analysis conducted after the completion of the survey’s administration for the measurement item perceived ease of use. This section aims to highlight the conceptual framework’s perceived ease of use by implementing frequency, mean, variance, regression and correlation analyses. Data summaries pertaining to the survey’s questions outlined in category 2 and 3, refer to Table 6-5, are also provided.

6.4.2.1 Frequency analysis for perceived ease of use

Frequency analysis represents the first step taken in evaluating the perceived ease of use of the conceptual framework and its foundations. Section 6.4.2.1 aims to present the perceived ease of use outcomes of the survey for both the nine collective framework foundations as well as comparing the individual constituents of each foundation.

To improve the readability of this research study, the Likert scale for the perceived ease of use measurement item, first shown in Table 6-10, is restated below in Table 6-25. Survey questions that obtained responses of three, or higher, are considered as managerial best practices that are commonplace or achievable for TT ventures in SSA. However, it is important to state that Section 6.4.2.1 only focusses on outcomes pertaining to perceived ease of use and items deemed difficult to implement should not be disregarded merely on this basis alone. Section 6.4.3.1 displays the frequency graphs pertaining to usefulness which should be utilised in conjunction with perceived ease of use outcomes. To this extent, comparisons between the perceived ease of use and usefulness frequency analysis outcomes are discussed in Section 6.4.3.1.

Table 6-25 - Restated measurement items for perceived ease of use

Measurement scales	Measurement items				
Perceived ease of use	Impossible to implement 1	Difficult to implement 2	Routine to implement 3	Easy to implement 4	Trivial to implement 5

Figure 6-28 provides an overview of the perceived ease of use frequency outcomes for each framework foundation. This frequency graph is filtered to display the framework foundation scores in a descending order to highlight which foundations are deemed to be comparably easier to implement. The frequency graphs of the nine individual foundations are subsequently displayed in Figure 6-29 to Figure 6-37 and are ordered in accordance with the ranking shown in Figure 6-28. All frequency graphs presented in Section 6.4.2.1 contained a sample size of 89 survey respondents.

In terms of perceived ease of use, approximately 70% of survey respondents reported that project evaluation, training, project standardisation, the workings of the TT team and stakeholder co-creation are considered routine or easy to facilitate. This appears to indicate that the constituents of these foundations are fairly commonplace in healthcare TT ventures and are addressed on a regular basis.

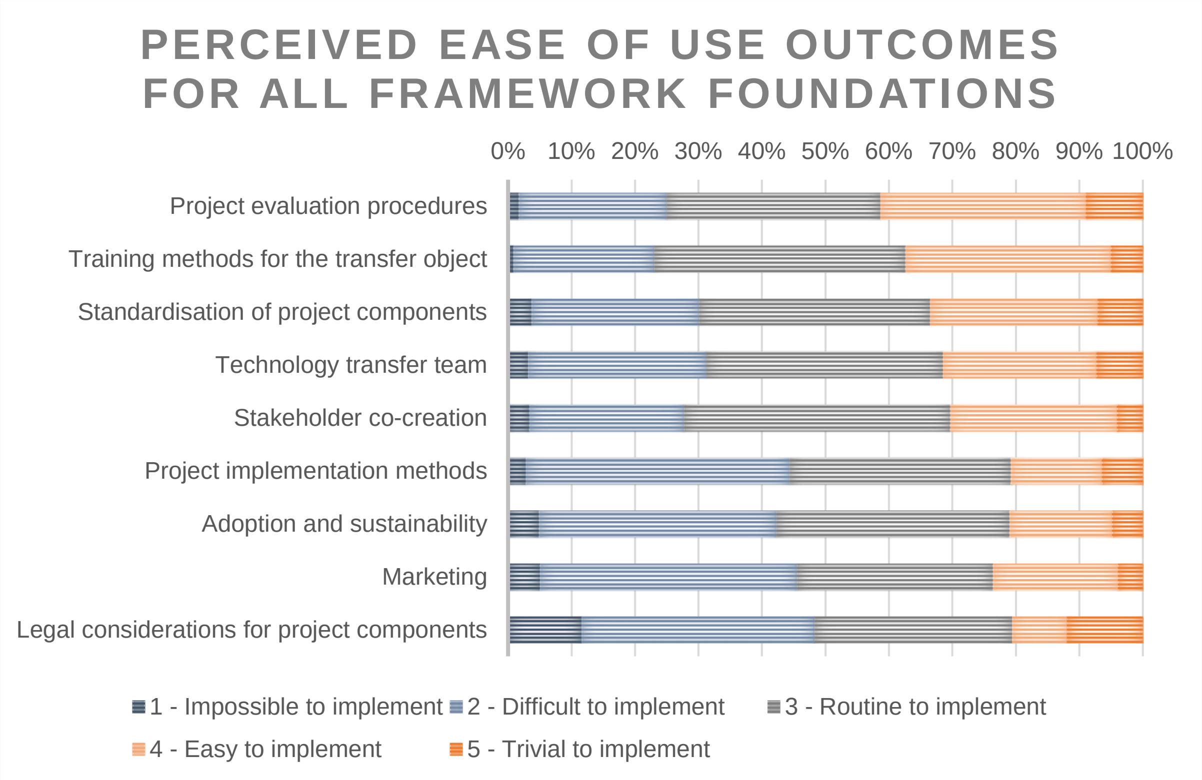


Figure 6-28 - Summary of frequency analysis for perceived ease of use for all framework foundations

Project implementation, adoption and sustainability, marketing and legal considerations received scores indicating they are comparably more difficult to facilitate. Approximately 40% of these aggregated foundation scores indicate that a specific section of the conceptual framework is considered "difficult" to implement in healthcare TT ventures within SSA. However, each foundation is argued to be feasible as "impossible to implement" scores represent less than 6% of the survey's responses if legal considerations are excluded.

Figure 6-28 shows that TT evaluation procedures are considered the easiest to implement when compared with the other foundations. A frequency graph of the individual constituents of evaluation procedures measured during the survey is shown in Figure 6-29.

The first three survey questions pertaining to a TT's evaluation broadly received the same perceived ease of use scores and more than 70% of the survey's respondents concluded that these items are routinely easy to implement. As compiling multiple stakeholder opinions forms part of implicit knowledge capture, highlighted to be complex during Chapter 3, the outcome of the final survey question shown in Figure 6-29 is expected.

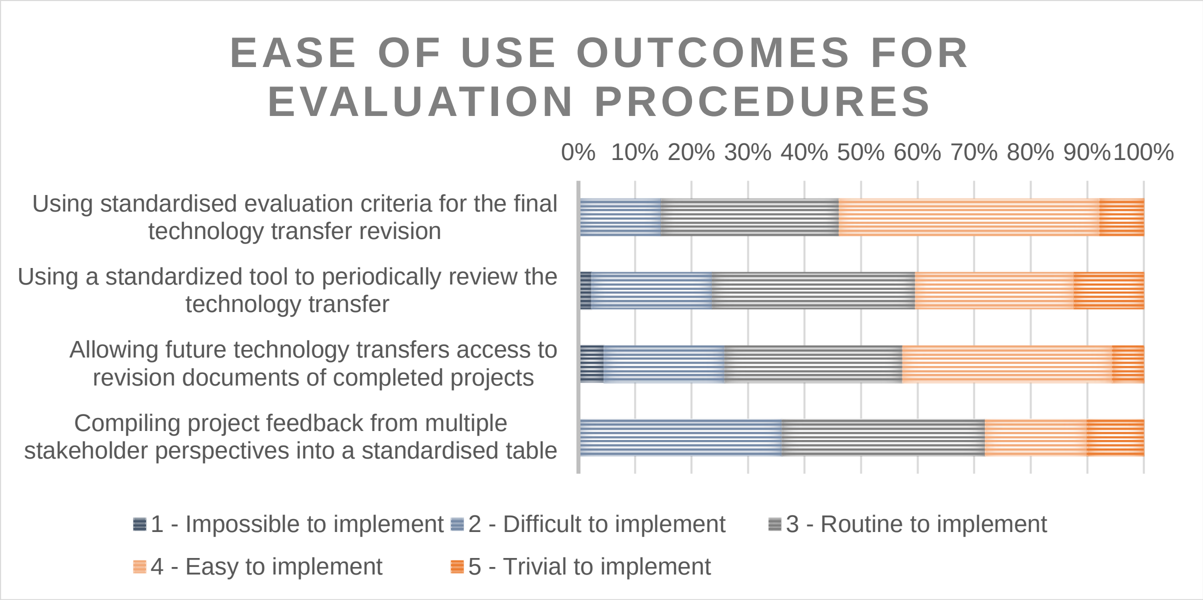


Figure 6-29 - Frequency analysis outcomes for perceived ease of use regarding evaluation procedures

Figure 6-30 displays the four individual survey questions relating to training procedures. Approximately 55% of all respondents consider these training procedures at least routine to implement with more than 90% of the respondents concluding that on-site training is routine to implement. This also indicates that survey respondents do not perceive any substantial barriers preventing the transferor to conduct training within the transfer environment itself.

Training end-users to train additional transfer object adopters is also considered an achievable managerial best practise by approximately 75% of the survey respondents. Comparatively, tailored training programs are considered difficult to construct and implement but only by a nominal amount.

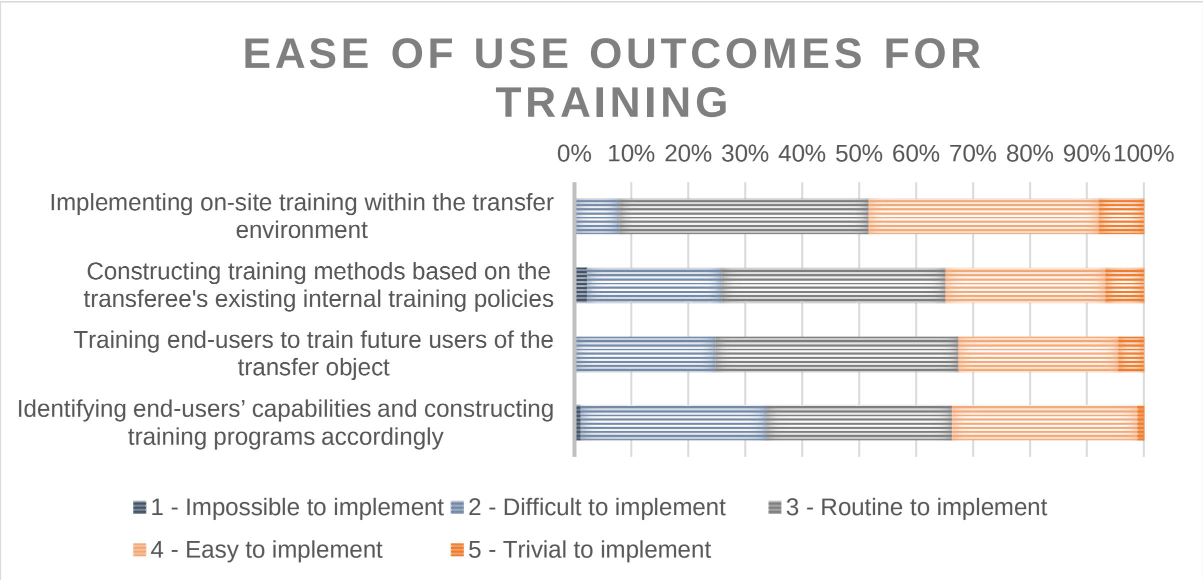


Figure 6-30 - Frequency analysis outcomes for perceived ease of use regarding training

The conceptual framework's managerial best practices pertaining to standardisation are generally perceived as easy to implement as shown in Figure 6-31. This is further strengthened by the high scores obtained by the evaluation procedures, shown in Figure 6-29, as three of the four survey questions pertaining to evaluation also contain elements promoting standardisation.

More than 70% of the respondents indicated that screening the TT team and assigning standardised tasks are both routine to implement while approximately 60% of respondents indicated that implementing a standardised communication channel is also feasible. As these three best practices collectively form a large proportion of the extended stakeholder screening tool, shown in Figure 5-12, from Phase I of the conceptual framework, it highlights the overall feasibility of the framework's dictated stakeholder integration procedures.

Comparatively, documenting a TT venture's components into standardised tables is shown to be the most difficult standardisation procedure to accomplish. As this entails capturing both implicit and explicit knowledge, a high difficulty level is expected. However, 76% of respondents provided favourable scores when allowing future TT ventures access to the documentation of previously completed TTs. This indicates that roadblocks identified during the conceptual literature review such as legal constraints, patents and political interference are generally circumventable for healthcare TT ventures in SSA.

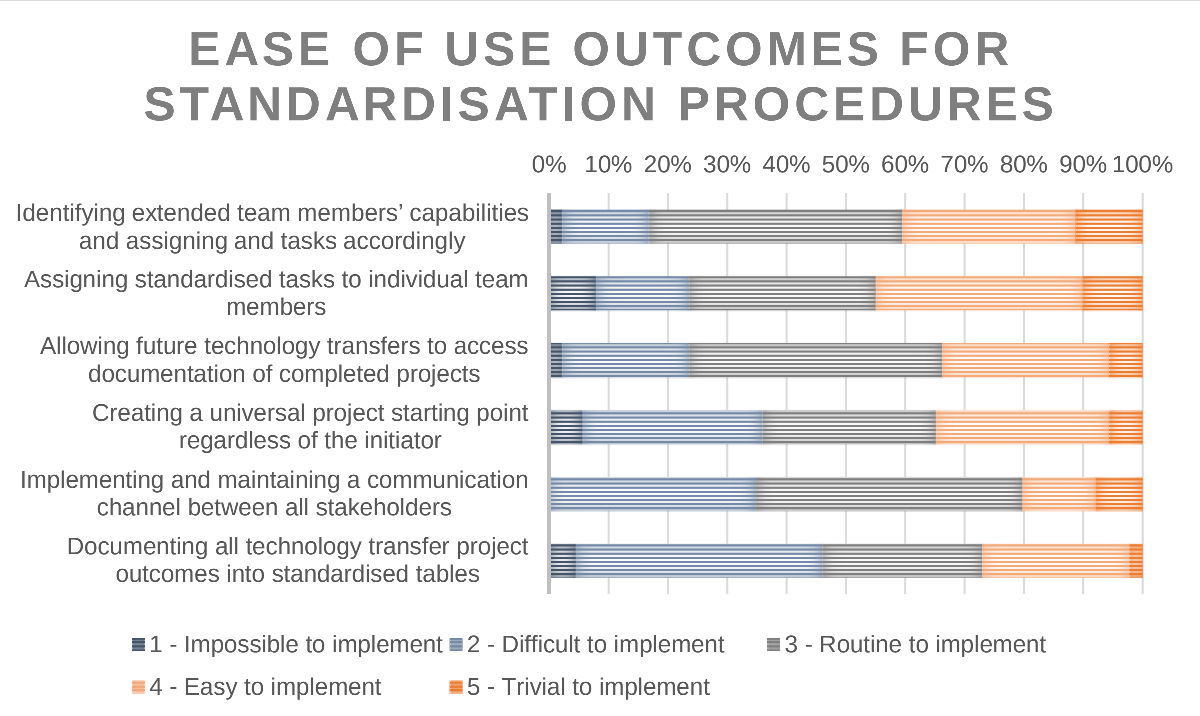


Figure 6-31 - Frequency analysis outcomes for perceived ease of use standardisation procedures

Figure 6-32 presents the frequency graph regarding the TT team outcomes. Figure 6-32 also displays the first two instances where the majority of survey respondents considered a framework managerial best practise to be difficult to implement. Furthermore, approximately 10% of the respondents felt that a monetary incentive scheme and removing redundant stakeholders would be impossible to implement.

In contrast, 74% of the survey's respondents considered the implementation of an intangible incentive scheme as a feasible option. As funding is a common barrier for TT ventures of all maturities, the managerial hierarchy is better placed to incentivise the TT team with items such as personal marketing, recognition, additional responsibility and training.

Approximately 80% of the survey respondents considered the establishment of a dedicated TT team with a recognised managerial hierarchy a feasible outcome. This, in conjunction with the other routine to implement best practices, refer to Figure 6-31, of the extended stakeholder screening tool illustrates feasibility of this tool within the conceptual framework.

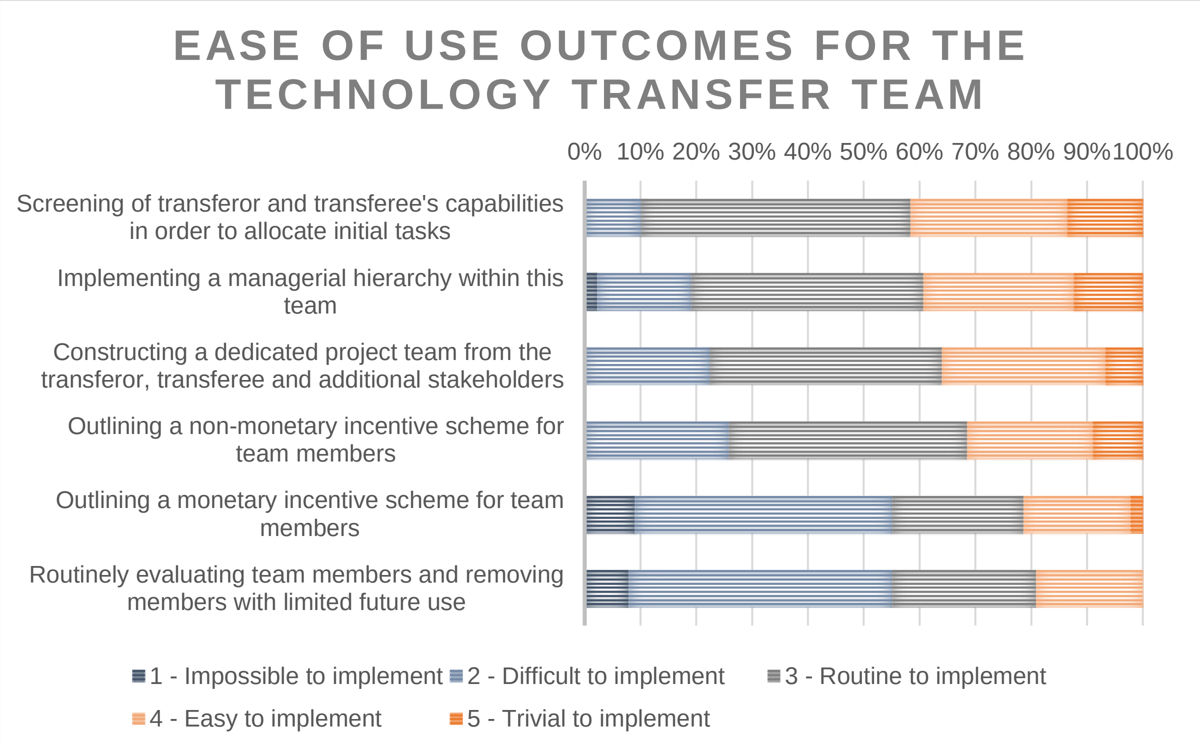


Figure 6-32 - Frequency analysis outcomes for perceived ease of use regarding the technology transfer team

Figure 6-33 presents the frequency graph regarding stakeholder co-creation and also represents the final framework foundation where the clear majority of respondents considered the foundation routine to implement. Sharing implicit and explicit knowledge between the TT members is considered routine to implement by more than 90% of the survey's respondents. This is considered an inherent feature of the creation of a dedicated TT team working in close proximity thus further strengthening the utility of the extended stakeholder tool.

A recommendation drawn from the outcomes of the semi-structured interviews, refer to Section 6.3.2, is the inclusion of the end-user in the transfer object's design and subsequent implementation strategy. Figure 6-33 highlights that this recommendation is feasible as 77% of the survey respondents ranked it routine to implement.

However, the recommendation regarding how the TT venture is to be defined, also derived from the semi-structured interviews, received a more balanced outcome with approximately 50% of respondents indicating that this would be difficult to implement and 8% stating it would be impossible. While the creation of a profit-seeking business venture or strategic partnership may not be feasible for the entire range of healthcare TT ventures in SSA, this best practise still strongly aligns with the framework's core goal of co-creation.

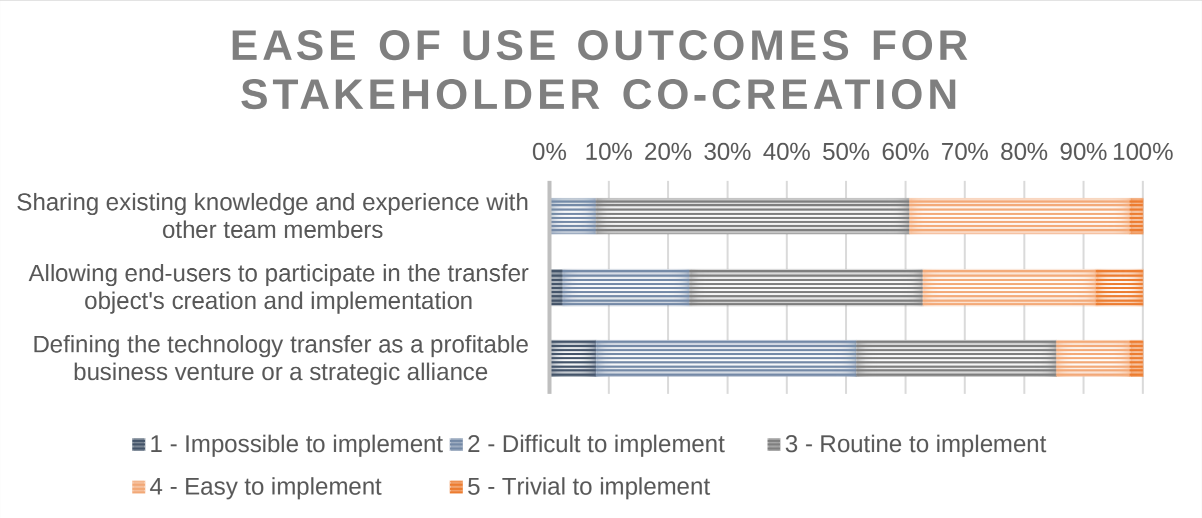


Figure 6-33 - Frequency analysis outcomes for perceived ease of use regarding stakeholder co-creation

Figure 6-34 presents the frequency graph regarding implementation procedures and primarily addresses infrastructure concerns in the transfer environment and the nature in which the TT team is operating within the transfer environment. Standardised as well as tailored infrastructure mitigation practices both received a balanced respondent score indicating the ease of these best practices is dependent on the individual TT venture. It also shows that the managerial hierarchy of the TT team must consider both options when addressing infrastructure concerns within the transfer environment, as a combination of both may be required. Additionally, this will allow the management team to distinguish which route may be easier to implement for their applicable transfer environment.

Screening infrastructure components are considered routine to implement by 70% of the survey's respondents. As this is an inherent requirement to address future infrastructure barriers it is valuable to highlight than none of the 89 respondents indicated this is an impossible procedure to implement.

Lastly, almost 60% of respondents highlighted that it will be difficult to implement a joint venture transfer. As the conceptual literature review highlighted that joint ventures are more complex than traditional TTs or even FDIs, refer to 3.3.4, this is an expected result. However, the difficulty in implementing a joint venture may be offset by the usefulness of this TT method and to this extent is further discussed in the frequency analysis pertaining to usefulness in Section 6.4.3.1.

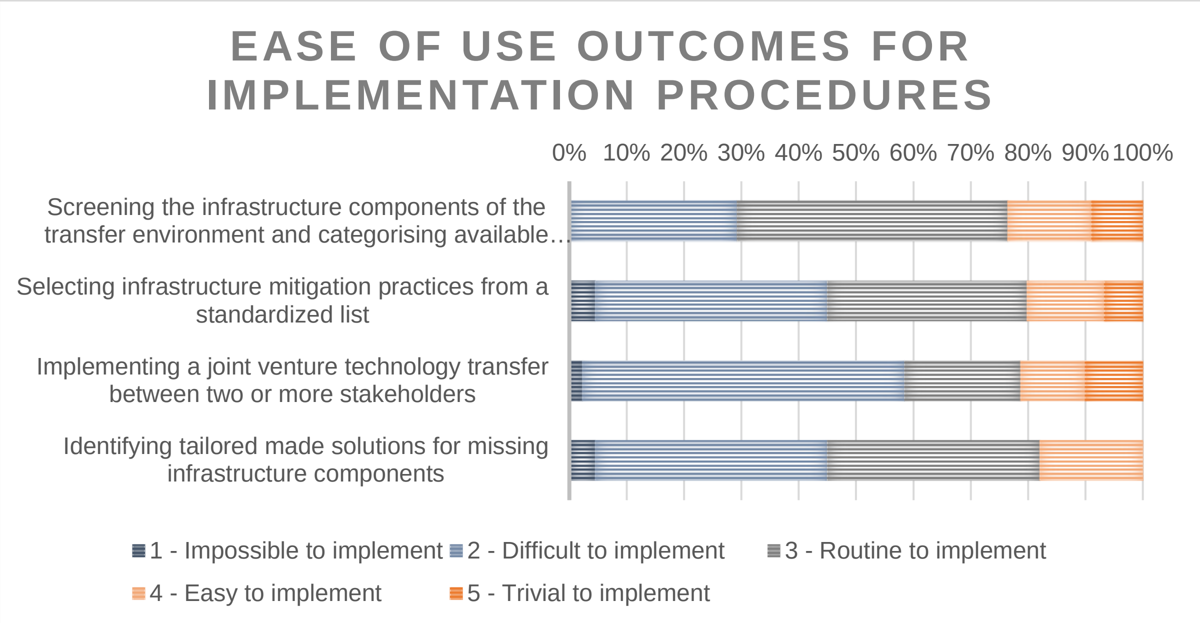


Figure 6-34 - Frequency analysis outcomes for perceived ease of use regarding implementation procedures

Figure 6-35 presents the frequency graph regarding adoption and sustainability. During the first level of the framework's evaluation, multiple interview candidates stressed the importance of ensuring end-user adoption but simultaneously stated it may often present the most challenging part of a TT venture. The three managerial best practices shown in Figure 6-35, all stem from the semi-structured interviews as the most practical solutions to promote end-user adoption and continued use.

The feasibility of these best practices is reaffirmed by Figure 6-35 as more than 50% of the survey's respondents indicated that they are routine to implement. Additionally, only 8% of respondents indicated that a prototype would be impossible to construct. The 40% of survey respondents claiming that incentivising early adopters is difficult to implement may refer to the use of tangible reward methods or alternatively to identifying suitable early adopters.

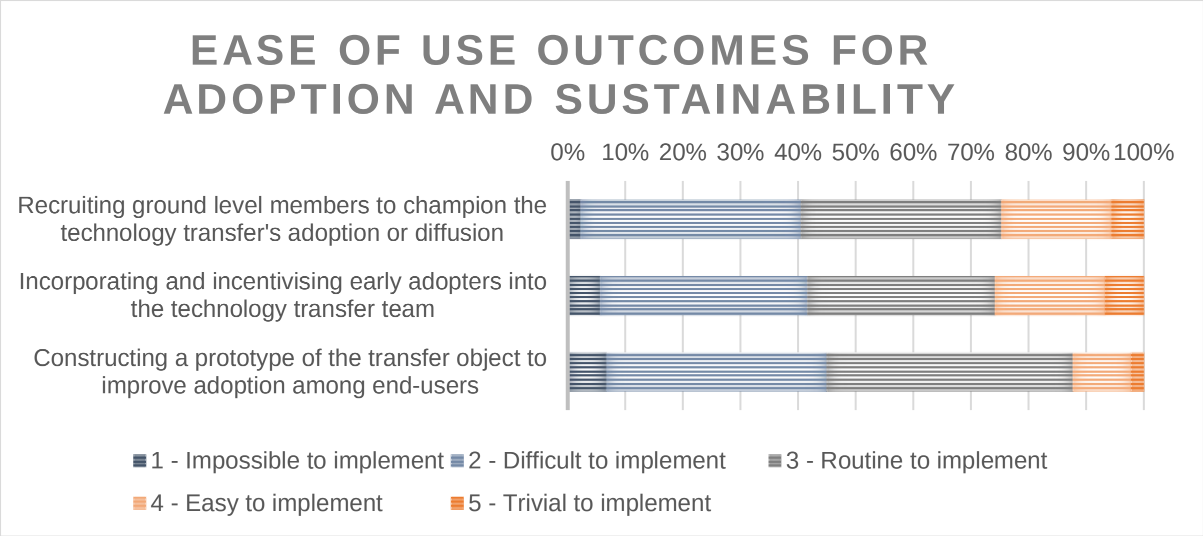


Figure 6-35 - Frequency analysis outcomes for perceived ease of use regarding adoption and sustainability

Figure 6-32 presents the frequency graph regarding marketing and represents the foundation that received the least attention during the survey with only two survey questions pertaining to this foundation. While marketing to the public-sector received scores indicating it is easier when compared with the private sector, the increase is marginal. In terms of additionally marketing procedures there exists no tangible difference in the ease of implementation between focussing on the public-sector versus the private-sector.

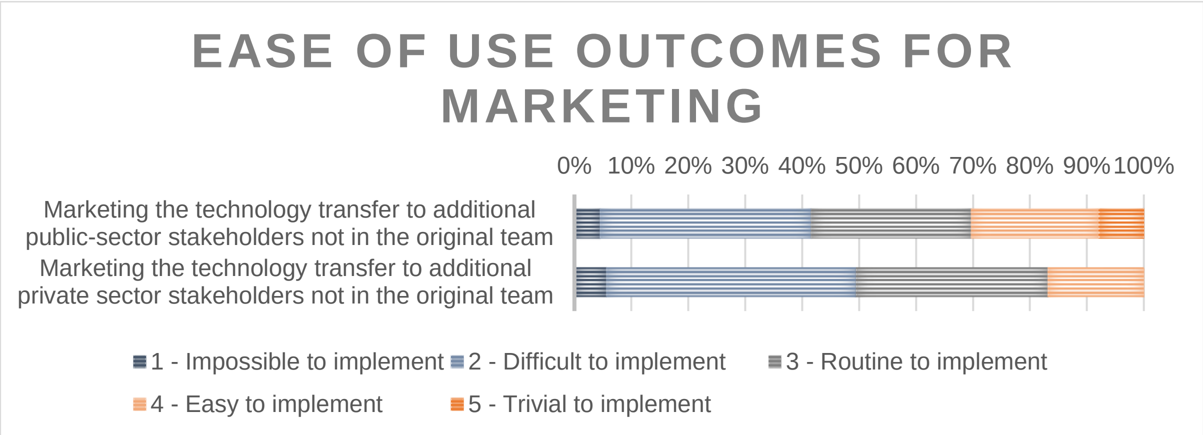


Figure 6-36 - Frequency analysis outcomes for perceived ease of use regarding marketing

Figure 6-37 presents the frequency graph regarding legal consideration and represents the foundation that is collectively the most difficult to implement when compared with the other foundations of the conceptual framework. An explanation may stem from TT teams generally not containing a legal expert and such expertise is often expensive to incorporate as more than 10% of the survey's respondents indicated this would be impossible during the transfer object's design and 46% indicating it would be difficult during the transfer object's implementation.

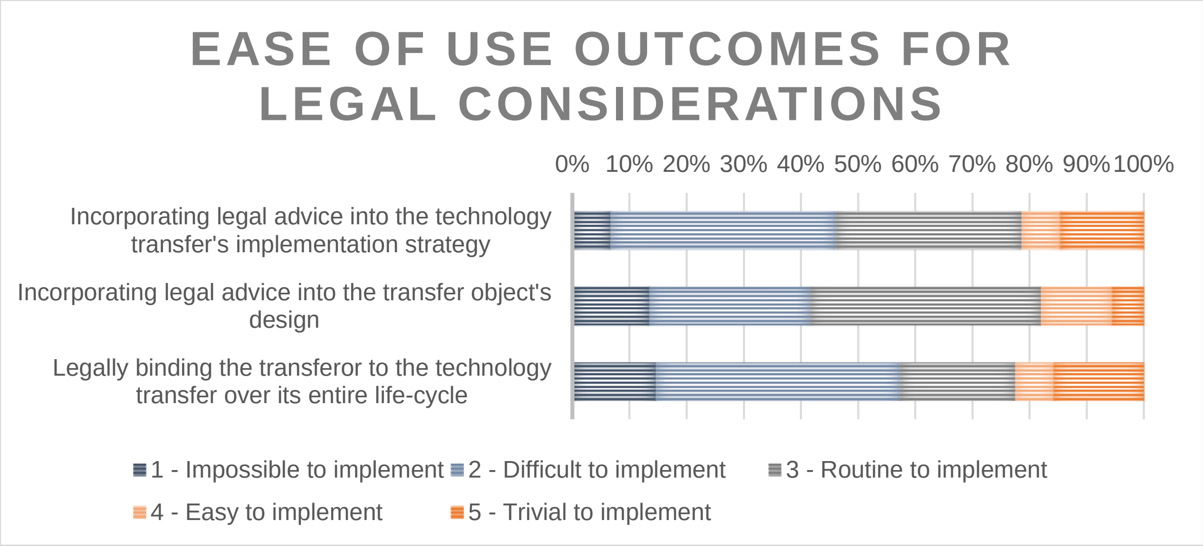


Figure 6-37 - Frequency analysis outcomes for perceived ease of use regarding legal considerations

Lastly, approximately 60% of the survey's respondents indicated that legally binding the transfer to the entire life cycle of the TT would be difficult. This may both stem from a reluctance of the transferor to commit for an extended period of time as well as the cost and time implications of finalizing and enforcing such a legal agreement.

6.4.2.2 Mean analysis for perceived ease of use

The second step implemented when evaluating the perceived ease of use of the framework is to determine the arithmetic means of each action statement presented to the survey respondents. The complete data table outlining the various arithmetic means for perceived ease of use is shown in Table F-6 in Appendix F. Table 6-26 provides an abridged summary of these components by showing the arithmetic means for the nine framework foundations as well as the five phases of the conceptual framework. Table F-6 and Table 6-26 serve to partly answer question 2.1, 2.2, 2.3, 2.5 and 3.5 of the survey, as outlined in Table 6-5.

While this represents a basic method of data analysis it does provide a high-level indication that the framework's phases, individually as well as collectively, are 'routine to implement' across the respondents of the survey with a grand mean approximating a score of 3. However, it must be noted that no comparison between the phases or foundations can be statistically determined by this mean analysis and rather is addressed in the variance and regression analyses shown in Section 6.4.2.3 and Section 6.4.2.4.

Table 6-26 - Arithmetic means for framework foundations and phases (perceived ease of use)

Framework foundation	x̄
Technology transfer team	3.064
Stakeholder co-creation	3.034
Legal considerations for project components	2.727
Standardisation of project components	3.067
Project implementation methods	2.801
Project evaluation procedures	3.236
Training methods for the technology	3.185
Adoption and sustainability	2.787
Marketing	2.770
Framework phase	**x̄**
Phase I: Technology development	3.050
Phase II: Technology analysis	2.943
Phase III: Transfer method application	2.930
Phase IV: Change management	3.016
Phase V: Commercialisation	3.019
Grand mean	**2.992**

Table 6-26 also highlights the consistency of the perceived ease of use of the framework's phases as the individual arithmetic means are all within a 2% margin of the grand mean. A visual representation of the consistency of the perceived ease of use of the framework's phases is shown in Figure 6-38.

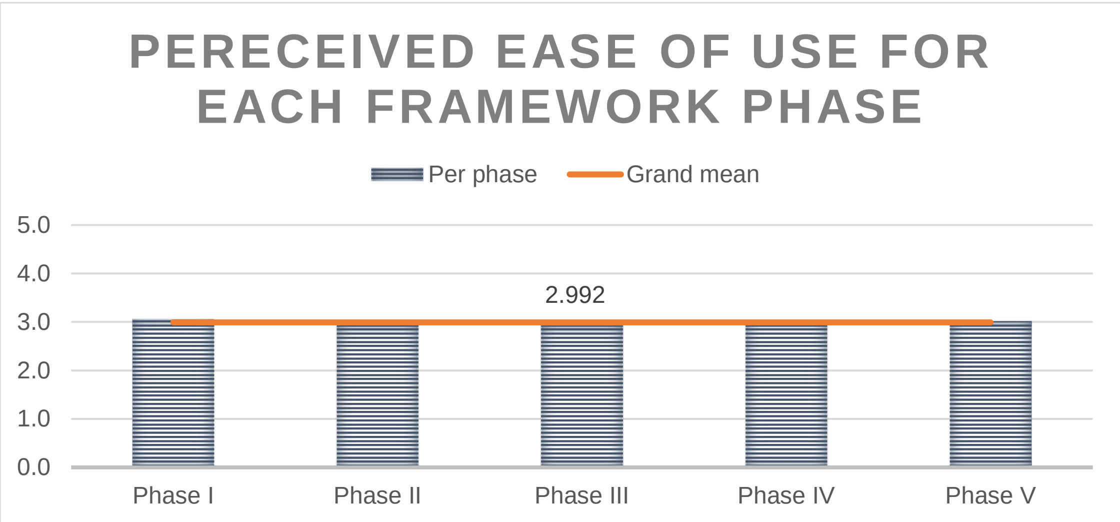


Figure 6-38 - Arithmetic mean for framework phases (perceived ease of use)

A conditional formatting tool is implemented within Microsoft Excel to highlight the lowest 10% of all the managerial best practices evaluated by the survey instrument, as shown by the highlighted items in Table F-6 in Appendix F. Three best practices are subsequently highlighted and presented for review in Table 6-27.

Table 6-27 - Lowest scoring components (perceived ease of use)

Perceived ease of use			
Managerial best practices	Foundation	Phase	x̄
Outlining a monetary incentive scheme for team members.	TT team	Phase I	2.596
Defining the project as a profitable business venture or a strategic alliance.	Stakeholder co-creation	Phase II	2.573
Routinely evaluating team members and removing members with limited future use for the project.	TT team	Phase IV	2.562

Two managerial best practices from the TT team foundation are among the lowest 10%. However, when comparing the lowest-scoring component with the grand mean, only a 0.43 difference is observed indicating a very low range, 0.921 in total, among all the managerial best practices. All best practices components are thus considered to lean towards ‘routine to implement’ across the respondents of the survey.

6.4.2.3 Variance analysis for perceived ease of use

The variance analysis completed for the perceived ease of use measurement item aims to highlight variances within the four regions within SSA. To this extent, each SSA region is evaluated using an LSD ANOVA test, as outlined in Section 6.2.2.10, to determine if a specific region differs from the rest of SSA. This allows for the perceived ease of use of each phase of the conceptual framework to be compared between each major region within SSA and the rest of SSA which will subsequently allow for modifications to the conceptual framework aimed at maximizing the framework’s ease of use for specific regions within SSA.

The results of the LSD ANOVA test are summarised in a graphical format in Figure 6-39. All error bars represent a 95% confidence interval and thus an alpha value of 0.05 is implemented during the statistical calculations. Figure 6-39 serves to partly answer all questions in category 3 of the survey.

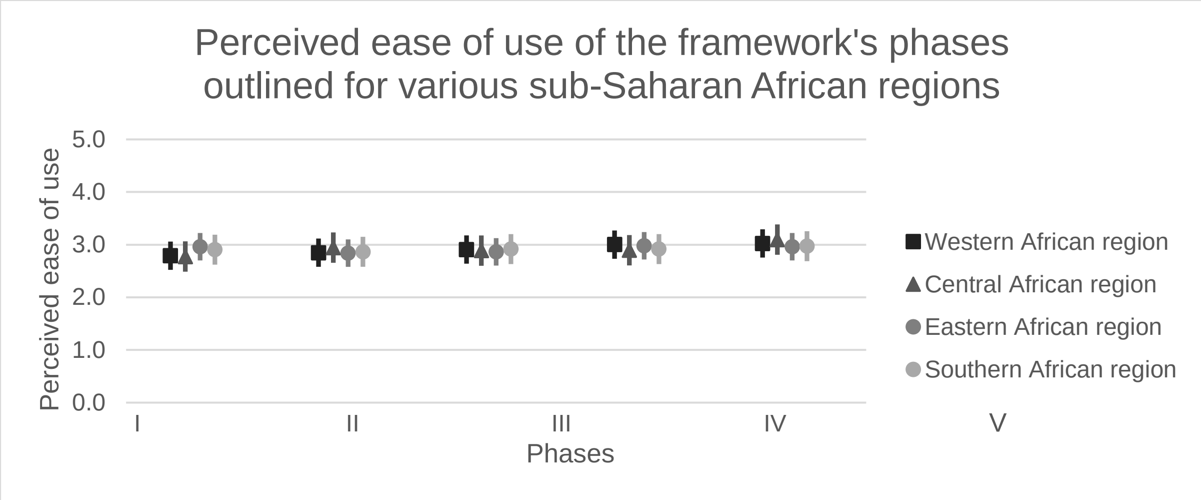


Figure 6-39 - Variance analysis results for perceived ease of use over the regions of sub-Saharan Africa

When reviewing the outcomes of the variance analysis per SSA region, both Western- and Central Africa produced p-values indicating a statistically significant difference in their means with the other regions of SSA. The outcomes of the ANOVA test for perceived ease of use is shown in Table 6-28.

Table 6-28 - ANOVA outcomes for perceived ease of use

Source	F-value	p-value	F-critical value
Western Africa	3.276	0.012	2.398
Central Africa	2.877	0.023	2.398
Eastern Africa	0.246	0.912	2.398
Southern Africa	0.420	0.794	2.398

The p-values of Western Africa and Central Africa are 0.01178 and 0.02288 respectively across all phases of the framework with the F-value exceeding the F-critical value for both these regions. While not immediately apparent when reviewing Figure 6-39, a definite graphical variance is witnessed when individually comparing Western and Central Africa to the other SSA regions, as shown in Figure 6-40 and Figure 6-41.

When further investigating the trendlines within the individual phases shown in Figure 6-40, Phase I and Phase II are the primary contributors to the statistically significant difference produced by the LSD ANOVA test for Western Africa. Phase III to Phase V do not yield any statistically significant results for this region in comparison to the rest of SSA. Thus, based on the results of this variance analysis, a conclusion is made that Phase I and Phase II of the conceptual framework are not as easy to implement in the region of Western Africa.

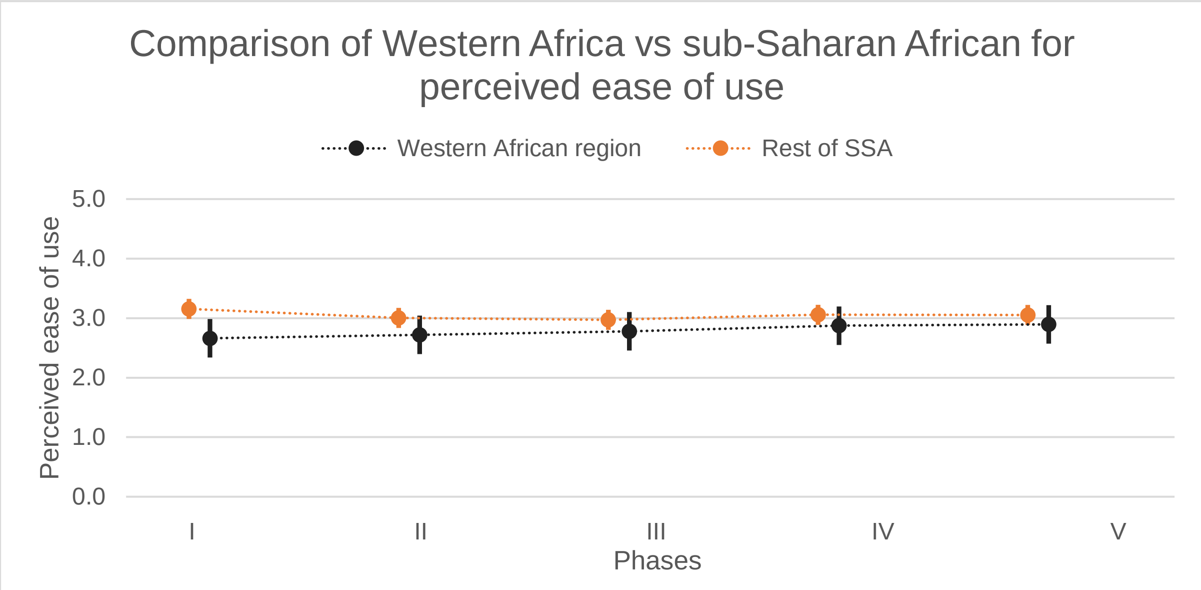


Figure 6-40 - Variance analysis comparison for perceived ease of use between Western Africa and sub-Saharan Africa

Similarly, to Western Africa, when further investigating the trendlines within the individual phases shown in Figure 6-41, Phase I is the primary contributor to the statistically significant difference produced by the LSD ANOVA test for Central Africa. Phase II to Phase V do not yield any statistically significant results for this region in comparison to the rest of SSA. Thus, based on the results of this variance analysis, a conclusion is made that Phase I of the conceptual framework is not as easy to implement in the region of Central Africa.

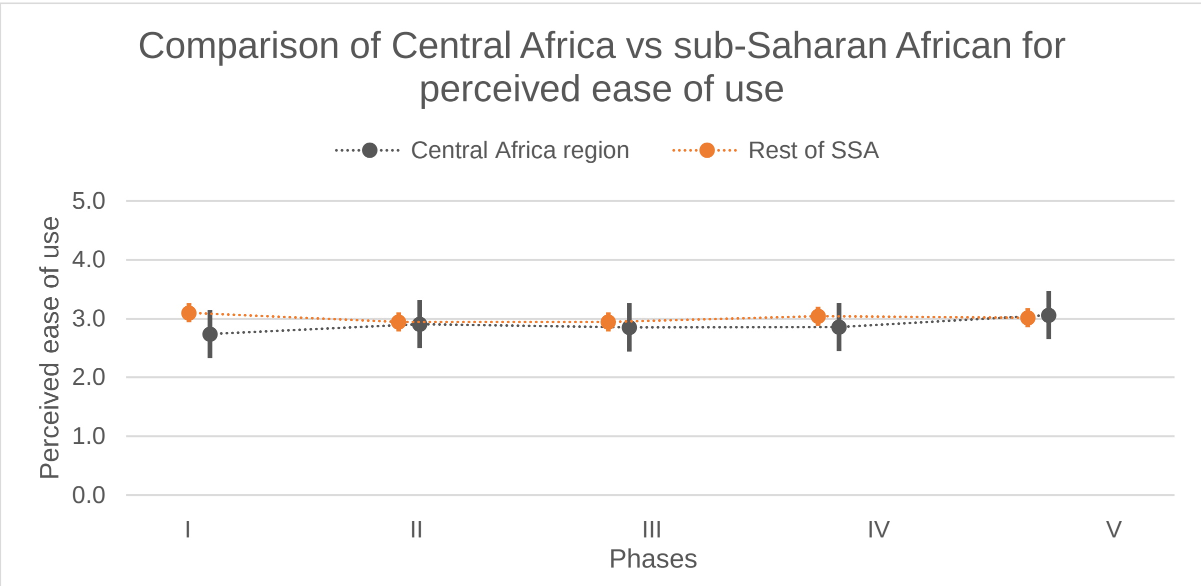


Figure 6-41 - Variance analysis comparison for perceived ease of use between Central Africa and sub-Saharan Africa

The LSD ANOVA tests for Eastern and Southern Africa did not produce any statistically significant results indicating that these regions perceived any of the individual phases of the conceptual framework differently compared with the rest of SSA. The p-values of Eastern Africa and Southern Africa are 0.912 and 0.793 respectively across all phases of the framework. As such, these graphs have been omitted from Section 6.4.2.3.

6.4.2.4 Regression and correlation analyses for perceived ease of use

The following section presents the results of the regression and correlation analyses highlighting the relationship between the perceived ease of use and the evaluation items captured during the survey's administration. The completed methodology of these analyses is presented in Section 6.2.2.12.

As outlined in Table 6-9, each respondent is asked to rank the relative adoption, diffusion and satisfaction levels of their respective TT venture. These three evaluation items are subsequently utilized as three reflective indicators for the latent variable, relative success as shown in the structural equation model, shown in Figure 6-10.

The purpose of the regression and correlation analysis will be to evaluate the relationship between the five phases of the conceptual framework and the relative success latent variable. This will enable conclusions to be made regarding on *H1*, *H2, H3, H4* and *H5* which are restated below to simplify readability:

(H1:) There will be a positive association between the ease of use of the best practices in the first phase of the conceptual framework and the relative success of a technology transfer venture

(H2:) There will be a positive association between the ease of use of the best practices in the second phase of the conceptual framework and the relative success of a technology transfer venture

(H3:) There will be a positive association between the ease of use of the best practices in the third phase of the conceptual framework and the relative success of a technology transfer venture

(H4:) There will be a positive association between the ease of use of the best practices in the fourth phase of the conceptual framework and the relative success of a technology transfer venture

(H5:) There will be a positive association between the ease of use of the best practices in the fifth phase of the conceptual framework and the relative success of a technology transfer venture

An abridged summary of the main path diagram of the structural equation model, pertinent to these analyses, is shown below in Figure 6-42. As before, $\eta_{1 \text{ ease of use}}$ to $\eta_{5 \text{ ease of use}}$ represents the five phases of the conceptual framework and η_6 represents the relative success of the technology transfer venture.

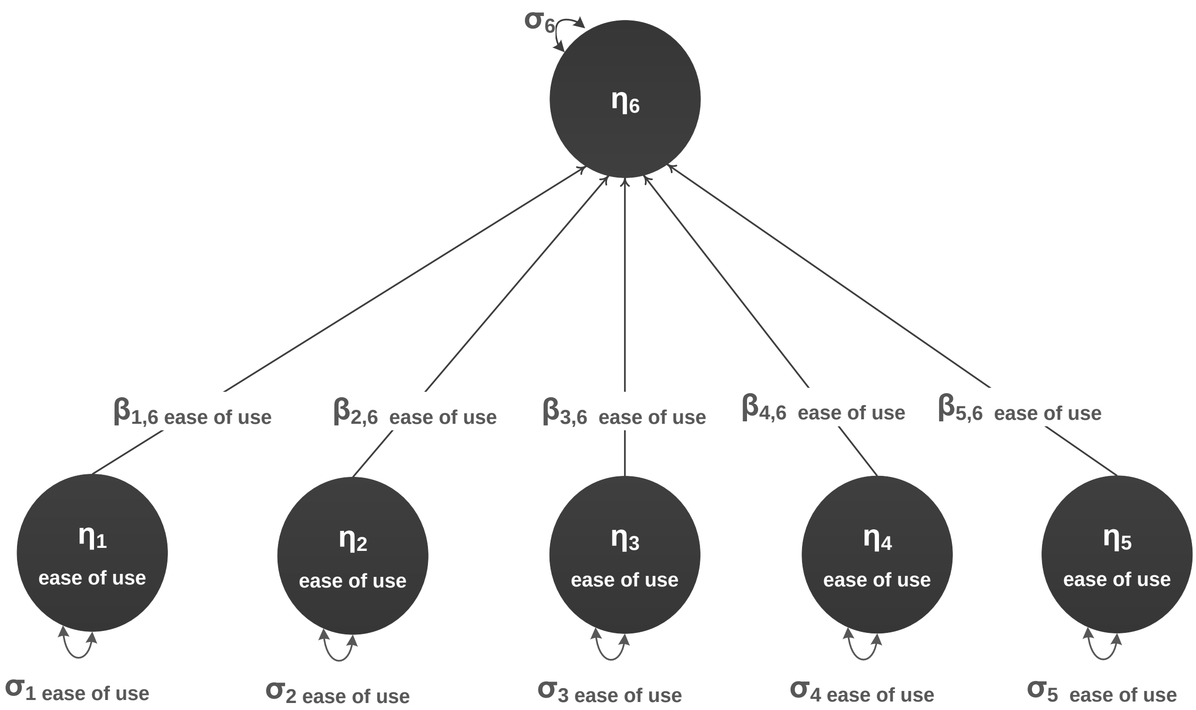


Figure 6-42 - Abridged path diagram for regression and correlation analyses for perceived ease of use data set

As outlined in Section 6.2.2.10, a standardized approach is adopted and all latent variable variances are scaled to unity. Thus, in Figure 6-42 $\sigma_{1 \text{ ease of use}}$ through $\sigma_{5 \text{ ease of use}}$ as well as σ_6 are all fixed to 1.0. Additionally, in pursuit of optimizing model fit, shown in Section 6.2.2.11, the formative indicators $X_{2 \text{ ease of}}$ use, $X_{10 \text{ ease of use}}$, $X_{16 \text{ ease of use}}$ and $X_{35 \text{ ease of use}}$ are excluded from the regression and correlation analyses.

The multiple regression analysis for the perceived ease of use data set is computed with Statistica (TIBCO Inc., 2019) with the results shown in Table 6-29. All results shown in Table 6-29 are computed with a significance level of 0.05.

Table 6-29 - Multiple regression analysis outcomes for perceived ease of use data set

Dependent variable - relative success (η_6)					
Independent variables	**Beta**	**t-statistic**	**SM**	**SD**	**p-value**
η_1	0.332	3.052	0.392	0.109	0.002
η_2	0.294	1.760	0.359	0.167	0.079
η_3	0.343	3.520	0.404	0.097	<0.001
η_4	0.311	1.970	0.365	0.158	0.049
η_5	0.338	2.984	0.390	0.113	0.003
R-squared	0.160				
Adjusted R	0.109				
F-value	2.6547				0.028
Number of cases	89				

The results show that the F-value was statistically significant ($p = 0.028$) which indicates that the structural equation model shown in Figure 6-42 predicts the dependent variable better than the observed means of the dependent variable. In this instance the dependent variable is the relative success of the TT venture, represented by η_6 in Figure 6-42. Thus, the relationship between the structural equation model and the dependent variable is deemed to be statistically significant for the perceived ease of use data set.

However, when reviewing the R-squared value, only 16% of the variance is explained by the model. Thus, less than 20% of the variance around the mean of the observed data is explained by the structural equation model for the perceived ease of use data set. When comparing this to similar structural equation models pertaining to TT ventures, this variance is well below what is expected (Boateng *et al.*, 2002; Philip F Musa *et al.*, 2005). An R-squared value of 0.25 is typically regarded as consistent with previous studies of a similar nature measuring perceived ease of use (Boateng *et al.*, 2002; Philip F Musa *et al.*, 2005).

One explanation may stem from the inherently complex nature of healthcare TT ventures. This is repeatedly outlined throughout various literature items with TT being described as complex, dynamic, all-encompassing and convoluted to a large degree (Bozeman, 2000; Ansari *et al.*, 2001; Mosse *et al.*, 2005; Jesse *et al.*, 2010; Bradley *et al.*, 2013; Bozeman *et al.*, 2015). The conceptual framework does contain five major phases each containing three or more nodes and each node dictating multiple best practices, however, this only represents the necessities of health-related TT. Thus, the balancing act between practicality and conciseness while still containing enough relevant content to cover the multiple facets of TT may be a possible explanation for the low R-squared value.

Another explanation may result from the relationship between the independent variables and the dependent variable. The independent variables, $\eta_{1\text{ ease of use}}$ to $\eta_{5\text{ ease of use}}$, are predicated by the observed formative indicators, X_1 to X_{34}. These observed formative indicators aim at capturing survey respondents' perceived ease of use of various best practices listed within the five phases of the conceptual framework. The dependent variable, η_6, aims to measure the relative success of a TT venture.

The relative success of a TT venture should engage beyond the ease of use of the individual steps to complete it. This is reinforced by literature studies which document significant difficulty with items such as stakeholder engagement, infrastructure limitations and training protocols (Akinsola, 2005; Bagayoko *et al.*, 2006; Kifle *et al.*, 2006; Aker *et al.*, 2010; Latourette *et al.*, 2011). However, the relative success of these TT ventures all exceeded the initial requirements of the TT teams in charge. Thus, the value, or usefulness, that certain items contribute to the relative success of a TT venture may far outweigh how easily these items are implemented (Bozeman *et al.*, 2015; Handoko *et al.*, 2016). The outcomes of the regression and correlation analyses for the usefulness data set, shown in Section 6.4.3.4, supplements this standpoint.

When further examining the outcomes within Table 6-29, the independent variable $\eta_{2\text{ ease of use}}$, did not produce a statistically significant outcome ($p = 0.079$). Thus, there is no evidence to support hypothesis *H2* and $\beta_{2,6}$ will be disregarded as the coefficient does not significantly predict the outcome of the relative success of a TT venture. However, the remaining outcomes of the multiple regression analysis suggest that Phase I ($p = 0.002$), Phase III ($p < 0.001$), Phase IV ($p = 0.049$) and Phase V ($p = 0.003$) of the conceptual framework are statistically significant and support hypotheses *H1*, *H3, H4* and *H5*.

The hypotheses *H1*, *H3, H4* and *H5* are further supported by $\beta_{1,6}$, $\beta_{3,6}$, $\beta_{4,6}$ and $\beta_{5,6}$ as these standardized regression coefficients all have positive signs. Thus, a positive association exists between these four independent variables and the dependent variable. These four standardized regression coefficients all have similar weights with $\beta_{3,6}$, representing Phase III of the conceptual framework, returning the strongest relationship.

Lastly, $\beta_{1,6}$, $\beta_{3,6}$, $\beta_{4,6}$ and $\beta_{5,6}$ all returned similar weights when compared to previous studies pertaining to health-related TT in SSA (Meso *et al.*, 2005; Kifle *et al.*, 2010). This reinforces the assumption that the ease of use of TT items does hold a positive association with the relative success of the TT venture, albeit may be less profound than other considerations such as usefulness.

After the completion of the multiple regression analysis, a correlation analysis is completed. The correlation analysis focussed on determining the Spearman rank-order correlation coefficient for each phase of the conceptual framework. The correlation analysis for the perceived ease of use data set is computed with Statistica (TIBCO Inc., 2019) with the results shown in Table 6-30 as well as individual discussions for each phase of the conceptual framework.

All results shown within Table 6-30 are computed with a sample size of 89 and a significance level of 0.05 with all computed correlation coefficients return p-values indicating they are statistically significant. All five phases of the conceptual framework display positive weak correlations with the relative success of a TT venture.

As mentioned previously in this section, the relative success of a TT venture will most likely be dependent on additional factors that may exhibit a stronger relationship. Thus, the positive, albeit weak, correlation coefficients shown in Table 6-30 are in accordance with what is expected. For evaluation purposes, the regression and correlation analyses evaluating the relationship between the usefulness of each phase of the framework and the relative success of a TT venture will be required. These outcomes of these analyses are shown in Section 6.4.3.4.

Table 6-30 - Correlation analysis outcomes for the relative success of a technology transfer venture and the five phases of the conceptual framework for perceived ease of use data set

Dependent variable	Independent variables	ρ	t-statistic	p-value	Discussion
Relative success η_6	Phase I η_1 ease of use	0.302	2.954	0.004	Returned result: **Positive - Weak** The perceived ease use of Phase I returned a weak positive correlation with the relative success of a TT venture. This outcome highlights that the TT team does value the ease of use in the construction protocols for the TT team when considering the success of their TT venture. Similar observations can be noted for the establishment of a co-creation relationship between the transferor and transferee. How easily the transferor is legally binding to the TT venture across its entire life cycle and implementing a universal starting point regardless of the transfer object also shares a weak positive correlation the relative success of a TT venture.
	Phase II η_2 ease of use	0.212	2.026	0.045	Returned result: **Positive - Weak** The perceived ease use of Phase II returned a weak positive correlation with the relative success of a TT venture. The framework nodes promoting knowledge dissemination and co-creation between an extended TT team all returned the strongest correlation coefficients within Phase II, highlighting their relative importance. The use of a standardised tool to screen the transfer environment as well as best practices pertaining to legal counsel both produced coefficients indicating weak to very weak correlations with regards to the relative success of a TT venture.
	Phase III η_3 ease of use	0.271	2.624	0.010	Returned result: **Positive - Weak** The perceived ease use of Phase III returned a weak positive correlation with the relative success of a TT venture. The framework best practices advocating the use of the joint venture TT method produced the strongest correlation coefficient with respect to the relative success of a TT venture. Other best practices within Phase III such as the creation of a prototype and incorporating and incentivising early-adopters produced very weak positive coefficients, which can be attributed to the increase difficulty in performing such actions.
	Phase IV η_4 ease of use	0.243	2.334	0.022	Returned result: **Positive - Weak** The perceived ease use of Phase IV returned a weak positive correlation with the relative success of a TT venture. The implementation of all training related best practices advocated within Phase IV of the conceptual framework returned weak positive correlation coefficients, highlighting that despite the difficulty of training it does still have a positive effect on the outcome of a TT venture. Best practices promoting sustainable communication for the TT team, both internally and externally, returned very weak positive correlation coefficients.
	Phase V η_5 ease of use	0.287	2.798	0.006	Returned result: **Positive - Weak** The perceived ease use of Phase V returned a weak positive correlation with the relative success of a TT venture. The framework best practice advocating for the implementation of knowledge codification and future co-creation knowledge sharing both produced very weak positive correlation coefficients. Best practices within the framework pertaining to marketing to additional stakeholders produced weak positive correlation results. However, marketing items only produced very weak positive correlation coefficients.

6.4.3 Rank of usefulness

Section 6.4.3 presents the results of the data analysis conducted after the completion of the survey's administration for the measurement item usefulness. This section aims to highlight the conceptual framework's perceived ease of use by implementing frequency, mean, variance, regression and correlation analyses. Data summaries pertaining to the survey's questions outlined in category 2 and 3, refer to Table 6-5, are also provided.

6.4.3.1 Frequency analysis for usefulness

Frequency analysis represents the first step taken in evaluating the usefulness of the conceptual framework and its foundations. Section 6.4.3.1 aims to present the usefulness outcomes of the survey for both the nine collective framework foundations as well as comparing the individual constituents of each foundation.

To improve the readability of this research study, the Likert scale for the usefulness measurement item, first shown in Table 6-10, is restated below in Table 6-31. Survey questions that obtained responses of three, or higher, are considered as managerial best practices that are beneficial for TT ventures in SSA.

Table 6-31 - Restated measurement items for perceived ease of use

Measurement scales	Measurement items				
Usefulness	Not useful at all 1	Negligible utility added 2	Moderately useful 3	Useful 4	Extremely useful 5

Figure 6-43 provides an overview of the usefulness frequency outcomes for each framework foundation. This frequency graph is filtered to display the framework foundation scores in a descending order to highlight which foundations are deemed to be comparably more beneficial to implement. The frequency graphs of the nine individual foundations are subsequently displayed in Figure 6-44 to Figure 6-52 and are ordered in accordance with the ranking shown in Figure 6-43. All frequency graphs presented in Section 6.4.3.1 contained a sample size of 89 survey respondents.

Figure 6-43 highlights the utility of the framework's foundations as 80% of the respondents considered the nine individual foundations beneficial. Furthermore, 90% of respondents considered training, adoption and sustainability, stakeholder co-creation, evaluation procedures, standardization and implementation methods as beneficial.

Thus, in contrast with the perceived ease of use frequency graph, refer to Figure 6-28, the usefulness outcomes clearly highlight that the majority of the survey respondents consider the framework's best practices to be beneficial to a TT venture. As TT is a dynamic and complex process, it is expected that the difficulty of several best practices greatly varies when compared with others. However, as Figure 6-43 indicates, these best practices are all considered beneficial to a healthcare TT venture in SSA.

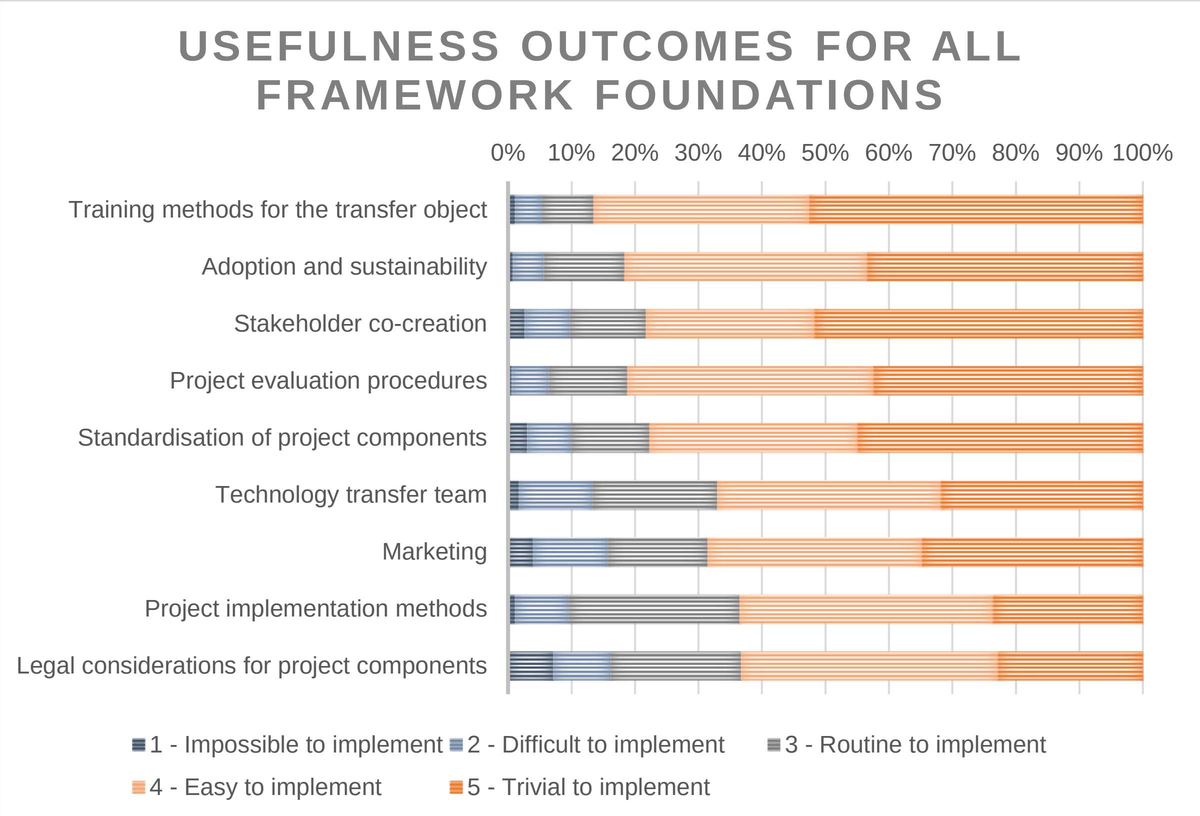


Figure 6-43 - Summary of frequency analysis for usefulness for all framework foundations

Figure 6-44 presents the usefulness outcomes pertaining to training and also represents the foundation which survey respondents considered the most beneficial to a TT. All four best practices, more than 80% of the survey's respondents considered useful with the majority of respondents considering these best practices very useful if familiar training procedures are excluded.

The usefulness outcomes regarding training clearly highlight the importance of this foundation with respect to TTs. Additionally, as training is also considered comparatively easy to implement by ranking second, refer to Figure 6-28, these managerial best practices provide a large beneficial impact while also being comparatively simple to implement.

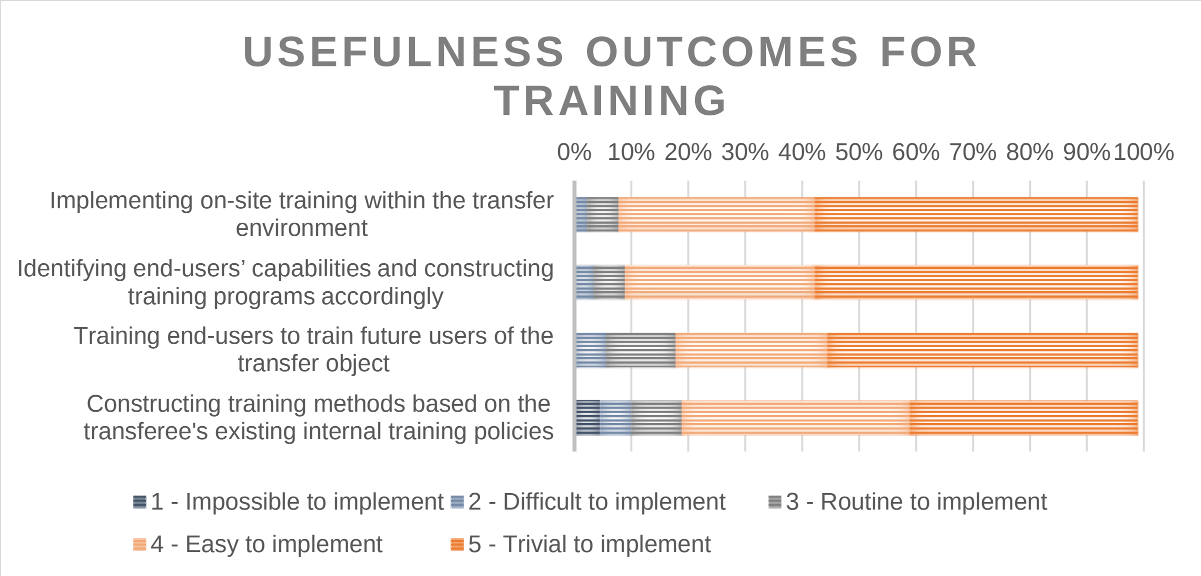


Figure 6-44 - Frequency analysis outcomes for usefulness regarding training

Figure 6-45 highlights that adoption and sustainability best practices are similarly beneficial with 90% of the survey's respondents considering this foundation as beneficial. There is no discernible difference in the usefulness of utilising ground level champions, a prototype and early adopters. However, in contrast with the training foundation, the adoption and sustainability outcomes are considered far more difficult to implement, refer to Figure 6-35, as only 55% of respondents considered these best practices as routine to implement.

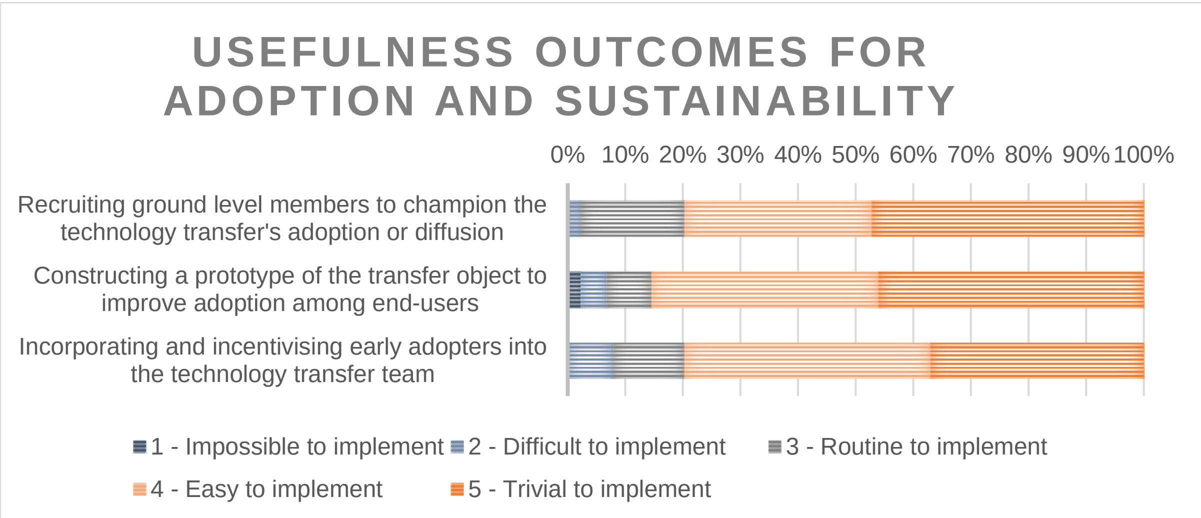


Figure 6-45 - Frequency analysis outcomes for usefulness regarding adoption and sustainability

Figure 6-46 presents the usefulness outcomes regarding stakeholder co-creation. The majority of survey respondents highlighted that all three best practices pertaining directly to stakeholder co-creation are considered beneficial. However, early end-user participation and sharing knowledge between team members received much higher respondent scores with 95% and 100% respectively.

Defining the TT as a profitable business venture or strategic alliance received a comparatively low score. In addition, the majority of respondents considers it difficult to implement, refer to Figure 6-33. The TT team should thus be less encouraged to formally define the TT in stakeholder meetings when compared to other best practices.

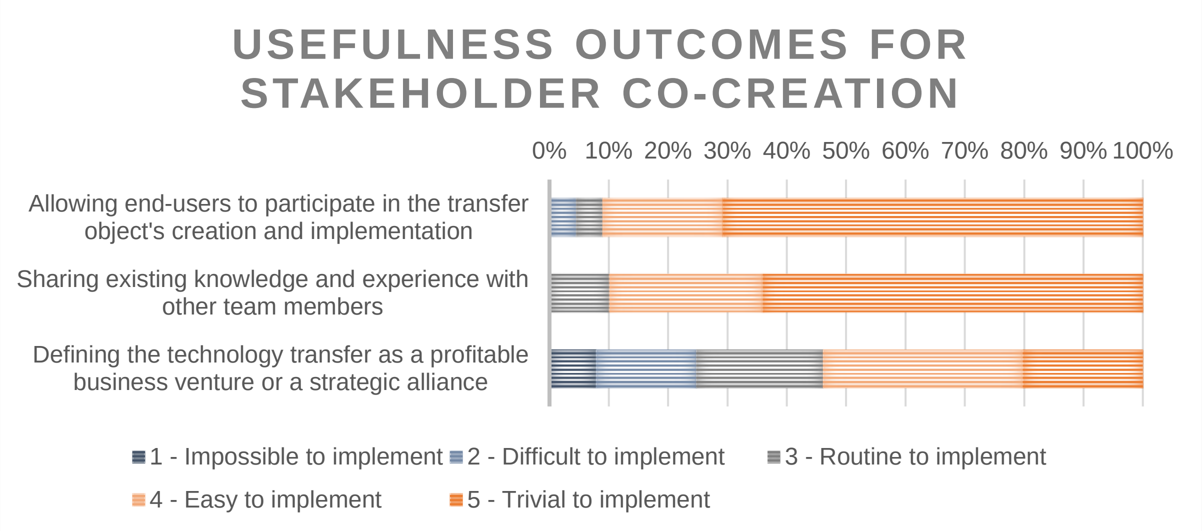


Figure 6-46 - Frequency analysis outcomes for usefulness regarding stakeholder co-creation

Figure 6-47 presents the usefulness outcomes regarding evaluation procedures. As with training procedures, all the measured evaluation procedures are considered beneficial to a TT by 90% of the survey respondents. Again, there is little discernible difference between the four best practices. Using a standardised stage-gate to periodically review the TT is considered extremely useful by the majority of the survey respondents, while approximately a third of the respondents consider standardised evaluation criteria extremely useful for the final TT revision.

As shown in Figure 6-28, evaluation procedures ranked the easiest to implement out of all the framework foundations. As such, these best practices represent a comparatively easy manner in which the TT team may conduct procedures with great use for both the current subsequent TTs of a similar nature.

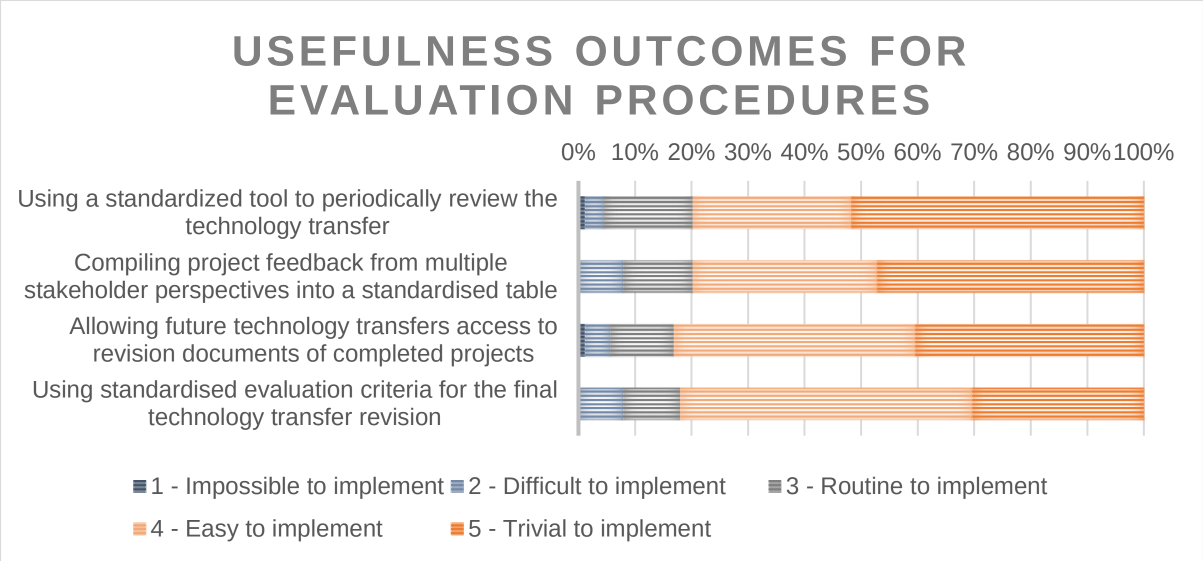


Figure 6-47 - Frequency analysis outcomes for usefulness regarding evaluation procedures

Figure 6-48 presents the usefulness outcome regarding standardisation. From Figure 6-48 it is clear that standardising TT team members' task based on their individual capabilities is required for all TT ventures as 100% of the survey respondents considered this best practice beneficial. Additional items such as a standardised communication channel, access to past TT venture outcomes, standardised documentation and assigning standardised tasks are also considered beneficial by more than 80% of the respondents. Creating a standardised initiation point is comparatively less beneficial, however, approximately 70% of the survey's respondents still indicated that this best practice is beneficial.

When reviewing the perceived ease of use of standardisation procedures, refer to Figure 6-31, there are no outcomes which detract from this foundation as each best practice is considered routine to implement by the majority of the survey respondents. This, in conjunction with the usefulness outcomes, displays the utility of standardising TT project components.

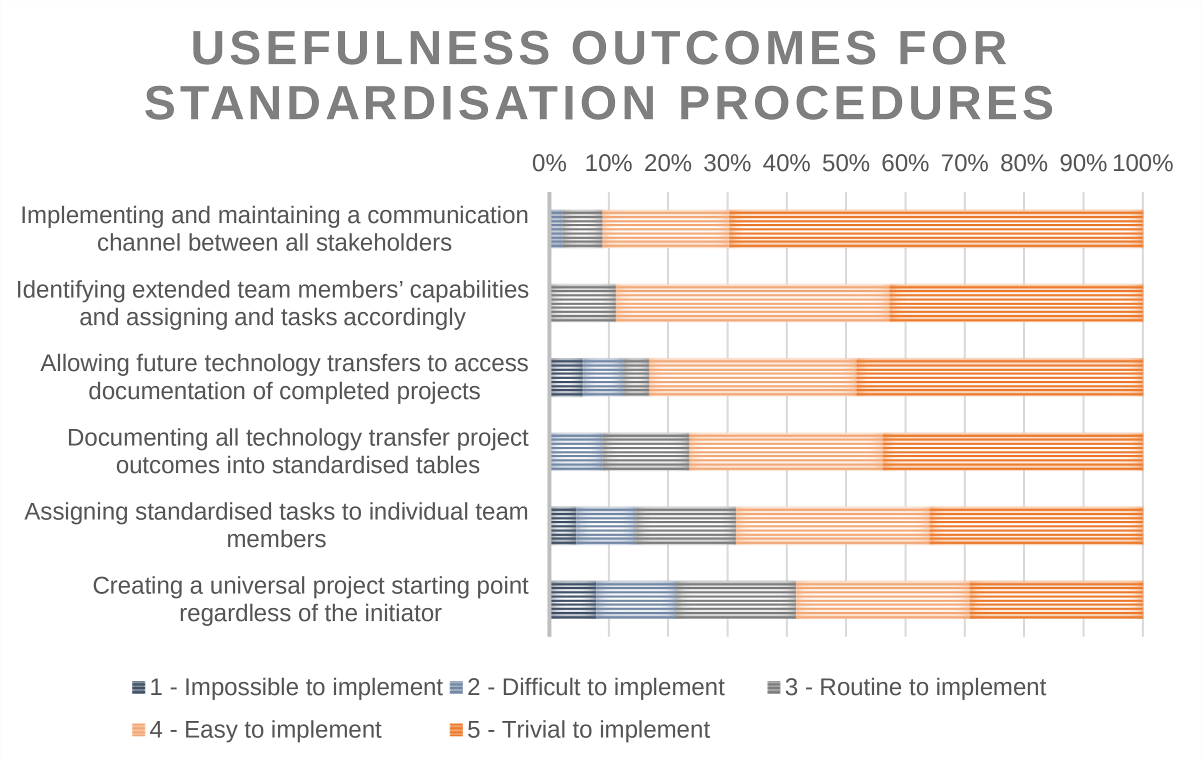


Figure 6-48 - Frequency analysis outcomes for usefulness regarding standardisation procedures

Figure 6-49 presents the usefulness outcomes for the TT team. Approximately 90% of the survey's respondents indicated that a managerial hierarchy would be beneficial towards a TT. Almost all of the respondents indicated that a dedicated project team is required as well as identifying the capabilities of the transferor and transferee within this team.

Routinely evaluating team members and removing them is also considered useful by 85% of the respondents although when reviewing Figure 6-32 it is clear that this best practice is considered difficult to implement by the majority of the respondents. While other best practices such as outlining an incentive scheme is considered as less beneficial these best practices are comparatively much easier to implement.

Finally, outlining a monetary incentive scheme is considered less beneficial when compared with an intangible incentive scheme. As an intangible incentive scheme is considered easier to implement, refer to Figure 6-32, the TT team should always be encouraged to use intangible reward first and only consider monetary incentives if they are deemed critical to the TT venture's success.

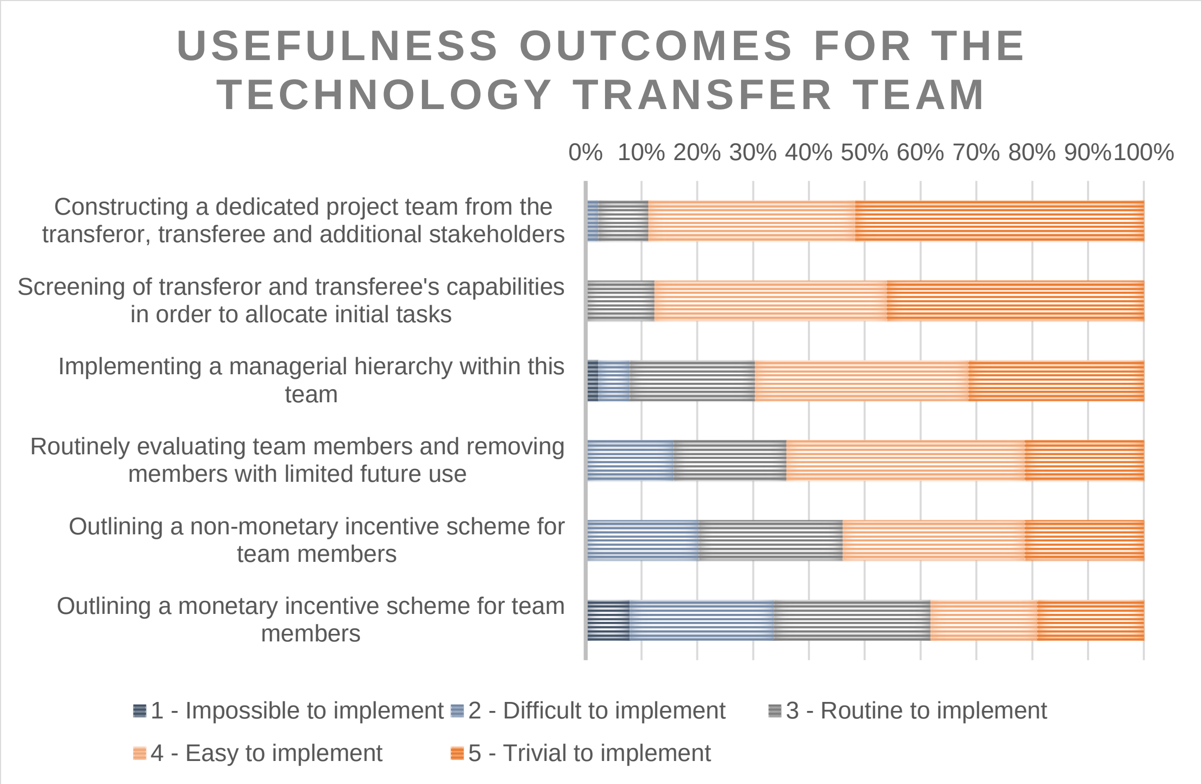


Figure 6-49 - Frequency analysis outcomes for usefulness regarding the technology transfer team

Figure 6-50 presents the usefulness outcomes regarding marketing. Approximately 80% of the survey respondents indicated that marketing both to additional public-sector and private-sector is beneficial to a TT venture with public-sector marketing considered marginally more useful than the private-sector. This outcome also coincides with the perceived ease of use with marketing to the public-sector considered slightly easier to implement than private-sector marketing, refer to Figure 6-36.

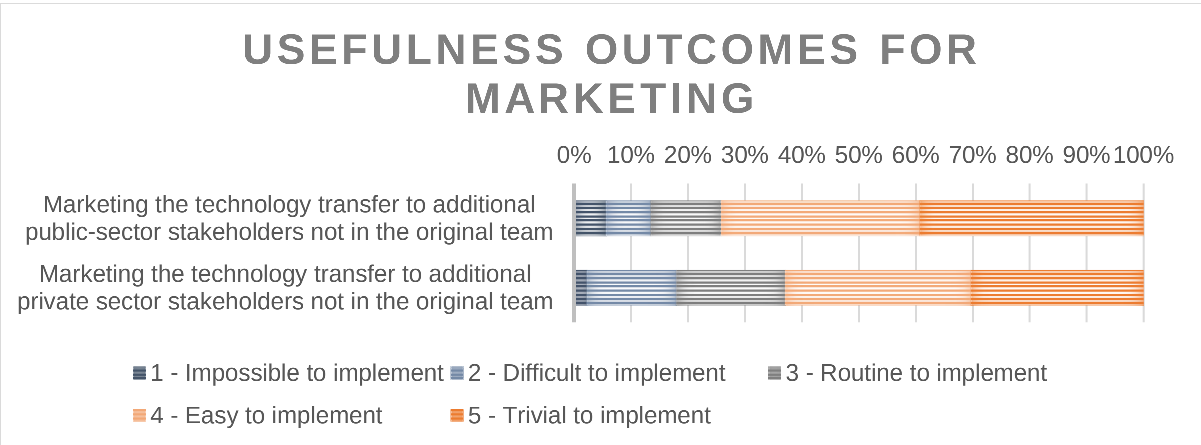


Figure 6-50 - Frequency analysis outcomes for usefulness regarding marketing

Figure 6-51 presents the usefulness outcomes regarding implementation procedure. Approximately 95% of survey respondents indicated that screening the transfer environment to categorise available and missing components as well as implementing a joint venture will be beneficial to TT. While the perceived ease of use for implementing a joint venture is comparatively low, refer to Figure 6-34, the usefulness outcomes highlight that this is still a useful TT method to utilise despite the increased difficulty when compared with other TT methods such as traditional TT and FDIs.

Identifying tailored infrastructure mitigation practices for selecting standardised infrastructure mitigation practices are both considered useful by approximately 85% of the respondents. There is a similar balance for the perceived ease of use of these components with the majority of the survey's respondents indicating that they are routine to implement. Thus, the TT team should always consider a combination of tailored and standardised procedures to mitigate lacking infrastructure.

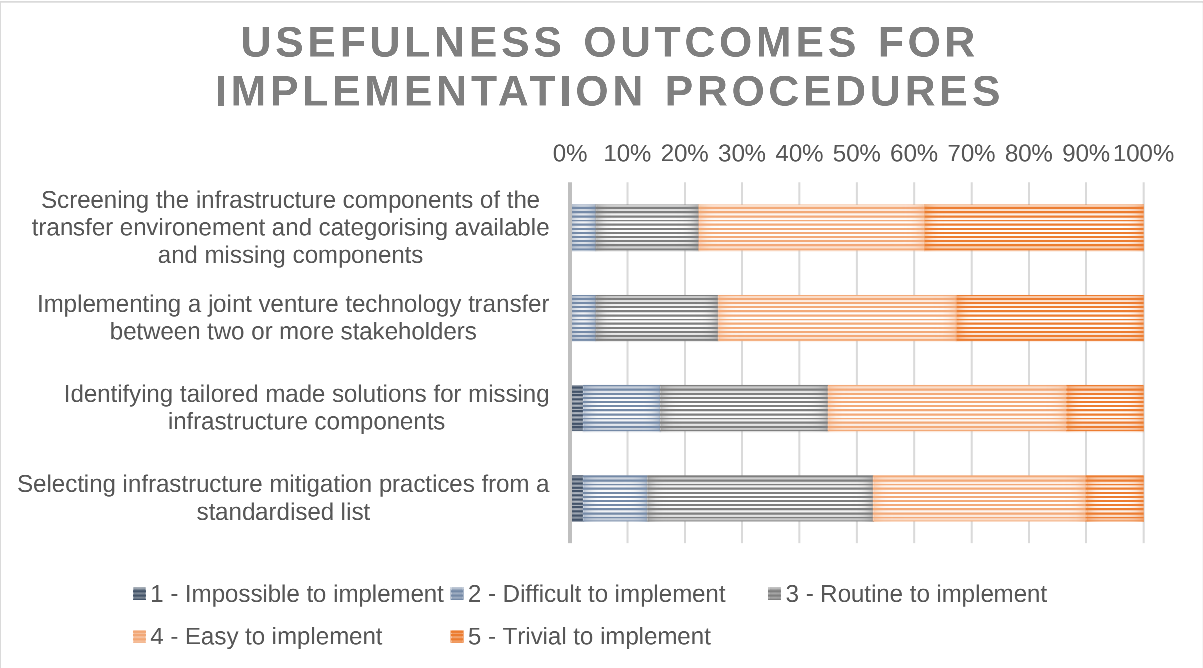


Figure 6-51 - Frequency analysis outcomes for usefulness regarding implementation procedures

Figure 6-52 presents the usefulness outcomes regarding legal considerations and is the least useful framework foundation indicated by the survey respondents. However, despite this, approximately 80% of the respondents indicated that the best practices of incorporating legal counsel into the transfer object's design and implementation and legally binding the transferor to the TT are useful best practices. This highlights the utility of the overall framework as foundations which are regarded as comparatively less useful, have still received a high frequency of respondents indicating they are beneficial to a TT venture.

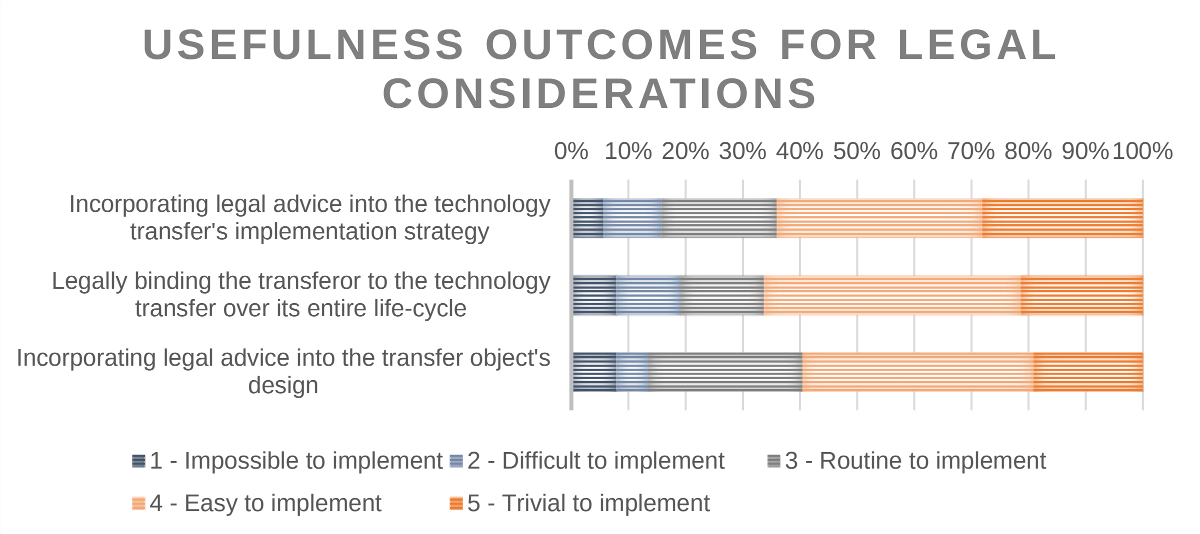


Figure 6-52 - Frequency analysis outcomes for usefulness regarding legal considerations

6.4.3.2 Mean analysis for usefulness

The second step implemented when evaluating the usefulness of the framework is to determine the arithmetic means of each action statement presented to the survey respondents. The complete data table outlining the various arithmetic means for usefulness is shown in Table F-7 in Appendix F. Table 6-32 provides an abridged summary of these components by showing the arithmetic means for the nine framework foundations as well as the five phases of the conceptual framework. Table F-7 and Table 6-32 serve to partly answer research 2.1, 2.2, 2.5 and 3.5 of the survey, as outlined in Table 6-5.

Table 6-32 - Arithmetic means for framework foundations and phases (usefulness)

Framework foundation	$\bar{x}$
Technology transfer team	3.944
Stakeholder co-creation	4.176
Legal considerations for project components	3.629
Standardisation of project components	4.097
Project implementation methods	3.764
Project evaluation procedures	4.166
Training methods for the technology	4.326
Adoption and sustainability	4.187
Marketing	3.837
Framework phase	**$\bar{x}$**
Phase I: Technology development	3.790
Phase II: Technology analysis	3.826
Phase III: Transfer method application	4.234
Phase IV: Change management	4.262
Phase V: Commercialisation	4.047
Grand mean	**4.032**

While this represents a basic method of data analysis it does provide a high-level indication that the framework's phases, individually as well as collectively, are considered to be "useful" across the respondents of the survey with a grand mean approximating a score of 4. However, it must be noted that no comparison between the phases or foundations can be statistically determined by this mean analysis and rather is addressed in the variance and regression analyses shown in Section 6.4.3.3 and Section 6.4.3.4.

Table 6-32 also highlights the consistency of both the framework's phases as the various arithmetic means are all within a 6% margin of the grand mean. A visual representation of the consistency of the perceived ease of use of the framework's phases is shown in Figure 6-53. While the small variance in range does not lend credence to conclusive framework revisions, Figure 6-53 does indicate that to a small extent the later phases of the framework are more useful than Phase I and Phase II.

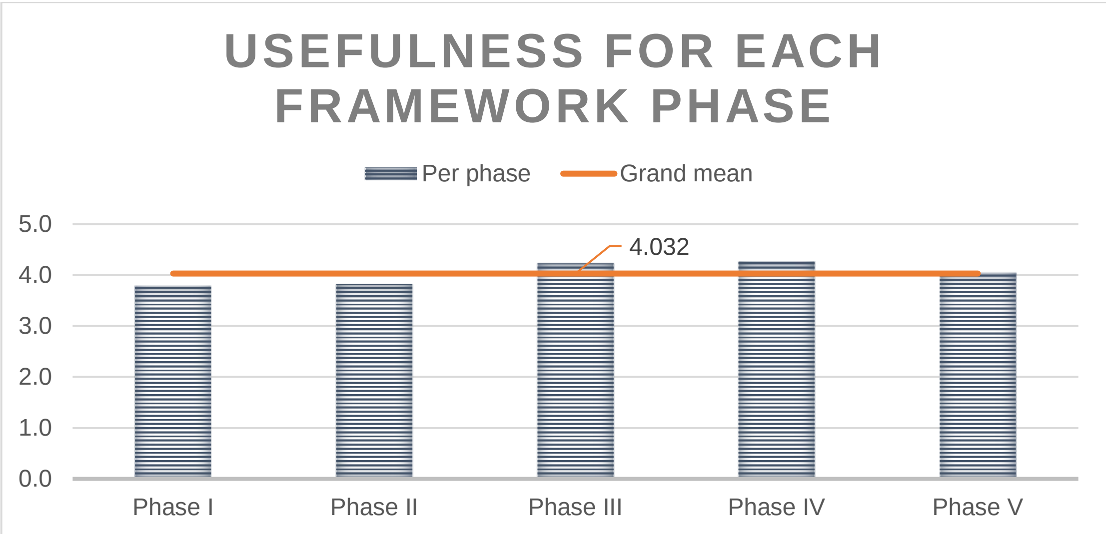


Figure 6-53 - Arithmetic mean for framework phases (usefulness)

A conditional formatting tool is implemented within Microsoft Excel to highlight the lowest 10% of all the managerial best practices evaluated by the survey instrument, as shown by the highlighted items in Table F-7 in Appendix F. Three best practices are subsequently highlighted and presented for review in Table 6-33.

Table 6-33 - Arithmetic mean for framework phases (usefulness)

Usefulness			
Managerial best practices	Foundation	Phase	$\bar{x}$
Outlining a monetary incentive scheme for team members.	Technology transfer team	Phase I	3.157
Defining the project as a profitable business venture or a strategic alliance.	Stakeholder co-creation	Phase II	3.416
Selecting infrastructure mitigation practices from a standardised list.	Project implementation methods		3.416

Two managerial best practices from Phase III are among the lowest 10%. When compared with the rank of perceived ease of use, the data results display a wider range, in total 1.427, with the lowest-scoring component being 0.783 below the grand mean. To this extent outlining a monetary incentive scheme is concluded to be less useful during the initial phase of a TT venture.

6.4.3.3 Variance analysis for usefulness

As with the perceived ease of use item, the variance analysis completed for the usefulness measurement item aims to highlight variances within the four regions within SSA. To this extent, each SSA region is evaluated using an LSD ANOVA test, as outlined in Section 6.2.2.10, to determine if a specific region differs from the rest of SSA. This allows for the usefulness of each phase of the conceptual framework to be compared between each major region within SSA and the rest of SSA which will subsequently allow for modifications to the conceptual framework aimed at maximizing the framework's utility for specific regions within SSA.

The results of the LSD ANOVA test are summarised in a graphical format in Figure 6-54. All error bars represent a 95% confidence interval and thus an alpha value of 0.05 is implemented during the statistical calculations. Figure 6-54 serves to partly answer all questions in category 3 of the survey.

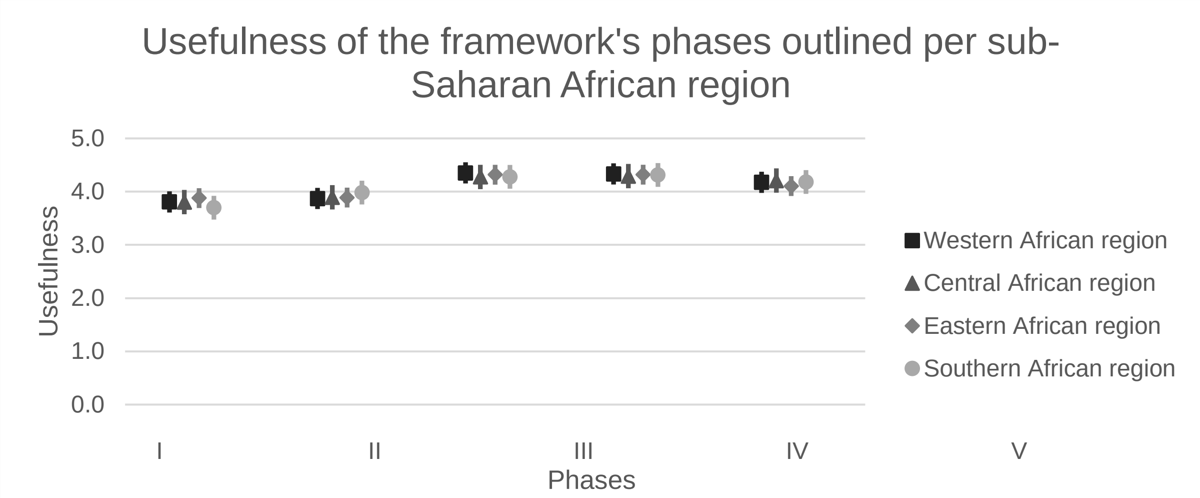


Figure 6-54 - Variance analysis results for usefulness over the regions of sub-Saharan Africa

When reviewing the outcomes of the variance analyses per SSA region for usefulness, the LSD ANOVA tests produced no statistically significant results for any region. Thus, no conclusion can be made regarding the comparative level of utility of the conceptual framework between the four major regions of SSA. This holds true over each individual phase of the conceptual framework. The outcomes of the ANOVA test for perceived ease of use is shown in Table 6-28.

Table 6-34 - ANOVA outcomes for usefulness

Source	F-value	p-value	F-critical value
Western Africa	0.508	0.730	2.398
Central Africa	0.443	0.777	2.398
Eastern Africa	0.069	0.991	2.398
Southern Africa	0.420	0.794	2.398

The p-values of Western, Central, Eastern and Southern Africa are 0.730, 0.777, 0.991 and 0.794 respectively across all phases of the framework. As all these p-values are larger than 0.05 and the F-values are lower than the F-critical values, no graphical illustrations are included in Section 6.4.3.3 as each individual region closely follows the trendlines of the rest of SSA.

6.4.3.4 Regression and correlation analyses for usefulness

The following section presents the results of the regression and correlation analyses highlighting the relationship between the usefulness and the evaluation items captured during the survey's administration. The completed methodology of this regression analysis is presented in Section 6.2.2.12.

As outlined in Table 6-9, each respondent is asked to rank the relative adoption, diffusion and satisfaction levels of their respective TT venture. These three evaluation items are subsequently utilized as three reflective indicators for the latent variable, relative success as shown in the structural equation model, shown in Figure 6-10.

The purpose of the regression and correlation analysis will be to evaluate the relationship between the five phases of the conceptual framework and the relative success latent variable. This will enable conclusions to be made regarding on *H6*, *H7, H8, H9* and *H10* which are restated below to simplify readability:

(H6:) There will be a positive association between the usefulness of the best practices in the first phase of the conceptual framework and the relative success of a technology transfer venture

(H7:) There will be a positive association between the usefulness of the best practices in the second phase of the conceptual framework and the relative success of a technology transfer venture

(H8:) There will be a positive association between the usefulness of the best practices in the third phase of the conceptual framework and the relative success of a technology transfer venture

(H9:) There will be a positive association between the usefulness of the best practices in the fourth phase of the conceptual framework and the relative success of a technology transfer venture

(H10:) There will be a positive association between the usefulness of the best practices in the fifth phase of the conceptual framework and the relative success of a technology transfer venture

An abridged summary of the main path diagram of the structural equation model, pertinent to these analyses, is shown below in **Figure 6-55**. As before, $\eta_{1\ \text{usefulness}}$ to $\eta_{5\ \text{usefulness}}$ represents the five phases of the conceptual framework and η_6 represents the relative success of the technology transfer venture.

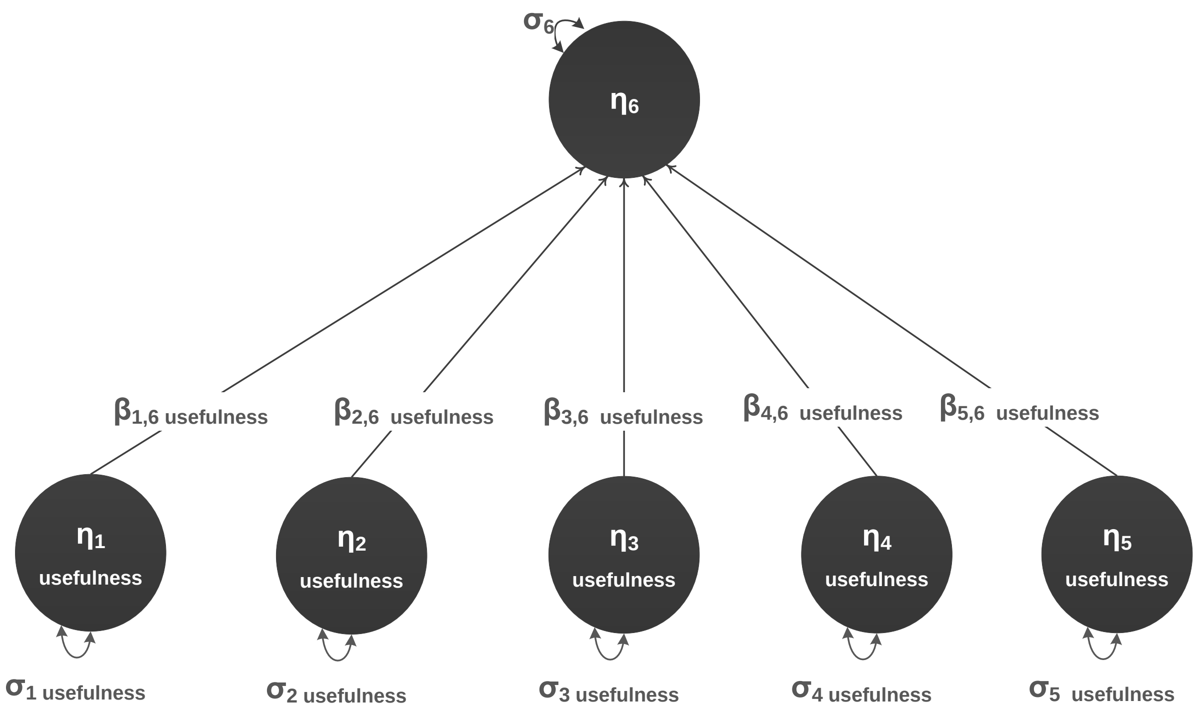


Figure 6-55 - Abridged path diagram for regression and correlation analyses for usefulness data set

As outlined in Section 6.2.2.10, a standardized approach is adopted and all latent variable variances are scaled to unity. Thus, in **Figure 6-55** $\sigma_{1\text{ usefulness}}$ through $\sigma_{5\text{ usefulness}}$ as well as σ_6 are all fixed to 1.0. Additionally, in pursuit of optimizing model fit, shown in Section 6.2.2.11, the formative indicators $X_{2\text{ usefulness}}$, $X_{10\text{ usefulness}}$, $X_{16\text{ usefulness}}$, $X_{22\text{ usefulness}}$, $X_{32\text{ usefulness}}$ and $X_{33\text{ usefulness}}$ are excluded from the regression and correlation analyses.

The multiple regression analysis for the usefulness data set is completed with Statistica (TIBCO Inc., 2019) with a shown in **Table 6-35**. All results shown in **Table 6-35** are computed with a significance level of 0.05.

Table 6-35 - Multiple regression analysis outcomes for usefulness measurement set

Dependent variable - relative success (η_6)					
Independent variables	Beta	t-statistic	SM	SD	p-value
η_1	0.702	23.21	0.72	0.03	<0.001
η_2	0.535	8.83	0.56	0.06	<0.001
η_3	0.496	7.97	0.53	0.06	<0.001
η_4	0.415	5.88	0.44	0.07	<0.001
η_5	0.548	10.79	0.57	0.05	<0.001
R-squared	0.71				
Adjusted R	0.69				
F-value	12.008				<0.001
Number of cases	89				

The results show that the F-value was statistically significant ($p < 0.001$) which indicates that the structural equation model shown in Figure 6-55 predicts the dependent variable better than the observed means of the dependent variable. In this instance, the dependent variable is the relative success of the TT venture, represented by η_6 Figure 6-55. Thus, the relationship between the structural equation model and the dependent variable is deemed to be statistically significant for the usefulness data set.

The R-squared value indicates that more than 70% of the variance is explained by the model. When comparing this to similar structural equation models this high variance is above what is expected for TT model studies (Boateng *et al.*, 2002; Philip F Musa *et al.*, 2005). An R-squared value of 0.4 is consistent with previous studies of a similar nature measuring usefulness (Boateng *et al.*, 2002; Philip F Musa *et al.*, 2005).

Furthermore, the outcomes of the multiple regression analysis suggest that all five phases of the conceptual framework, and the best practices within each, are statistically significant ($p < 0.001$) and support hypotheses *H6*, *H7, H8, H9* and *H10*. Interestingly, the comparative strength of $\beta_{1,6}$ suggests that the best practices in Phase I of the conceptual framework have a stronger association with the relative success of a TT venture than the four subsequent phases.

The outcomes shown in Table 6-35 are not surprising given the strong link present in the literature between the best practices outlined in the five phases of the conceptual framework and the relative success of a TT venture. Phase I best practices such as a managerial hierarchy within the TT team and an incentive scheme for team members is frequently advocated (Kimaro *et al.*, 2005; Meso *et al.*, 2009; Ryu *et al.*, 2010; Shiferaw *et al.*, 2012; Link *et al.*, 2016). Additionally, the legal act of binding the transferor the TT is regarded as highly beneficial to the TT's adoption and stakeholder satisfaction (Connell *et al.*, 2007).

Phase II best practices primarily surround the TT team with items such as the dissemination of knowledge between team members, incorporating legal advice and standardizing team members all recognized as relevant and useful in literature (Geissbuhler *et al.*, 2003; Jagoda *et al.*, 2010; Ramanathan, 2011). Similarly, the Phase III best practises on incorporating end-users in the transfer objects design and the use of joint ventures are also very well established as beneficial to the outcome of a TT venture (Rebentisch *et al.*, 1995; Boateng *et al.*, 2002; Braa *et al.*, 2004; Nhampossa, 2005; Hoekman *et al.*, 2006; Bozeman *et al.*, 2015)

The Phase IV best practices relating to training procedures, such as on-site training, training to train and tiered training structures are all directly linked to end-user adoption and as such the relative success of a TT venture (Connor *et al.*, 2009; Karari *et al.*, 2011; Aranda-Jan *et al.*, 2014). Lastly, the best practices of Phase V, such as standardized revision criteria, marketing protocols and documentation procedures are all also suggested to be paramount for a TT venture (Bozeman, 2000; Jagoda *et al.*, 2010; Bozeman *et al.*, 2015; Handoko *et al.*, 2016)

After the completion of the multiple regression analysis, a correlation analysis is completed. The correlation analysis focussed on determining the Spearman rank-order correlation coefficient for each phase of the conceptual framework. The correlation analysis for the usefulness data set is computed with Statistica (TIBCO Inc., 2019) with the results shown in **Table 6-36** as well as individual discussions for each phase of the conceptual framework.

All results shown within **Table 6-36** are computed with a sample size of 89 and a significance level of 0.05 with all computed correlation coefficients return p-values indicating they are statistically significant. All five phases of the conceptual framework display positive moderate correlations with the relative success of a TT venture.

The results presented within **Table 6-36** are arguably the most important within Chapter 6 with respect to the evaluation of the conceptual framework. The correlation analysis and the resulting Spearman rank-order correlation coefficients clearly highlight the usefulness of the conceptual framework's phases as well as the individual nodes within these phases. As each item measured within the survey instrument produced a Spearman coefficient indicating a positive moderate coefficient, it can be concluded that all the nodes presented within the conceptual framework are useful in facilitating the relative success of a healthcare transfer object in the geographic regions of SSA. Thus, there is an association between implementing the conceptual framework and the TT venture's final level of success.

Table 6-36 - Correlation analysis outcomes for the relative success of a technology transfer venture and the five phases of the conceptual framework for the usefulness data set

Dependent variable	Independent variable	ρ	t-statistic	p-value	Discussion
Relative success η_6	Phase I η_1 usefulness	0.531	5.840	<0.001	Returned result: **Positive - Moderate** The usefulness of Phase I returned a moderate positive correlation with the relative success of a TT venture. This outcome highlights the importance of the construction of the dedicated TT team and establishing a co-creation relationship between the transferor and transferee as outlined within Phase I of the conceptual framework. Legally binding the transferor to the TT venture of its entire life cycle and implementing a universal starting point regardless of the transfer object also shares a moderate positive correlation with the transfer object's levels of adoption.
	Phase II η_2 usefulness	0.580	6.633	<0.001	Returned result: **Positive - Moderate** The usefulness of Phase II returned a moderate positive correlation with the relative success of a TT venture. The framework nodes promoting knowledge dissemination and co-creation between an extended TT team all returned strong correlation coefficients. The use of a standardised tool to screen the transfer environment as well as best practices pertaining to legal counsel both produced positive moderate correlation coefficients with regards to the relative success of a TT venture.
	Phase III η_3 usefulness	0.463	4.869	<0.001	Returned result: **Positive - Moderate** The usefulness of Phase III returned a moderate positive correlation with the relative success of a TT venture. The framework best practices advocating the use of the joint venture TT method produced a moderate coefficient with respect to the relative success of a TT venture l. This again highlights the importance of the TT team and a co-creation relationship between team members. Other nodes advocated within Phase III such as the creation of a prototype and incorporating and incentivising early-adopters produced moderate coefficients. The use of standardised internal revision protocols for the TT produced the lowest positive correlation within all five phases. However, as this item is still producing a positive, albeit weak, correlation, it shows the overall strength of each framework node with respect to the relative success of a TT venture.
	Phase IV η_4 usefulness	0.524	5.728	<0.001	Returned result: **Positive - Moderate** The usefulness of Phase IV returned a moderate positive correlation with the relative success of a TT venture. The implementation of all training related best practices advocated within Phase IV of the conceptual framework returned strong positive correlation coefficients with respect to the relative success of a TT venture. Nodes promoting sustainable communication for the TT team, both internally and externally, returned moderate positive coefficients.
	Phase V η_5 usefulness	0.555	6.227	<0.001	Returned result: **Positive - Moderate** The usefulness of Phase V returned a moderate positive correlation with the relative success of a TT venture. The framework node advocating for the implementation of knowledge codification and future co-creation knowledge sharing both produced moderate positive correlation coefficients. Best practices within the framework pertaining to marketing to additional stakeholders comparatively less strongly correlation results highlighting that the relative success of a TT venture is less dependent on incorporating additional stakeholders. However, marketing items still produced positive moderate correlation coefficients.

6.4.4 Outcomes of the survey

The outcomes of the regression analysis supported hypotheses *H1, H3, H4, H5, H6, H7, H8, H9* and *H10* but no evidence was uncoverd to support hypothesis *H2*. Thus, there is evidence to support that a positive association exists between the best practices within the conceptual framework's five phases and the relative success of a TT venture for both the perceived ease of use and usefulness data sets. This is true for all phases apart from Phase II for the perceived ease of use data set.

To improve the readability of the outcomes of the survey instrument, the survey's questions, first stated in Table 6-5, and their corresponding answers are summarised in Table 6-37, Table 6-38 and Table 6-39. Table 6-37, Table 6-38 and Table 6-39 also provides the reader with reference points to the specific data results upon which individual answers have been founded. These answers provide specific insights into the demographics, TT operating principles and operating regions of industry leaders in SSA responsible for the facilitation of healthcare initiatives.

Table 6-37 - Summary of the questions and answers of the survey instrument for category 1

Category 1	Descriptive statistics and industry experience of respondents		
	Survey question	Answer	Refer to
1.1	What is the ratio of organisations working for profit versus not for profit?	A sample size of 89 produced a ratio of 60:1 in favour of social impact. It is noted that 28 respondents indicated a combination of both.	Figure 6-20
1.2	From which countries have the respondents gained their experience?	Every country listed within SSA received at least one response. The regions of Western, Eastern, Central and Southern Africa received 19, 24, 12 and 13 responses respectively.	Figure 6-21 and Figure 6-22
1.3	In which areas of TT do the respondents have experience?	In total, 14 different sub-components of TT received more than 5 responses. Technology development, stakeholder integration, public liaison, training operations and post TT evaluation represent the five highest-ranking sub-components.	Figure 6-26
1.4	In which fields of healthcare do the respondents have experience?	In total, 8 different fields of healthcare received more than 20 responses. Healthcare services, HIS, e-Health, patient care and supply chain improvements represent the five highest-ranking fields of healthcare.	Figure 6-24
1.5	What was the relative success of the respondent's TT ventures?	In general, respondents indicated a positive level of end-user adoption as well as additional diffusion of the transfer object. The satisfaction levels of the parent organisations follow a similar trendline. It is noted that 7 respondents did not yet know the full extent of the transfer object's additional diffusion.	Figure 6-27

Table 6-38 - Summary of the questions and answers of the survey instrument for category 2

Category 2	Healthcare TT principles		
	Survey question	Answer	Refer to
2.1	What is the importance of stakeholder co-creation?	Collectively, stakeholder co-creation received an average response of 3.034 and 4.176 for perceived ease of use and usefulness respectively, indicating it is perceived as being routine to implement and a useful component of TT.	Table 6-26, Table 6-32, Figure 6-33 and Figure 6-46
2.2	What components determine a successful TT team?	For both perceived ease of use and usefulness, the TT team best practice of outlining a monetary incentive scheme returned respondent scores ranking within the bottom three of all measurement questions. Similarly, the best practice of routinely evaluating team members and removing members returned the lowest overall score for perceived ease of use. Thus, these best practices are considered comparatively less importance with respect to a successful TT team.	Table 6-27, Table 6-33, Figure 6-32 and Figure 6-49
2.3	What is the perceived ease of use for the joint venture TT method?	For perceived ease of use and usefulness the best practice advising the implementation of a joint venture received respondent scores of 2.708 and 4.022 respectively. This indicates that joint ventures are considered useful but rank between difficult and routine to utilise.	Table F-6, Figure 6-34 and Figure 6-51
2.4	How do different training methods compare for TT ventures?	For both perceived ease of use and usefulness all training related best practices received similar scores indicating that training is in general routine to implement and considered useful. Additionally, of all the foundations measured, training received the highest average score for the usefulness measurement item.	Table 6-26 and Table 6-32
2.5	What is the importance of legal considerations on a TT venture?	The framework foundation relating to the legal considerations of project components received a collective respondent score of 2.727 for perceived ease of use and 3.629 for usefulness. Both these scores represent comparatively low values indicating legal considerations are more difficult to implement and less useful when considering the other framework foundations.	Table 6-26, Table 6-32, Figure 6-37 and Figure 6-52

Table 6-39 - Summary of the questions and answers of the survey instrument for category 3

Category 3	Geographic application area of SSA		
	Survey question	Answer	Refer to
2.1	How does Western Africa differ from SSA as whole when executing the phases of TT?	The variance analysis comparing Western Africa with the rest of SSA produced a statistically significant result indicating that both Phase I and Phase II of the conceptual framework are more difficult to implement in Western Africa. No statistically significant result is produced for any phase of the conceptual framework when evaluating the usefulness measurement item.	Figure 6-40
2.2	How does Central Africa differ from SSA as whole when executing the phases of TT?	The variance analysis comparing Central Africa with the rest of SSA produced a statistically significant result indicating that Phase I of the conceptual framework is more difficult to implement in Central Africa. No statistically significant result is produced for any phase of the conceptual framework when evaluating the usefulness measurement item.	Figure 6-41
2.3	How does Eastern Africa differ from SSA as whole when executing the phases of TT?	The variance analysis comparing Eastern Africa with the rest of SSA did not yield any statistically significant results indicating any difference. This is applicable for all five phases of the conceptual framework when evaluating either perceived ease of use of usefulness.	Figure 6-39 and Figure 6-54
2.4	How does Southern Africa differ from SSA as whole when executing the phases of TT?	The variance analysis comparing Southern Africa with the rest of SSA did not yield any statistically significant results indicating any difference. This is applicable for all five phases of the conceptual framework when evaluating either perceived ease of use of usefulness.	Figure 6-39 and Figure 6-54
2.5	What is the perceived ease of use and usefulness of the framework over SSA as a whole?	When evaluating the framework over the entire region of SSA, the grand mean for perceived ease of use and usefulness is 2.992 and 4.032 respectively. This indicates that respondents consider the framework to be collectively routine to implement and useful.	Figure 6-38, Figure 6-53, Figure 6-28 and Figure 6-43

However, as stated in Step 1 of the survey's methodology in Section 6.2.2.1, the survey instrument's primary aim is to enable a second level of evaluation for the conceptual framework. In contrast with the first and third levels of evaluation, the implementation of the survey ensures that a quantitative research method is also applied during the conceptual framework's evaluation procedure. Thus, in accordance with the primary aim of the survey instrument, four key outcomes are identified:

i. Applicable

As shown by the descriptive statistics presented in Section 6.4.1, the survey respondents possessed healthcare TT knowledge which is directly applicable to the geographic region of SSA. The proportionally high number of respondents who claimed to operate on an executive or managerial level also lends further authority to the data collected by the survey.

ii. Practical

As shown by the frequency and mean analysis presented in Section 6.4.2.1, Section 6.4.3.1 Section 6.4.2.2 and Section 6.4.3.2, the survey respondents consider each phase of the conceptual framework to be in line with routine or normal operating procedures with respect to perceived ease of use. Similarly, survey respondents consider each framework component to be at least marginally useful, with the majority ranked as useful. Thus, the survey highlights that the framework is not complicated to implement yet still useful for TT stakeholders in SSA.

iii. Relevant

As shown by the variance analysis presented in Section 6.4.2.3 and Section 6.4.3.3, the survey's data results highlight the relevance of the phases of the conceptual framework within the four regions of SSA. It also allows the conceptual framework to be tailored depending on the individual transfer environment by highlighting the differences, both for perceived ease of use and usefulness, between the four major regions in SSA.

iv. Useful

As shown by the correlation analysis, shown in Section 6.4.2.4 and Section 6.4.3.4, the relative of success of respondents' TT ventures exhibit a moderate positive correlation with the usefulness of the best practices stated within the conceptual framework across all five phases. These correlation cofficients, along with the regression coefficients and the results of the mean analysis and variance analyses, display the collective usefulness of the conceptual framework for healthcare TT ventures in SSA.

6.5 Results: Case studies

The results of the third level of the conceptual framework's evaluation are outlined by presenting the similarities between the framework's primary foundations and the managerial actions undertaken during three independent case studies. Furthermore, each individual phase of the conceptual framework is expanded to present the retrospective application of the framework upon each case study. A high-level overview of each case study is also outlined.

As the third level of evaluation only attempts to prove the applicability of the conceptual framework to real-world healthcare TT projects, no additional framework consolidation is undertaken after the completion of the framework application. Lastly, the applicability and versatility of the conceptual framework are discussed based on the outcomes of the three case study applications.

6.5.1 Case study overviews

The following section provides a detailed exposition of each individual case study utilised during the conceptual framework's third level of evaluation. These case study overviews are constructed after the conclusion of the interviews with project leaders. As such, they depict the experience and findings of the project leaders and parent organisations involved in the development and implementation of the healthcare technologies. The relevance of these case studies with respect to the conceptual framework is presented in Section 6.5.2.1. A high-level summary of all three case studies is provided in Table 6-40 with each individual case study outlined in Section 6.5.1.1, Section 6.5.1.2 and Section 6.5.1.3.

Table 6-40 - Summary of each case study.

	Case study 1	Case study 2	Case study 3
Project name	Safer Deliveries Program	Mobile Phone Microscopy Diagnosis	Chipatala cha pa Foni
Parent organisation	D-Tree International	University Health Network	VillageReach
Transfer object	Mobile application for maternal healthcare support	Mobile microscope attaching to a mobile smart device and mobile support application	A mobile information application and SMS service
Healthcare fields	e-Health, Telemedicine, HIS, Public Liaison and Improving patient reach	e-Health, Telemedicine, Medial devices, Patient care, Research and development and Improving patient reach	e-Health, Telemedicine, Public Liaison and Improving patient reach
Transferor	D-Tree International	University Health Network	Village Reach
Transferee	Ministry of health - Zanzibar	Local healthcare clinics	Ministry of Health - Malawi
Transfer environment	Tanzania	Ivory Coast, Ghana, Laos and Tanzania	Malawi
Project initiation date	2011	2013	2011
Project completion date	Currently still active	Currently still active	Currently still active
TT method implemented	Joint venture	Joint venture	Joint venture
Abridged summary	The Safer Deliveries program is a joint venture between D-Tree international and the Tanzanian Ministry of health aimed at promoting childbirth in medical facilities rather than in rural settings. The transfer object is developed by an extensive set of healthcare, technical and community experts. The TT program started with a pilot case of 20 pregnant women in 2011 and in 2018 has expanded to approximately 80% of low- and middle-income women across Tanzania.	The Mobile Phone Microscopy Diagnosis project is a joint venture between the partners within the University Health Network and frontline clinic workers in SSA. It aims at eliminating the need for expensive microscope equipment in the diagnosis process by providing workers with a device coupled to their smartphone capable of delivering diagnoses in real-time. The transfer object is currently implemented in the Ivory Coast, Ghana, Tanzania and is also in the process of being implemented in Laos.	The Chapitala cha pa Foni program is a joint venture between VillageReach and the Malawian ministry of health. The program initially started as a pilot study within one district of Malawi and solely focussed on improving maternal healthcare. Since 2013 the program has been greatly expanded and covers nine districts in Malawi with the technology's scope being expanded to all healthcare fields. The program is set to be expanded to an additional three districts in late 2019.

6.5.1.1 Case study 1 - Safer Deliveries

The first case study to which the consolidated conceptual framework is applied is the Safer Deliveries program implemented in Zanzibar, Tanzania. D-Tree International is the parent organization responsible for the development and transfer of the program and thus also serves the role of the transferor.

The TT venture started was initiated in 2011 after D-Tree received an innovation grant for healthcare from the Gates Foundation. The first step in Safer Deliveries program was to conduct a feasibility and market study to determine if the use of mobile technology could support women to deliver in healthcare facilities. The mobile application represents the transfer object within this case study. Initially, the TT had a very small focus group of approximately 20 women and was very closely intertwined with the Tanzanian ministry of health. For this case study, the women represent the end-users and the ministry of health represents the transferee.

The pilot was completed and returned promising results after which the program rapidly evolved by incorporating both political, social and economic factors into the development and implementation of the TT. The program also shifted from traditional java phones onto smartphones which radically improved the data capturing and functionality of the mobile application. The design of the mobile application is done via a collaborative partnership between D-Tree International, the ministry of health, a telecommunications partner, local community leaders, technical advisors employed by the Tanzanian government, UNICEF and the Boston's Children Hospital.

The Safer Deliveries program is still in operation at the time of writing in late 2018. The mobile application is currently in use by approximately 80% of low- and middle-income women in Tanzania. Currently, D-Tree does not plan on expanding the program to additional SSA countries with the primary goal of the TT remaining a near-perfect adoption rate of the transfer object within Tanzania.

6.5.1.2 Case study 2 - Mobile Microscopy Diagnosis

The second case study to which the consolidated conceptual framework is applied is the Mobile Phone Microscopy Diagnosis project implemented in the Ivory Coast, Ghana, Tanzania and, more recently, Laos. The University Health Network is the parent organization responsible for the development and transfer of the program and thus also serves the role of the transferor.

The TT venture started in 2013 and was initially restricted to stand-alone commercially available smartphone devices. These smartphones are then utilised by the end-user to digitally capture a blood sample and, in conjunction with a mobile application, return a real-time diagnosis. However, the project was severely limited due to the capabilities of the built-in camera on standard smartphone devices. To overcome this barrier, a cost-effective mobile microscope is developed which is able to attach to any smartphone device. This combination of the mobile microscope, the mobile smartphone device and the mobile application allowed for easy, cost-effective, accurate and real-time diagnoses to be delivered to the end-user. The mobile microscope attachment and the mobile application represent the transfer object for this case study.

The end-users in question are primarily healthcare practitioners, technicians, clinic staff and village leaders in community settings. These end-users also represent the transferee of this TT venture.

The project was later expanded to include two additional mobile microscope attachments, each capable of delivering different spectrums of diagnoses. Additionally, the mobile application is also greatly evolved to not only provide the end-user with a real-time diagnosis but also with an action plan based on the end user's specific transfer environment and available resources.

The Mobile Phone Microscopy Diagnosis project is still in operation at the time of writing in late 2018. Currently, three mobile healthcare devices are deployed in Tanzania, Ghana and the Ivory Coast with an expansion underway to bring the devices into Laos as well. As such, a field study is underway in one region within Laos at the time of writing.

6.5.1.3 Case study 3 - Chipatala cha pa Foni

The third case study to which the consolidated conceptual framework is applied is the Chipatala cha pa Foni program implemented in the in Malawi. VillageReach is the organization responsible for the development and transfer of the program and thus also serves the role of the transferor.

The project started in 2011 as a pilot study in a single Malawian district. The pilot was subsequently expanded to two additional districts and in 2013 a formal impact assessment was conducted by VillageReach. Based on the positive results of this impact assessment the Malawian ministry of health was incorporated with the goal to both expand the transfer object and the transfer environment over the coming years.

During the pilot study, the transfer object consisted of a simple hotline offering healthcare services restricted to maternal healthcare. After the joint venture with the ministry of health was established, the transfer object was evolved to cover all aspects of healthcare.

Additionally, the hotline was supplemented by the creation of a mobile smartphone application providing end-users with similar healthcare services.

The transfer object was also expanded into six additional districts within Malawi, with targets to penetrate three additional districts per year. Stakeholders such as Airtel, USAID and the Vitol foundation were also incorporated to provide technical and infrastructure support for both the hotline and the mobile application.

The Chipatala cha pa Foni program is currently still in operation at the time of writing in late 2018. The hotline and mobile application are currently operational in roughly 40% of Malawi. The Malawian ministry of health's primary target for the program remains nationwide coverage.

6.5.2 Applicability outcomes per foundations

To highlight the applicability of the framework within the context of the three case studies, nine framework foundations are individually compared against the managerial actions taken by the parent organisations responsible for the case study's execution. These nine foundations directly align with the measurement items utilised during the survey instrument as shown in Section 6.3.3.

To simplify the comparison, Section 6.5.2.1 to Section 6.5.2.9 first provides a summary of the primary best practices advocated within the consolidated conceptual framework. The detailed outlines of the initial best practices are shown in Section 5.4 with modification and additions derived from the semi-structured interviews and survey shown in Section 6.3.2 and Section 6.3.3 respectively.

In turn, these summaries are compared to the real-world events which occurred during the three case studies' life cycles. The comparison for each of the nine framework foundations is outlined in Section 6.5.2.1 to Section 6.5.2.9.

It is noted that during the case study interviews, no attempt is made to understand why managerial actions differed from the foundations or framework's best practices nor are these best practices postulated to the project leaders for feedback. The utility and ease of use of the following constructs are measured by the survey instrument in Section 6.3.3, with the case study solely attempting to highlight the applicability and practicality of the conceptual framework with regards to real-world healthcare TT ventures.

6.5.2.1 Technology transfer team

To simplify the comparison between the managerial best practices and the three case studies, the best practices advocated by the consolidated conceptual framework are first in restated Table 6-41 along with the individual case study outcomes. It is noted that all case studies presented examples for all TT team-related best practices.

Table 6-41 - Comparison of the managerial best practices and case studies for the technology transfer team

Best practices	Case study outcomes with respect to the TT team		
	Case study 1	**Case study 2**	**Case study 3**
Conduct a preliminary screening of the transferee's and transferor's abilities in order to allocate initial project tasks.	The entire TT team's capabilities are screened during the initial pilot study to both identify stakeholders suitable to specific roles as well as roles that could not be completed by the initial TT team.	The University Health Network conducts initial screening regarding the rural frontline health workers and assigns testing and feedback operations to the transferee while the transferor is responsible for the transfer object's development.	After the pilot study was completed, VillageReach and the Malawian ministry of health assigned project tasks based on the resources and capabilities available to both stakeholders.
Construct a dedicated project team from the transferee, transferor and additional stakeholders.	The Safer Deliveries program created a dedicated TT team which operated out of the same physical location.	The program includes multiple healthcare practitioners, engineers and project managers within the University Health Network, while also including additional consultants. Critically, the transferee is also included in the primary TT team.	Once the pilot study was completed, a dedicated TT team was established consisting primarily of members from the transferee and transferor. However, additional stakeholders such as a mobile application developer and a telecommunications company were also incorporated.
Implement a managerial hierarchy for this project team.	The TT team exhibited a very clear hierarchy with the Tanzanian Ministry of health acting as head of the program.	The TT team is structured into four distinct tiers namely, project managers, healthcare consultants, developing engineers and frontline healthcare workers in the transfer environment.	There is a clear managerial hierarchy present in the TT team with VillageReach acting as the management team.
Outline a tangible or intangible incentive scheme for team members.	A monetary incentive is provided to end-users by subsidizing their transportation cost. An intangible incentive was the cost-saving of the transfer object after birth.	An intangible incentive scheme is put in place for the transferee by marketing the transfer object's benefits in the diagnosis process to local clinic workers and clinic management in the transfer environments.	No monetary incentive scheme is implemented. An intangible incentive scheme is implemented on an ad-hoc basis as individual stakeholders would marketing the benefits of the hotline to different end-user segments.
Routinely evaluate team members to remove members with limited future use for the project.	The TT team members are continually monitored but no action is taken to remove a stakeholder as no significant diminishing stakeholder contributions are identified.	The TT team is deliberately constructed from a very fluid partnership. Thus, team members are incorporated as required and placed into a "passive consulting role" when not actively required.	Impact assessments are conducted each year to partly ensure that team members achieved their targets set forth for that year. To date no stakeholder has failed to reach their target or displayed diminishing returns.

6.5.2.2 Stakeholder co-creation

As before, to simplify the comparison between the managerial best practices and the three case studies, the best practices advocated by the consolidated conceptual framework are first in restated Table 6-42 along with the individual case study outcomes. It is noted that all case studies presented examples for all stakeholder co-creation related best practices.

Table 6-42 - Comparison of the managerial best practices and case studies for stakeholder co-creation

Best practices	Case study outcomes with respect to stakeholder co-creation		
	Case study 1	**Case study 2**	**Case study 3**
Incorporate end-user's participation with regards to the project's creation and implementation.	The TT venture's pilot study was immensely important as it allowed the transferor to interact with the end-user, and their immediate community, to gain feedback and refine the mobile application	Due to the complexity of the transfer object, no end-user is consulted during the initial creation. However, feedback from end-users regarding the usability of the transfer object are routinely captured and relayed to the engineering team within the transferor.	Before the transfer object is expanded to a new district within Malawi, the local District Health Community Centre is contacted to understand the unique workings of that community. The transfer object is then evolved based on these outcomes.
Actively share existing knowledge and experience with other project team members.	The implementation of a communal office space from which all TT members could operate allowed for a collaboration of knowledge, advice and political will".	Only a specific group of personnel within the University Health Network are actively involved in the TT. However, additional members are continually consulted regarding specific cultural and political considerations within the transfer environment.	All transfer object-related knowledge is freely shared between the transferor, transferee, the telecommunications company and the mobile software developer to ensure that the transfer object's design and implementation reflect the goals of all the stakeholders involved.
Define the project as a profitable business venture or a strategic alliance.	The transferee and transferor "formed strategic partnerships with groups like UNICEF and Save the Children as they standardize, scale and sustain [the transfer object] at a national level'.	The transferor and transferee created a partnership "in the truest sense of the word partnership". The transferor also established several additional partnerships with other stakeholders to help facilitate the TT venture.	After the pilot study was completed in 2013, the project was defined as a strategic partnership between VillageReach and the ministry of health to achieve the goal of a nationwide implementation.

6.5.2.3 Legal considerations

As before, to simplify the comparison between the managerial best practices and the three case studies, the best practices advocated by the consolidated conceptual framework are first in restated Table 6-43 along with the individual case study outcomes. It is noted that no substantial example could be uncovered for the managerial best practice advocating that the transferor be legally bound to the TT in case study 1 during the discussions with the case study's project management leaders. A possible explanation for this is there is inherently no requirement as the ministry of health's commitment to the TT is never called into question. Alternatively, the bureaucracy of entering into a legal contract with a government branch may have made this an impractical solution.

Table 6-43 - Comparison of the managerial best practices and case studies regarding legal considerations

	Case study outcomes with respect to legal considerations		
Best practices	**Case study 1**	**Case study 2**	**Case study 3**
Attempt to contractually bind the transferor to the TT over its entire life-cycle.	No mention of contractually binding the Tanzanian ministry of health to the TT.	The stakeholder co-creation partnership between the transferor and transferee is outlined on a legally binding document at the commencement of the TT.	As the transferor is the primary driving force for the TT, no legal contract is ever required. However, there is "a memorandum of understanding between VillageReach and Airtel" to ensure that the required infrastructure will be made available indefinitely.
Incorporate legal counsel into the transfer object's design and development.	Technical advisors working for the Tanzanian government are heavily involved in the design of the mobile application to ensure that patient data was captured in an ethically sound manner.	Advisors from the WHO are incorporated into the TT team to, among other things, provide legal consultation and best practices regarding the transfer object and the different transfer environments in SSA.	From a legal standpoint, medical counsel is routinely incorporated both from the ministry of health and from external partners to ensure that the transfer object adheres both to domestic and international laws and regulations.
Incorporate legal counsel into the transfer object's implementation strategy.	Technical advisors working for the Tanzanian government are heavily involved in the implementation of the mobile application to ensure that patient data was captured in an ethically sound manner.	As with the transfer object's design, the WHO are incorporated into the TT team to provide legal consultation and best practices regarding the transfer object and the different transfer environments in SSA.	Legal teams from the ministry of health are consulted to help establish the boundaries and policy developments which ultimately fit into the government's e-Health policies for Malawi.

6.5.2.4 Standardisation

As before, to simplify the comparison between the managerial best practices and the three case studies, the best practices advocated by the consolidated conceptual framework are first in restated Table 6-43 along with the individual case study outcomes. It is noted that no substantial example could be uncovered for the managerial best practice advocating that team members are evaluated using standardised criteria for case study 1 during the discussions with the case study's project management leaders. A possible explanation for this is as the TT team is based within one office space and "across the hall when advice was required". As such no formal review of the members' capabilities is necessary.

Table 6-44 - Comparison of the managerial best practices and case studies for standardisation

Best practices	Case study outcomes with respect to standardisation		
	Case study 1	**Case study 2**	**Case study 3**
Implement market analysis as a universal starting point regardless of the initiating stakeholder.	The transferor utilised a small pilot study which represents this TT venture's initiation point. One of the outcomes of the pilot study was to identify the market viability of the transfer object.	No mention of market analysis is identified for the TT venture's original initiation point in Ghana. However, when the TT is expanded to additional SSA countries, market analysis is first conducted.	The transferor utilised a detailed pilot study which, in part, served as the market analysis for the TT venture. This allowed VillageReach to establish the social impact value of the transfer object.
Assign standardised tasks to individual team members of the TT team.	Both the transferor and transferee assigned standard tasks aimed at furthering the TT to members of the TT team.	The various members of the transferor are assigned standardised tasks based on their relevant experience and career level within the University Health Network.	VillageReach assigns standardised task to the additional members of the TT team each time the transfer object is expanded to additional districts.
Identify team members' capabilities using standardised criteria.	No mention of standardised team member capability evaluation identified.	The frontline health workers are screened and assigned various models of the transfer object in accordance with their levels of digital literacy.	VillageReach utilises a default procedure to both rank and train members of the TT team each time the transfer object is expanded to additional districts.
Implement and maintain a communication channel between all stakeholders throughout the TT entire life cycle.	A standard weekly meeting between all TT stakeholders has been implemented since 2014 to discuss the TT venture.	The TT team conducts monthly meetings. Additionally, the transferor will often conduct on-site visits for training, development and feedback purposes.	The TT team uses a combination of individual feedback, monthly updates, ad-hoc updates and a "steering meeting with all stakeholders every quarter" as the communication channels for the TT.
Document all project outcomes into standardised tables.	After the initial phases of the TT venture, the transferor established a data capturing process to both serve as a method of project revision and as "a lesson from history when we do new programs in the future".	The transferor captures all field data in standardised manner to, among other, publish journal articles. These journal articles are deemed as highly beneficial to the TT venture as they are required to obtain further grant funding.	The outcomes from every district within Malawi are documented every month using a standard system across all the districts.

Allow future TT projects to access the documentation of completed TT projects.	After the initial phases of the TT venture, the transferor established a data capturing process to both serve as a method of project revision and as "a lesson from history when we do new programs in the future".	As the transfer object is expanded into additional SSA country, the results captured in the journal articles are used both in the transfer object's implementation and for end-user training.	Each time the transfer object is expanded to an additional district, the local community is trained on the transfer object's design and implementation best practices using data from previous districts.

6.5.2.5 Project implementation methods

As before, to simplify the comparison between the managerial best practices and the three case studies, the best practices advocated by the consolidated conceptual framework are first in restated Table 6-45 along with the individual case study outcomes. It is noted that all case studies presented examples for all project implementation best practices.

Table 6-45 - Comparison of the managerial best practices and case studies for project implementation methods

	Case study outcomes with respect to project implementation methods		
Best practices	**Case study 1**	**Case study 2**	**Case study 3**
Screen the infrastructure components of the transfer environment and categorize available and missing components.	The transferor conducted an extensive infrastructure analysis of the transfer environment after the completion of the initial pilot study highlighting that transportation represented the only component that is absent.	The transfer object's development and implementation are wholly predicated on the results of the transferor's transfer environment screening. All missing infrastructure components are accounted for in the transfer object's design such as power grid availability and cell phone signal coverage.	As the transfer object is expanded into a new district, an analysis of the telecommunications infrastructure is completed to determine if additional infrastructure is required. This is then relayed back to Airtel.
Select infrastructure mitigation practices from a pre-defined standardised list.	With respect to digital literacy of the end-user, the TT team implemented a training-to-train program where community leaders would receive primary transfer object training to further disseminate through the local community.	The transfer object's design is completed using a combination of standardised infrastructure mitigation practices, provided by WHO guidelines, and tailored mitigation practices, provided by the transferee.	In instances where telecommunication infrastructure is lacking, Airtel would implement a standardised expansion procedure to specifically facilitate the TT transfer if financially and technically possible.
Identify tailored-made solutions for missing infrastructure components.	When evaluating the missing transportation infrastructure, the transferee implemented an incentive scheme which would fund the end-user's transportation costs. The transferee would be responsible for linking drivers and end-users.	The transfer object's design is completed using a combination of standardised infrastructure mitigation practices, provided by WHO guidelines, and tailored mitigation practices, provided by the transferee.	In instances where telecommunication infrastructure is absent and can not be improved upon, the TT team would implement a modified offline application into the district.
Implement a joint venture TT project between two or more stakeholders.	The TT venture was defined as a "joint venture partnership between D-Tree and the ministry of health" from the commencement of the program.	The TT venture is explicitly defined as a joint venture between members of the University Health Network and the frontline healthcare workers in SSA.	After the pilot study, the TT venture is explicitly defined as a joint venture between VillageReach, Airtel, the ministry of health and USAID.

6.5.2.6 Project evaluation methods

As before, to simplify the comparison between the managerial best practices and the three case studies, the best practices advocated by the consolidated conceptual framework are first in restated Table 6-46 along with the individual case study outcomes. It is noted that no substantial example could be uncovered for the managerial best practice advocating the implementation of a standardised revision tool to periodically review the TT for case study 2 during the discussions with the case study's project management leaders. An explanation for this is that no stage-gate feature is presented in this case study. As such, the TT venture is only reviewed when additional funding is required, as such a review is demanded by potential funders. A standardised revision tool would thus streamline the acquisition of additional funding as revision outcomes are routinely updated and always available.

Table 6-46 - Comparison of the managerial best practices and case studies for project evaluation methods

	Case study outcomes with respect to project evaluation methods		
Best practices	**Case study 1**	**Case study 2**	**Case study 3**
Implement a standardised tool to periodically review the TT.	During the development of the mobile application, a "on the dashboard data evaluation" tool was created which would allow certain benchmarks to be evaluated over the mobile applications implementation and subsequent adoption.	No mention of a standardised revision tool is identified for this case study.	At the conclusion of every year "an impact assessment of the mobile app and the hotline are conducted". This allows the transfer object's usefulness to be measured while also allowing VillageReach to report back to the stakeholders with data.
Compile project feedback from multiple stakeholder perspectives into a standardised table.	The transferor implemented a standardised project feedback tool over the life-cycle of the TT venture which would subsequently be used to create peer-review journal articles and promote the TT venture's academic exposure.	End-user feedback regarding the transfer object's usability is captured using standardised feedback forms.	Feedback forms are routinely captured from the district communities regarding the hotline's use within the community and which improvements can be made.
Implement standardised evaluation criteria for the final TT project revision.	The TT team installed multiple evaluation criteria regarding the transfer object during Phase I of the TT venture. These included patient use, frequency of use, frequency of visits to healthcare facilities and interaction periods with community leaders.	The TT venture is evaluated using both healthcare-related goals such as throughput and consistency as well as more subjective measures such as end-user usability and uptake. These evaluation criteria are standardised across all SSA countries.	While the TT's targets shift every year, VillageReach implemented a standardised impact assessment to measure the transfer objects usage within the transfer environment.
Allow future TT projects access to the revision documents of completed TT projects.	A major focus of the transferor is to capture project data and lessons so that they can be reused in future projects within the D-tree family.	Every expansion to an additional SSA country is based on the outcomes of previous implementations. Currently, the transfer object is being implemented into Laos based on the outcomes captured in Ghana, Tanzania and the Ivory Coast.	Whenever the transfer object is expanded into a new district, the end-users are trained using the outcomes gathered from the previous districts.

6.5.2.7 Training methods

As before, to simplify the comparison between the managerial best practices and the three case studies, the best practices advocated by the consolidated conceptual framework are first in restated Table 6-47 along with the individual case study outcomes. It is noted that all case studies presented examples for all training method related best practices.

Table 6-47 - Comparison of the managerial best practices and case studies for training methods

	Case study outcomes with respect to training methods		
Best practices	**Case study 1**	**Case study 2**	**Case study 3**
Construct training methods based on the end-user's existing internal training policies.	As the end-user is represented by pregnant women in rural Tanzania no existing internal training policies are applicable. However, community leaders were incorporated into the training process to ensure that end-users would be trained in their local cultural setting.	As the transfer object is a novel technological device most akin to a smartphone, the transferor did not uncover any local training methods already present. However, site visits are conducted to develop an iterative training process where the transferor and transferee would implement the transfer object together in a collaborative manner.	The TT team actively incorporates nurses and clinicians with two or more years of applicable experience into the development process of training additional staff. This allows the creation of "training sessions which feel familiar [to the staff]".
Implement on-site training.	All training sessions with supervisors, community leaders and the pregnant women are completed within their personal environment.	All initial training is completed on-site by the transferor. Additional training sessions are also often completed on-site by a combination of healthcare practitioners and engineers affiliated with the University Health Network.	All training is facilitated by the Malawian ministry of health with a mixture of on-site training and training at regional hospital and medical centres.
Train end-users to train future users of the transfer object.	Supervisors and community leaders both received training on the transfer object as well as training to disseminate knowledge along the user base.	The transferor describes their end goal as being able to leave the transfer environment completely without detracting from the transfer object's implementation. With this in mind, "training-to-train" is very heavily prioritised by the transferor.	A requirement of the USAID is that a training to train model be implemented specifically to ensure the dissemination of knowledge happens more rapidly. The local district community structure also implements a training to train system, albeit on a smaller scale.
Identify end-users' capabilities and construct training programs accordingly.	Community leaders are consulted to allow the TT team to understand which training methods would be "most useful" to the final end-user.	Digital literacy screening is conducted during the initial phases of the TT venture by the transferor. This, in turn, is utilised to conduct appropriate training programs for the end-users.	As an example, when nurses are receiving their training related to the nutrition module, they receive the training level that is applicable to their nutritional experience. A levelled training structure is thus utilised and tailored in accordance with the individual's capabilities.

6.5.2.8 Adoption and sustainability

As before, to simplify the comparison between the managerial best practices and the three case studies, the best practices advocated by the consolidated conceptual framework are first in restated Table 6-48 along with the individual case study outcomes. It is noted that all case studies presented examples for all adoption and sustainability-related best practices.

Table 6-48 - Comparison of the managerial best practices and case studies for adoption and sustainability

	Case study outcomes with respect to promoting adoption and sustainability		
Best practices	**Case study 1**	**Case study 2**	**Case study 3**
Construct a prototype of the transfer object to improve adoption among end-users.	The transferor utilised the pilot study to test the multiple aspects of the mobile application including ease of use and the willingness to utilise the various functions built into the application.	Initial field tests in the Ivory Coast are conducted with a prototype "to specifically identify problems with the [transfer object's] usability among the frontline healthcare technicians".	The transfer object prototyping is completed during the initial pilot study. It also allowed VillageReach to identify which additional healthcare areas end-users would like to see in future iterations of the transfer object.
Incorporate and incentivise early adopters into the TT team.	While early adopters are not explicitly included in the TT team, their feedback is continually used to make improvements to the mobile application.	Early adopters in the Ivory Coast are incorporated during the initial field test. The transferor states that "no incentivising was ever required as the technology was very well received among our initial test group".	District community managers are incentivised by VillageReach, while end-users are directly incentivised by Airtel through marketing and discount offerings regarding airtime, SMS and data packages.
Recruit ground-level members to champion the transfer object's adoption and diffusion.	To incorporate early-adopters, community leaders are approached to act as gatekeepers of the transfer object as they are considered "trusted members of the local community and far more likely to get the women on board". These community leaders are in effect the ground level champions of the TT venture.	As mentioned earlier, the transferor describes their end goal as being able to leave the transfer environment completely without detracting from the transfer object's implementation. With this in mind, multiple ground level champions are identified in each community to ensure the continued adoption of the transfer object.	The nurses and clinicians that are responsible for the hotline, as well as the mobile application's support features, represent the ground-level champions. The incorporation of local community members subsequently led to the diffusion of transfer object within their communities.

6.5.2.9 Marketing

As before, to simplify the comparison between the managerial best practices and the three case studies, the best practices advocated by the consolidated conceptual framework are first in restated Table 6-49 along with the individual case study outcomes. It is noted that no substantial example could be uncovered for the managerial best practice advocating marketing to additional private-sector stakeholders for case study 2 during the discussions with the case study's project management leaders. A possible explanation for this is that the transferor did not require additional private-sector stakeholders to aid in either the development or implementation of the transfer object. This results from the transferor's aim to enable the transferee to independently utilise the transfer object with only marginal input from other stakeholders when required.

Table 6-49 - Comparison of the managerial best practices and case studies for marketing

	Case study outcomes with respect to marketing		
Best practice	**Case study 1**	**Case study 2**	**Case study 3**
Market the project to additional public-sector stakeholders not in the original TT team.	As the Tanzanian ministry of health served as the transferee, no additional marketing is required within the original transfer environment. However, through the course of the TT venture, the Indian ministry of health is approached to conduct a trial expansion of the transfer object.	The transferor utilised journal articles to reach additional stakeholders at universities which in turn produced additional partnerships. However, it is noted that the transferor did not publish journal articles with this in mind and is rather an unexpected additional benefit.	In terms of marketing, VillageReach continually implements an "aggressive business development model to get additional branches of government as interested as possible".
Market the project to additional private sector stakeholders not in the original TT team.	As the transfer object is adopted by more end-users, the TT team attempts to incorporate additional telecommunication providers to serve as infrastructure supply partners.	No mention of additional private-sector marketing is identified in this case study.	Airtel runs multiple marketing campaigns aimed at additional third-party telecommunications and infrastructure supply partners to help decrease the infrastructure supply burden as the transfer environment is expanded.

6.5.3 Applicability outcomes per phases

As stated in Section 6.1, the primary function of the case studies is to highlight the applicability of the conceptual framework with regards to multiple real-world healthcare TT ventures across different SSA countries. Section 6.5.3 provides a comparison of all three case studies for every node within the conceptual framework. This includes nodes from the conceptual framework developed in Chapter 5 as well as the additions and modifications made to consolidate the framework. Thus, as mentioned previously, the consolidated framework applied to the three case studies contains the outcomes of the semi-structured interview and survey instrument. These outcomes are available for review in Section 6.3.3 and Section 1.1.1.

Phase I to Phase V of the consolidated conceptual framework is first outlined in Figure 6-56 to Figure 6-60. A further expansion is also provided to allow for a discussion of the relevant case study component and managerial action for every node within the conceptual framework. These case study discussions are provided for all three case studies, linked to the appropriate node via a dotted grey connecting line.

As the consolidated conceptual framework is already complex, this process produces five figures densely populated with case study information. However, it does provide a concise visual and text-based outline of the applicability of the conceptual framework and its constituents with respect to real-world healthcare TT ventures.

It is noted that the consolidated framework presented in Figure 6-56 to Figure 6-60 is only first discussed in detail in Chapter 7. However, due to the conceptual framework's tiered evaluation procedure, it is deemed important to highlight that the previous levels of evaluation are incorporated as the procedure progresses. This, in turn, allows for the most refined version of the framework to be produced.

To conserve the readability of the text within Figure 6-56 to Figure 6-60, the case studies are identified by a numeric number. As a reminder for the reader, case study 1 is the Safer Delivery Program with the parent organisation D-Tree International, case study 2 is the Mobile Microscope Diagnosis program with the parent organisation University Health Network and case study 3 is the Chipatala cha pa Foni program with the parent organisation VillageReach. Additionally, each case study adheres to the colour coding assigned to it throughout Section 6.5. A summary of all three case studies is provided in Section 6.5.1 and should be reviewed before or in conjunction with the following applicability outcomes.

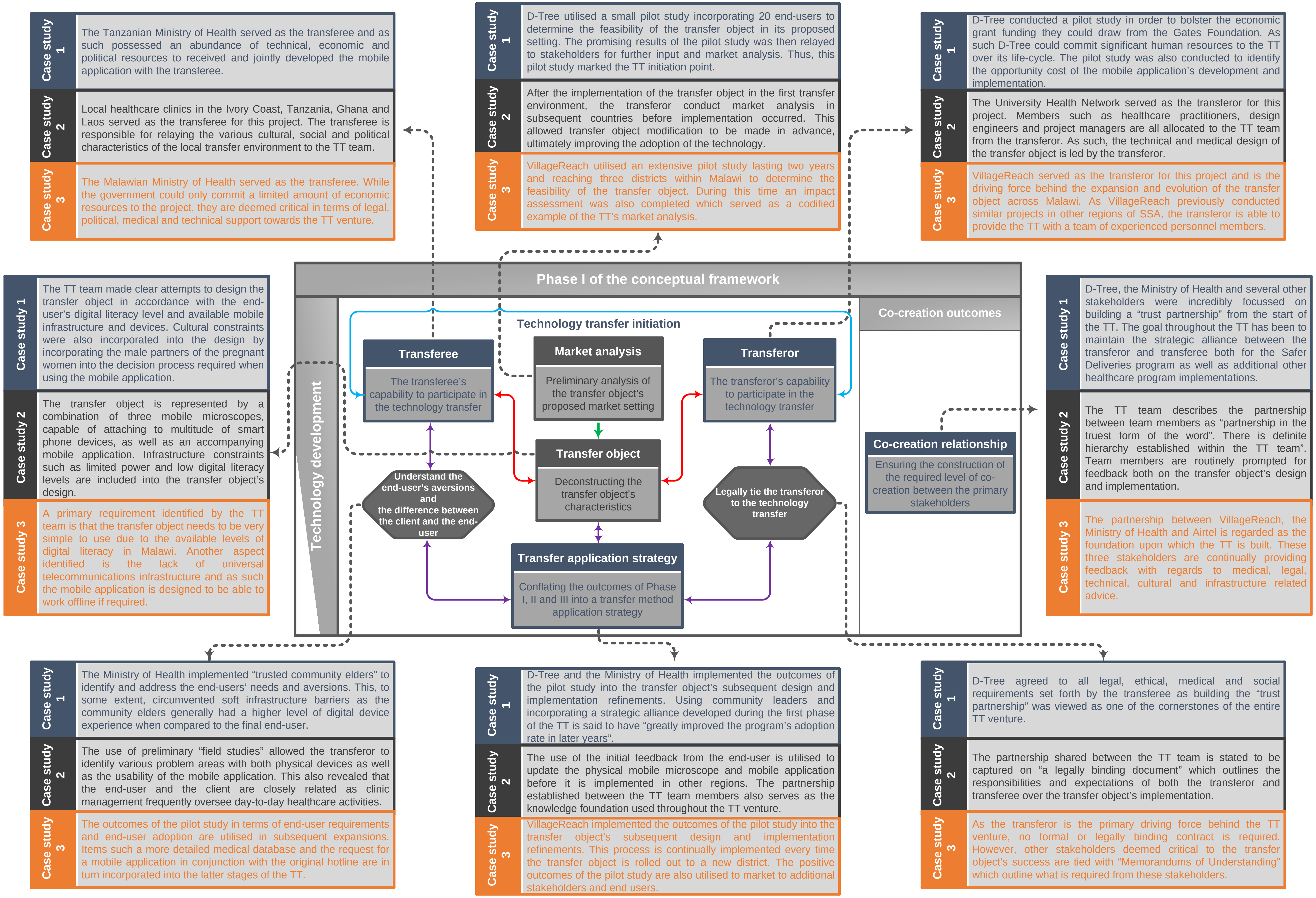


Figure 6-56 - Outcomes of the application of Phase I of the framework to the three case studies

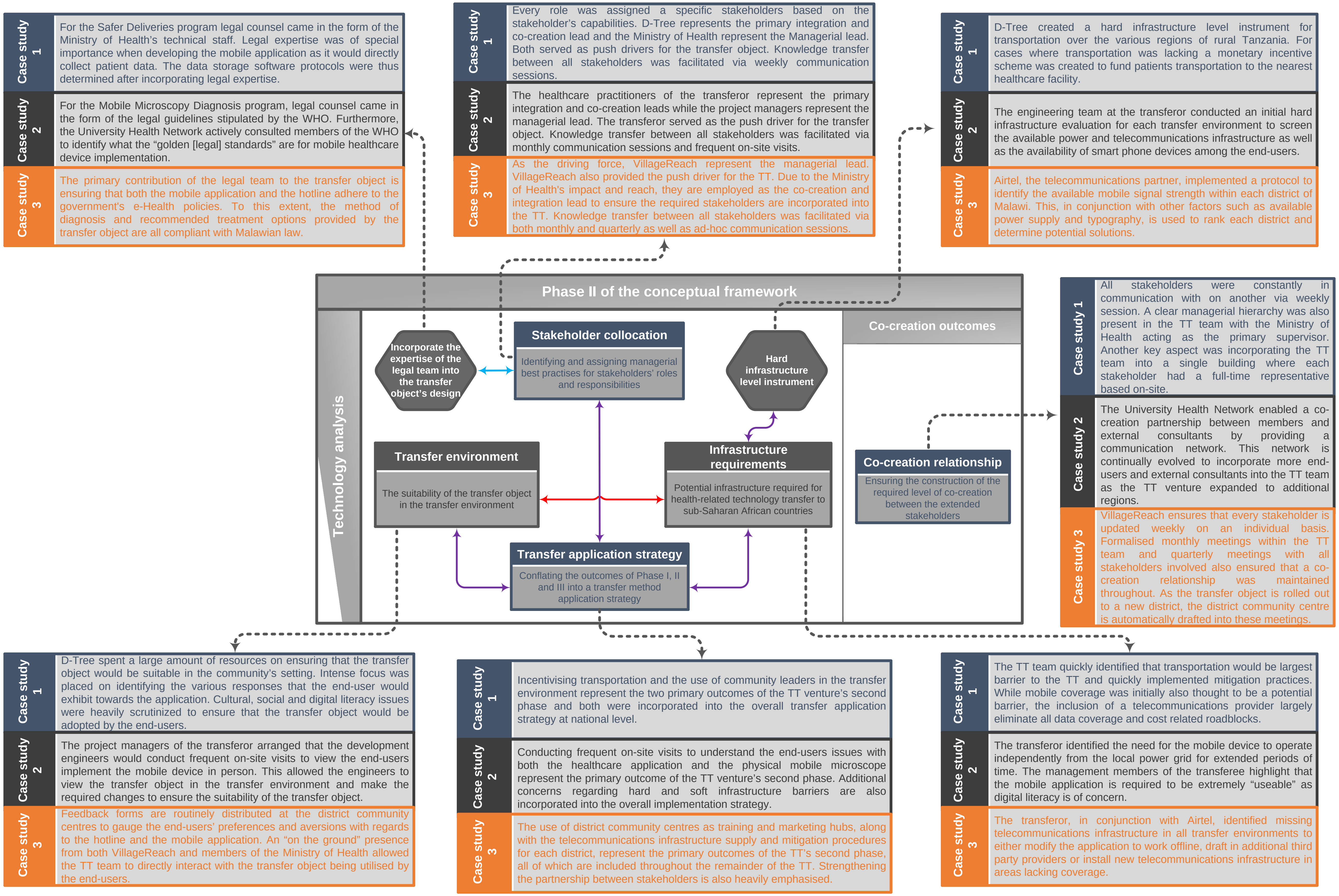


Figure 6-57 - Outcomes of the application of Phase II of the framework to the three case studies

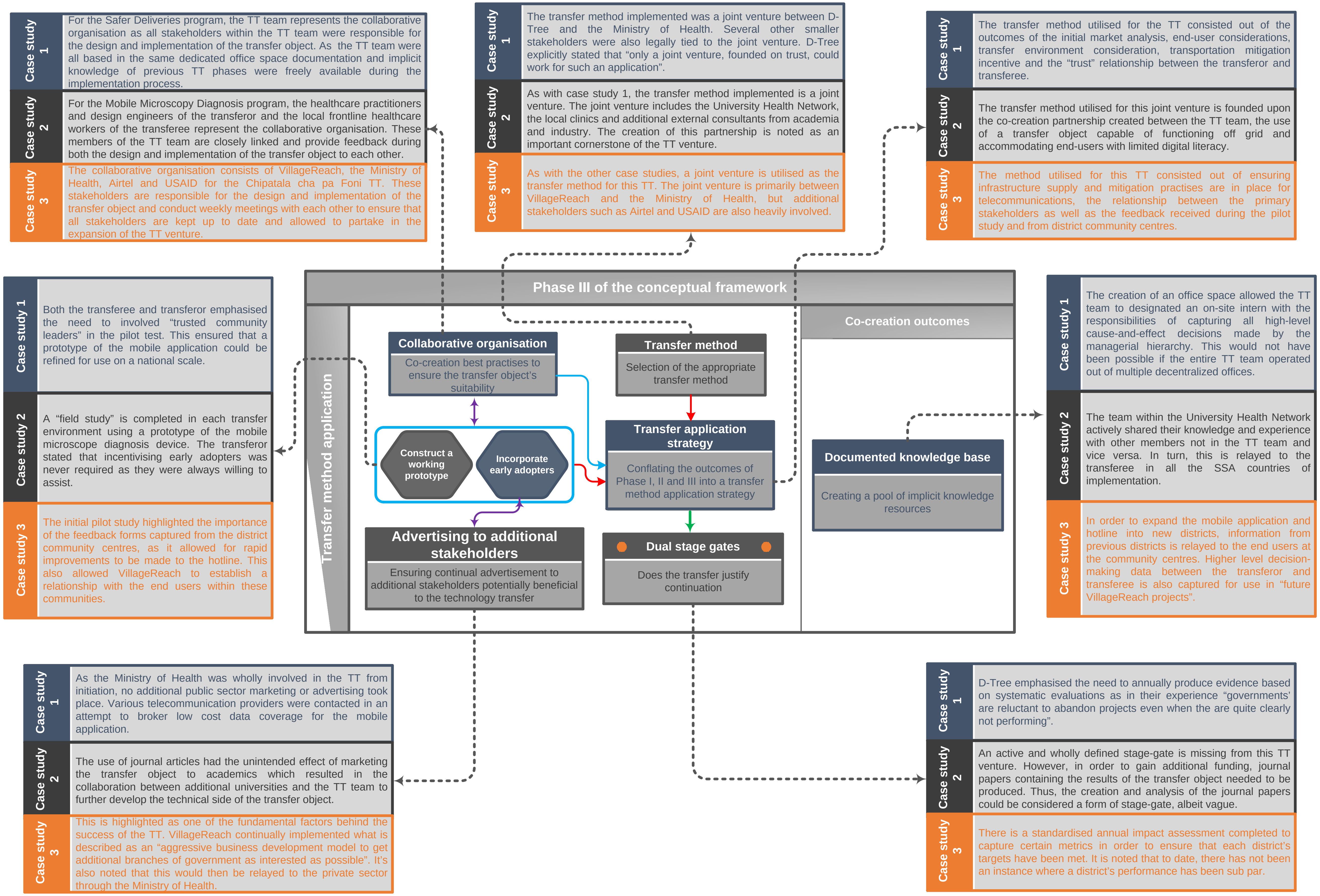


Figure 6-58 - Outcomes of the application of Phase III of the framework to the three case studies

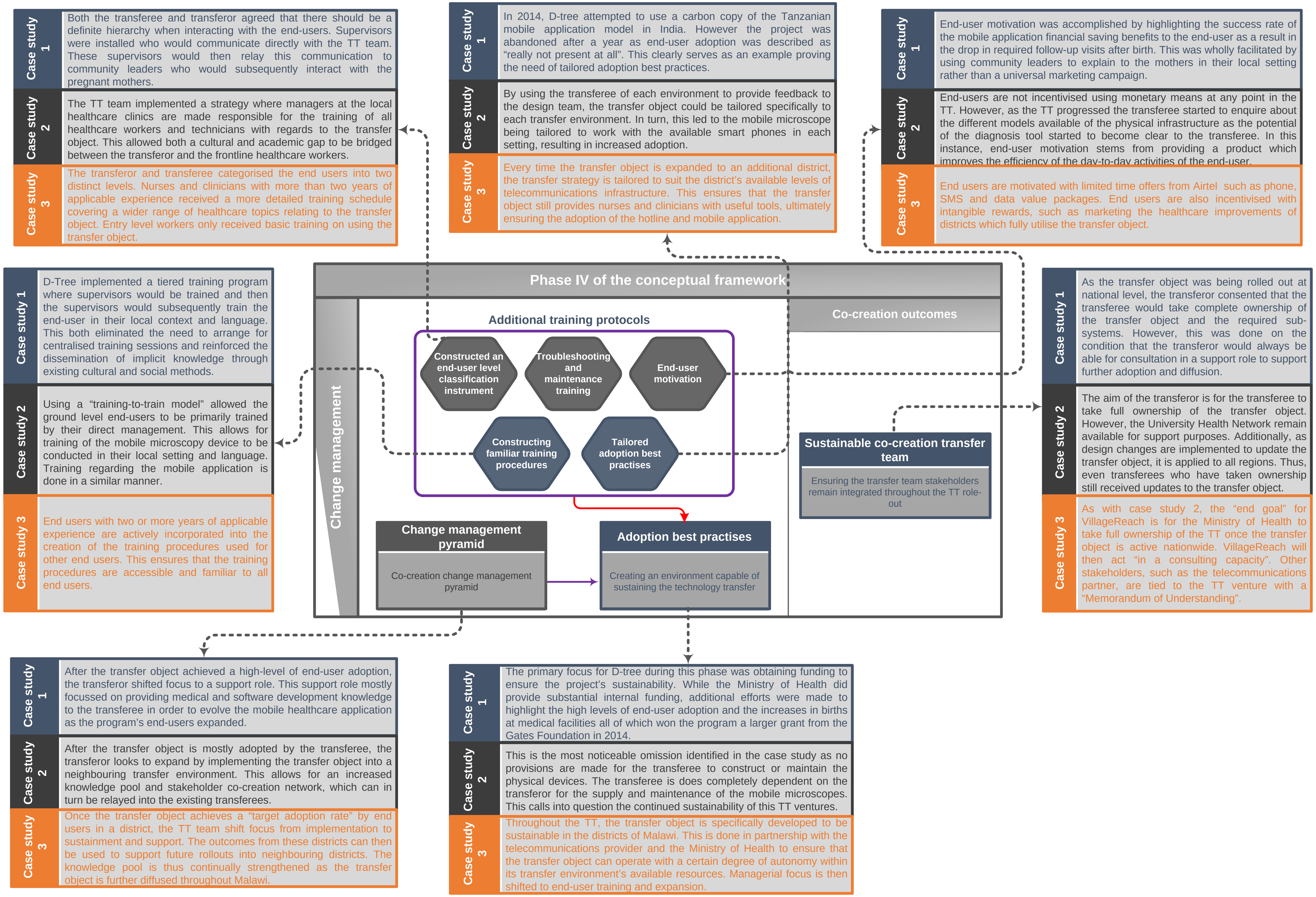


Figure 6-59 - Outcomes of the application of Phase IV of the framework to the three case studies

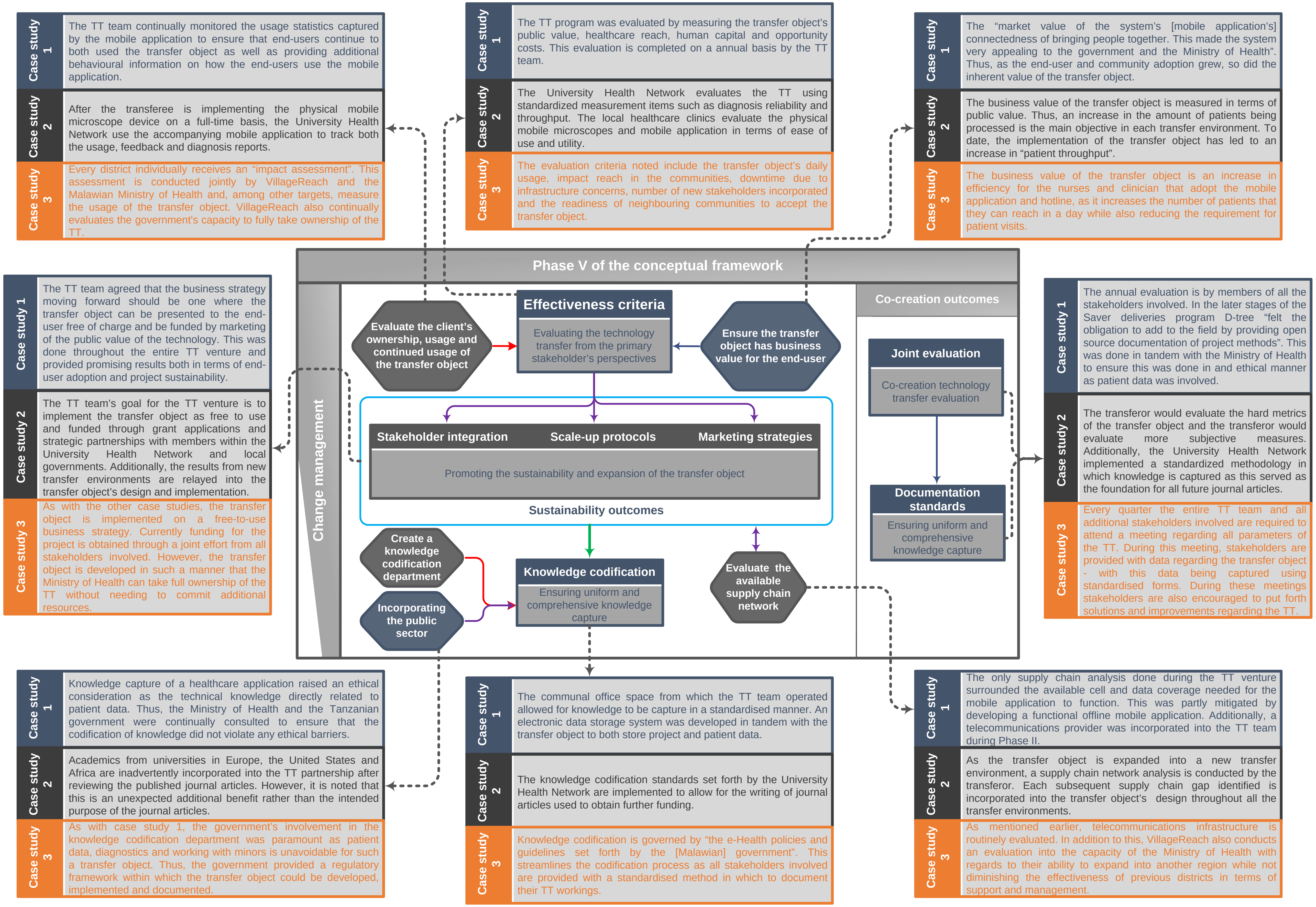


Figure 6-60 - Outcomes of the application of Phase V of the framework to the three case studies

6.5.4 Discussion of case studies outcomes

The application of the conceptual framework to the three case studies highlights the conceptual framework's applicability to healthcare TT ventures throughout the region of SSA. Furthermore, the differences between the three case studies in terms of stakeholders, transfer object and transfer environment prove the versatility of the conceptual framework for various forms of healthcare TT and their individual facets.

Additionally, the application of the framework also reveals some areas in which project managers may witness improved outcomes if the managerial best practices advised by the conceptual framework are implemented. The notion of standardised TT items surrounding knowledge codification and project evaluation methods are noted to be somewhat lacking in case study 2 yet these items are shown to be explicitly required when seeking further international funding.

On a final note, it is important to note the generalisability of case study applications. Literature suggests that the outcomes of case study applications should be regarded as credible and confirmable rather than valid and reliable (Merriam, 1985). This notion is somewhat mitigated by the application of the framework to multiple case studies rather than one, yet the framework's content and structure are better evaluated by the outcomes of the semi-structured interviews and the survey. This coupled with no identified framework refinements during the third level of framework evaluation, results in no further revisions made to the consolidated conceptual framework, shown in Chapter 7. The outcomes of the case studies thus only serve to highlight the applicability of the conceptual framework to healthcare TT ventures in SSA.

6.6 Chapter 6: Conclusion

Chapter 6 outlines the evaluation procedure for the conceptual framework, first developed in Chapter 5. This evaluation is completed in three levels, the first of which investigates the framework's content and structure by conducting semi-structured interviews with TT industry experts. The interview sessions extract industry expertise by questioning each interview candidate with predefined questions while posing tailored follow up questions based on the individual candidate's response.

A summary of the interview's outcomes is provided in Table 6-24 with multiple segments of the conceptual framework receiving validation by the interview candidates. However, multiple additions regarding all five framework phases are also uncovered and highlighted in Section 6.3 for inclusion in the final consolidated framework. Stakeholders considerations, prototyping, incorporating early adopters and the creation of value for businesses serve as some examples of these additions.

The interview candidates also highlighted several instances where theoretical literature and their practical case experience varies. To accommodate these differences, the required modifications are also outlined. The primary modifications to the conceptual framework surround the use of dual stage-gates as well as the flow of the framework's first three phases. Other modifications included, amongst others, exclusively altering the transfer object and constructing segmented stakeholder training programs.

The second level of the framework's evaluation utilised a survey instrument. The survey instrument's outcomes are based on 89 responses received from TT managers active in SSA. The survey aims to further investigate potential refinements to the framework's phases and structure, although to a lesser extent when compared with the semi-structured interviews. However, the survey enables the perceived ease of use and usefulness of the framework's individual managerial best practices to be evaluated as well as the various collective phases within the conceptual framework. The primary outcomes of the survey are shown in Section 6.4.2 and Section 6.4.3.

An additional function of the survey instrument is to identify how various regions within SSA interpret and utilise the framework, the results of which are shown in Figure 6-39 and Figure 6-54. While no statistically significant difference is uncovered regarding the usefulness of the framework, the variance analysis conducted shows that both Western and Central Africa perceive the initial phases of the framework to be more difficult to implement when compared with the rest of SSA.

As stated in Section 6.4.3.4, perhaps the most important results produced by the survey are those produced by the regression analysis regarding usefulness. These results confirm that the managerial best practices listed within each phase of the conceptual framework are positively correlated with the adoption levels obtained by the transfer objects of the survey's respondents. The results of this regression analysis are shown in Table 6-36.

The third and final level of evaluation surrounds the conceptual framework being retrospectively applied to three different case studies. The framework applied to each case study is first consolidated with the outcomes of the semi-structured interviews and survey. For all three case studies, the framework is regarded highly applicable as only select framework items are not observed during the case study interviews.

Chapter 7. Consolidated technology transfer framework

Chapter 7 represents the culmination of the research study as it presents the consolidated conceptual framework designed to facilitate health-related TT to SSA. This framework has been developed in Chapter 5, based upon the outcomes of the systematic literature reviews, shown in Chapter 3 and Chapter 4. The framework is subsequently evaluated and refined through the use of semi-structured interviews, a survey and case study applications, shown in Chapter 6. The main outcomes of Chapter 7 have been summarised in Figure 7-1.

Table 7-1 - The role of Chapter 7 within the research structure

Document framework							
Research objectives	i.	i. & ii.	i. & ii.	ii. & iii.	ii. & iii.	iii.	iii.
						iv.	
Conceptual Framework Analysis phases	Map data sources	Categorise data	Identify concepts	Deconstruct concepts	Integrate concepts	Synthesis	Validate
Corresponding chapters	Problem statement Chapter 1		Comparative literature review Chapter 4			TT facilitation tool Chapter 6 Chapter 7	
		Conceptual literature review Chapter 3			Conceptual framework Chapter 5		

Key outcomes

- Present the consolidated TT framework
- Highlight the required relationships between the nodes and phases of the consolidated TT framework
- Outline the individual phases of the consolidated TT framework
- Highlight the corresponding data for each node of the consolidated TT framework

Figure 7-1 - Key outcomes of Chapter 7

7.1 Consolidated conceptual technology transfer framework

Section 7.1 both depicts the completed framework as well as presenting the expanded individual phases of the framework. The completed framework is presented in Figure 7-2, while Phase I to Phase V are illustrated in Figure 7-3 to Figure 7-7 respectively. The illustrations of Phase I to Phase V are first shown in Section 6.5 as it is deemed important for the final consolidated framework to be retrospectively applied to the three case studies. The critical reflection of each phase is subsequently outlined during Section 7.1. along with references to individual node foundations as well as refinements made during the evaluation procedure.

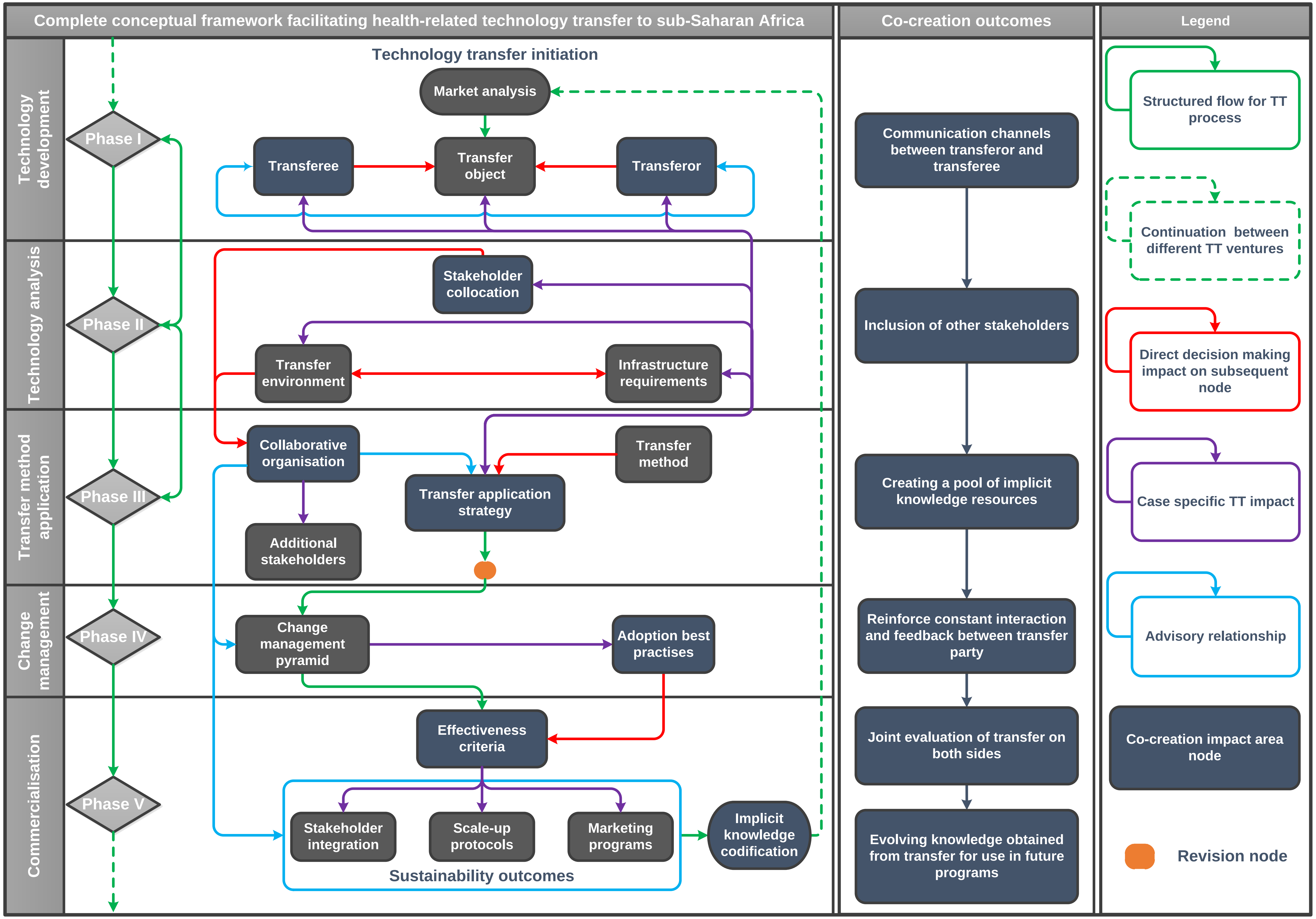


Figure 7-2 - The consolidated conceptual framework facilitating health-related technology transfer to sub-Saharan Africa

7.1.1 Summary and critical reflection on Phase I of the consolidated conceptual framework

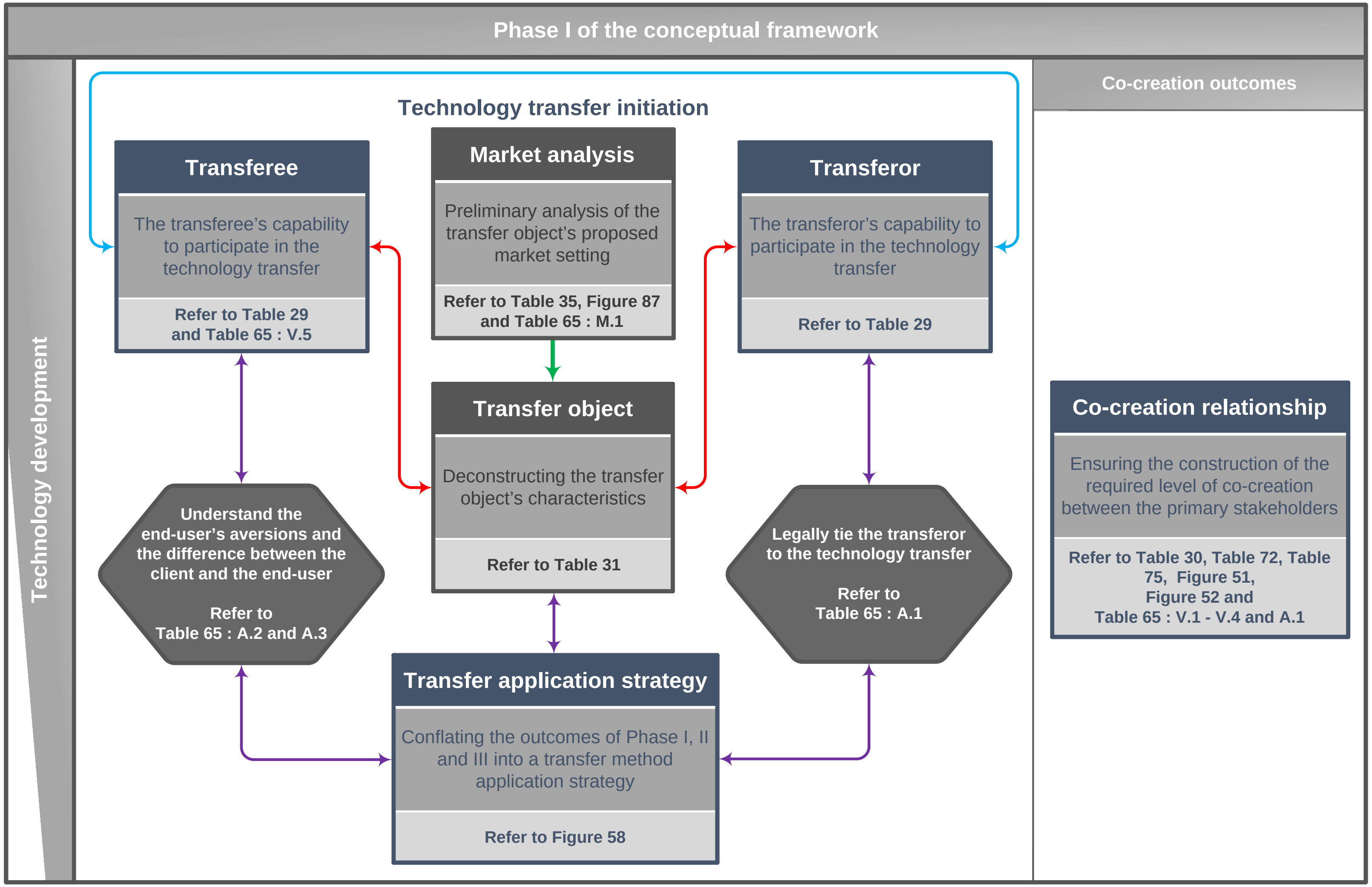


Figure 7-3 - Consolidated version of Phase I of the conceptual framework

Phase I of the consolidated conceptual framework aims to provide the framework's user with a universal starting point, market analysis, regardless of the user's association with the proposed TT. During the completion of the first phase, the framework will attempt to facilitate the construction of the primary transfer team, consisting of the transferee and transferor. Additionally, the co-creation outcome of Phase I provides recommended guidelines to promote the required quality and frequency of communication between the primary transfer team.

After the evaluation procedure highlighted the requirement for Phase I through Phase III to be collapsed into a concurrent sequence, refer to Table 6-19, the transfer application strategy, refer to Section 5.4.3.2, has been incorporated into Phase I. A potential beneficial change to Phase I's universal starting point could be the formulation of the transfer application strategy instead of market analysis to emphasise the need for a concurrent sequence. Similarly, Phase I and Phase II could be exchanged as it could be argued that technology analysis precedes technology development with respect to a TT venture.

As the primary transfer team represents the primary stakeholders of most TT ventures, it is important to include this relationship in the first phase of the framework regardless of the initial sequence of the framework's first three phases. Ultimately, as Phase I, Phase II and Phase III are completed concurrently, the exact sequence of the first three phases will generally be arbitrary. However, by providing the framework's user with a guided sequence, it provides the user with a step-by method with which to unpack, understand and complete a dynamic TT procedure with multiple requirements.

Another outcome of the evaluation procedure surrounded the need to outline the variance between the end-user of the transfer object, and the client who commissioned the TT. For healthcare TT, these two entities are rarely aligned as the end-user will typically either comprise of medical personnel or a patient, whereas the client will reside in an administrative role. If the consolidated conceptual framework were to be applied to a TT venture outside the sphere of healthcare, it would require additional analysis to determine if this variance still exists and if it requires specific attention. This may be necessary in certain industries, while in others the end-user and clients may represent the same entity.

The final major outcome highlighted by the evaluation procedure is the need to identify the transfer environment during the market analysis and tailor the framework appropriately. TT ventures that are conducted in Western and Central Africa are encouraged to implement intangible incentive schemes as monetary formats are shown to both increase the overall difficulty of Phase I's implementation while also reducing the usefulness of Phase I co-creation node.

7.1.2 Summary and critical reflection on Phase II of the consolidated conceptual framework

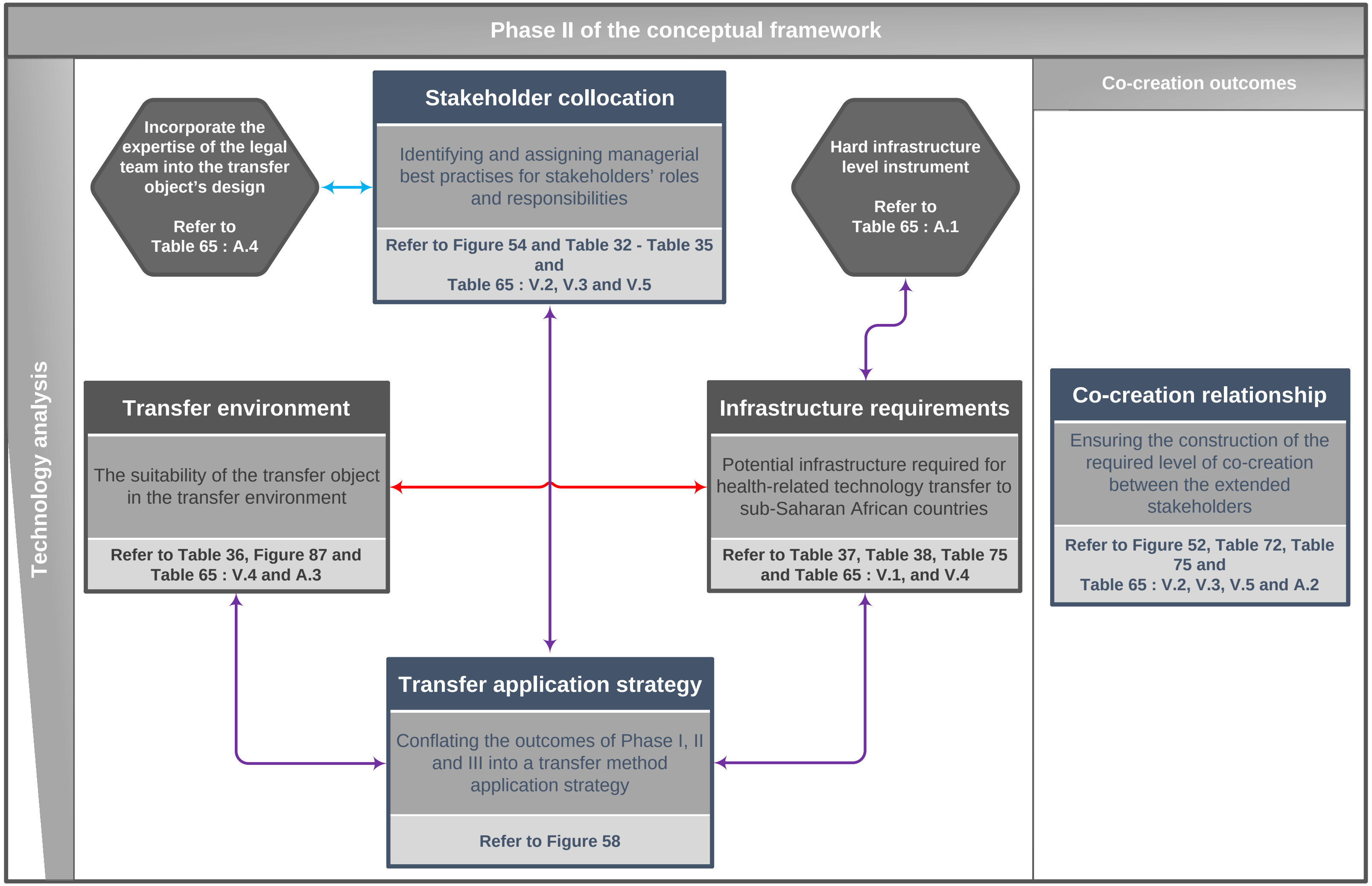


Figure 7-4 - Consolidated version of Phase II of the conceptual framework

Phase II of the consolidated conceptual framework aims to expand the primary transfer team by highlighting the high-level stakeholders which would generally be involved in a healthcare TT venture. Various roles and responsibilities are also provided which allow the extended transfer team to evaluate which stakeholders should be assigned to specific roles and responsibilities. In turn, this process also enables the extended transfer team to evaluate if additional stakeholders will be required to perform certain roles or responsibilities.

As with Phase I, the co-creation outcome of Phase II recommends the same guidelines to promote the required quality and frequency of communication between the extended transfer team. However, based on the outcomes of the second level of the evaluation procedure as shown in Table 6-27 and Table 6-33, the TT team should not prioritise the creation or explicit definition of a business venture or strategic partnership as this definition may require considerable human effort while producing limited additional utility. If the creation of a strategic partnership is considered a definite requirement for the initial TT team, it must be outlined as such as the very start of the TT venture. Additionally, it is recommended that such a relationship only be pursued between the transferor and transferee rather than the extended TT team.

The evaluation procedure of Phase II also highlights the benefits of incorporating legal counsel into the design outcomes of the transfer object, refer to Table 6-20. This gives credence to the argument that the stakeholder collocation node of Phase II is not exhaustive and additional stakeholders, with substantial utility towards the TT venture, may have been overlooked by this conceptual framework. Similarly, the stakeholder collocation node is tailored towards healthcare TT and may require substantial modification if the conceptual framework is applied to other industries.

Phase II revolves around ensuring that the extended transfer team analyses the transfer environment to determine the suitability of the transfer object, investigated in Phase I, in the proposed transfer environment. Phase II provides various transfer environment considerations as well as managerial best practices. Further investigation regarding the infrastructure of the transfer environment has also been provided. While the managerial mitigation practices provided for lacking infrastructure serves as a base guideline for the extended transfer team, it may not be applicable to TT ventures outside of SSA or the healthcare industry.

Other non-SSA developing nations could potentially suffer from similar infrastructure inadequacies but additional analysis will be required to ensure the elucidation of their infrastructure landscape. Likewise, the managerial mitigation practices identified for SSA nations may not be applicable to other developing nations due to economic, social, cultural or political reasons.

As with Phase I, the nodes outlined within Phase II should also be tailored to the specific geographic region in which the TT venture is being conducted. While the evaluation procedures did not indicate that Central, Eastern and Southern Africa require any specific modifications, TT ventures implemented in Western Africa displayed a decrease in the perceived ease of use of Phase II of the conceptual framework, refer to Figure 6-39. Specifically, the use of standardised infrastructure mitigation best practices is shown to be more difficult to implement in Western Africa. Thus, it is important for a TT team operating within Western Africa to tailor both the transfer environment and infrastructure requirement nodes to accommodate a more flexible approach when addressing lacking hard and soft infrastructure components.

An oversight in the original conceptual framework development's Phase II, refer to Figure 5-13, was the omission of a high-level managerial mitigation practice that allows for various levels of infrastructure to receive corresponding levels of transfer objects. The first level of the evaluation procedure highlighted the need to incorporate a hard infrastructure level instrument which enables the ranking of the transfer environment's available level of hard infrastructure, refer to Table 6-20. This instrument would subsequently provide guidelines stipulating the transfer object's recommended level of permittable technological complexity corresponding to the level of hard infrastructure available.

7.1.3 Summary and critical reflection on Phase III of the consolidated conceptual framework

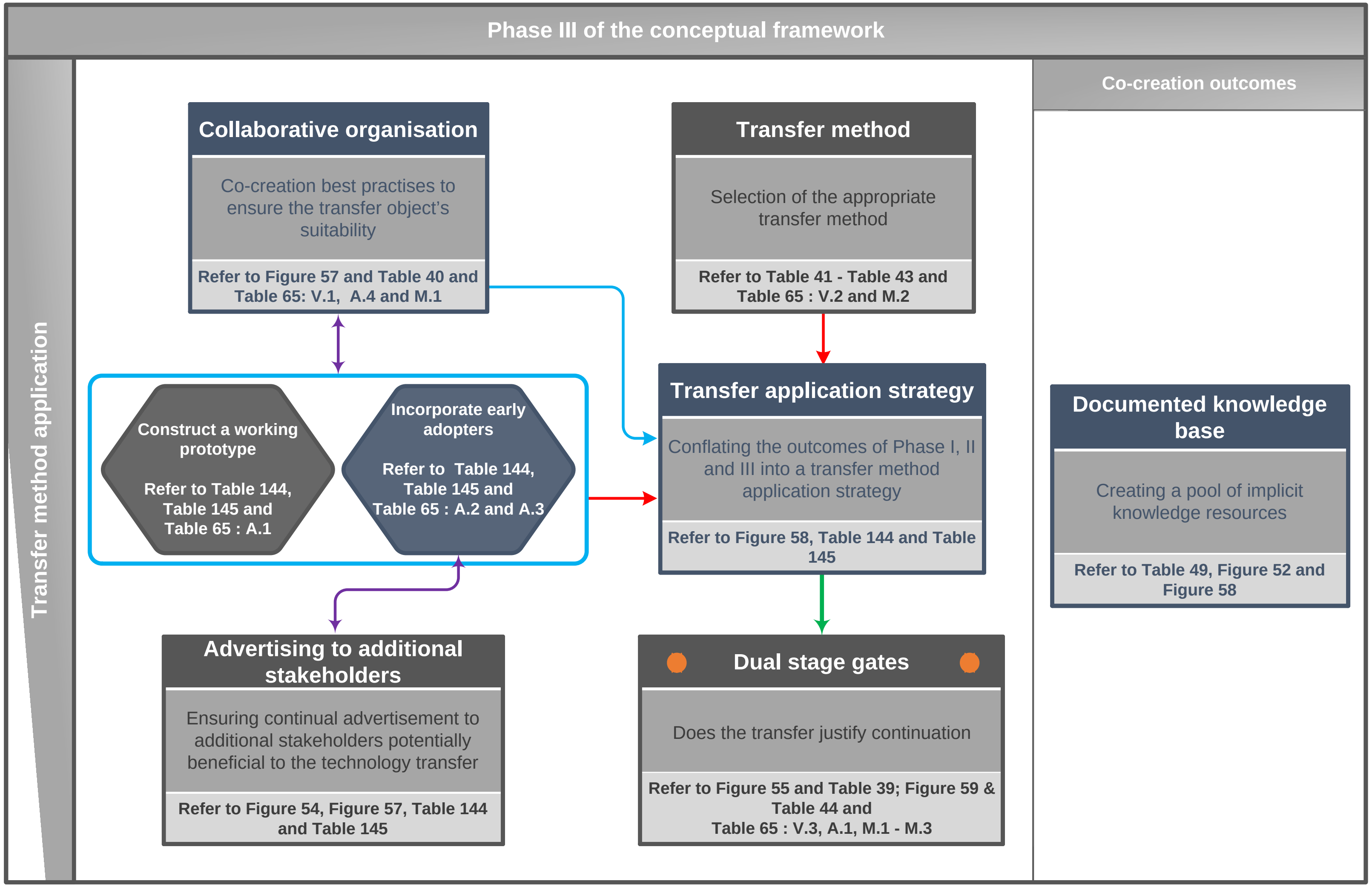


Figure 7-5 - Consolidated version of Phase III of the conceptual framework

Phase III of the consolidated conceptual framework aims to complete the transfer application strategy by incorporating the outcomes of Phase I, Phase II, the transfer method node and the collaborative organisation node. These outcomes are conflated into a strategy which can be utilised to facilitate the transfer of the transfer object into the transfer environment. The co-creation outcome of Phase III recommends documenting this transfer method application strategy and ensuring this resource is made available to all relevant TT stakeholders.

The collaborative organisation node provides an extension to the transfer environment node, shown in Phase II, by recommending the creation of an entity within the extended transfer team dedicated to ensuring the suitability of the transfer object within the transfer environment. While suitability is an important consideration for the transfer environment node, the framework could potentially be streamlined by completely removing suitability considerations from Phase II as it revisited in detail during Phase III. However, given the results of the second level of the evaluation procedure shown in **Table 6-36**, this is only recommended if a TT team's time and monetary resources are severely limited as suitability screening is deemed as very useful to healthcare TT ventures.

An improvement, highlighted by the first level of the evaluation procedure, to the collaborative organisation node was the inclusion of early adopters and the need to provide them with a working prototype of the transfer object, refer to Table 6-21. While the conceptual framework development's Phase III, refer to Figure 5-16, did highlight the need to advertise to additional stakeholders, the incorporation of early adopters was not explicitly recommended. The omission of recommending a working prototype was another oversight of the original conceptual framework's Phase III as this will highlight the required transfer object modifications early on in the TT venture. Both these modifications are also endorsed by the results of the second level of the evaluation procedure as shown in Table F-6 and are also items identified within all three case study applications, shown in Figure 6-58.

The transfer methods provided in the consolidated conceptual framework, refer to Table 5-20 and Table 5-21, represent a wide spectrum of potential transfer vehicles. However, when conducting the evaluation procedure there was no formal outcome regarding the use of any transfer method apart from joint ventures. Similarly, the TT models investigated in Appendix A do not promote a specific transfer method, apart from select licensing agreements. However, the utilisation of a predefined transfer method will provide the extended stakeholder team with a set of formalised, documented and legally binding standards while conducting the TT venture. Thus, the formal use of a transfer method is greatly encouraged by Phase III of the consolidated conceptual framework.

Lastly, the first level of the evaluation procedure led to removal of a stage-gate in Phase II. This stage-gate's contents have been conflated with the stage-gate in Phase III. Both theoretical literature and the evaluation procedure, refer to Table 6-21 and Appendix A.9, condoned the usage of stage-gates across multiple phases. However, several interviews conducted with TT project leads outlined the time and monetary implications of a stage-gate. Thus, the use of a single stage-gate was implemented as it retains the functionality of the original two but should provide a more economical revision structure.

7.1.4 Summary and critical reflection on Phase IV of the consolidated conceptual framework

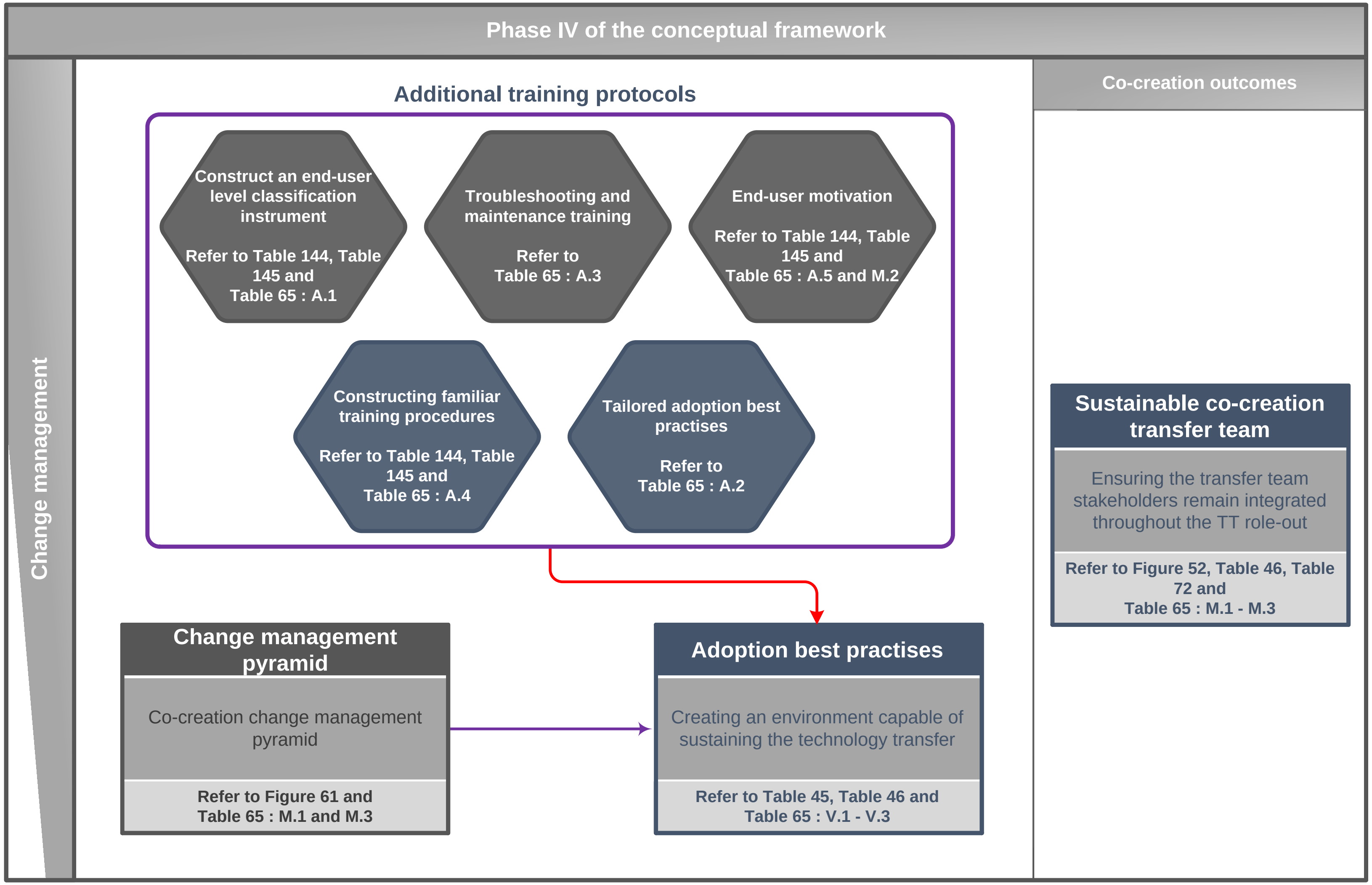


Figure 7-6 - Consolidated version of Phase IV of the conceptual framework

Phase IV of the consolidated conceptual framework aims to outline the recommended change management best practices for both the primary TT team, the transferor and transferee, and the extended TT team. These recommended change management and adoption best practices are presented in a change management pyramid shown in Figure 5-21. The base of the pyramid provides the recommended change management best practices for both the transferee and transferor in an attempt to cement the transfer object's sustainability. Once complete, the top of the pyramid advises a co-creation change management structure where the training, outreach and communication of the extended TT team are refined to reinforce the transfer object's sustainability within the transfer environment.

The adoption best practices have received multiple additions from the first and second levels of the evaluation procedure as shown in Table 6-22, Table F-6 and Figure 6-35. Phase IV of the original conceptual framework attempted to construct adoption best practices that could be universally applied to a wide spectrum of healthcare TT ventures. However, the outcomes of Table 6-22 contradicted the original adoption best practices by indicating that tailored managerial best practices will be required to increase the rate of adoption, and subsequent diffusion of the transfer object. Thus, the extended TT team must utilise the documented outcomes of Phase I, Phase II and Phase III to construct adoption best practices suited to the TT venture. Additionally, the TT team must evaluate the applicability of the universal best practices provided, refer to Figure 5-21, with respect to their individual TT venture.

In addition to the tailored change management practices, the extended TT team must utilise the outcomes of the transferee and transfer environment nodes to align all training programs with the transferee's existing internal training protocols. Another oversight of the original framework with respect to adoption was sufficiently motivating the end-user. The evaluation procedure outlined that an increase in end-user adoption will likely be observed if the end-user has been explicitly informed in how the transfer object will solve their individual problems.

The change management best practices advocating routine evaluation of TT team members and removing members who have become redundant is shown to be the most difficult managerial best practise to implement as outlined by the results of the second level of the evaluation procedure shown in Table 6-27. This evaluation outcome, coupled with the co-creation nature of the consolidated conceptual framework, requires the evaluation of TT team members to be revised. While the routine evaluation of the contributions of TT team members is still strongly advocated, the change management must instead focus on ensuring the continued inclusion of stakeholders with diminishing returns rather than explicitly removing them from all operations. Additionally, the third level of the evaluation procedure highlighted that maintaining a favourable relationship with all TT stakeholders may result in favourable stakeholder relationships for future TT ventures of a similar nature.

Similar to the hard infrastructure level instrument discussed in Section 7.1.2, evaluating the end-user's digital literacy, education, authority, ethical and compliance levels may promote the adoption of the transfer object. By creating an instrument that allows the extended TT team to screen different classes of end-users and rank them according to predefined criteria, it may allow for segmented tailored training procedures to be developed. This may, in-turn, allow for concentrated training and education programmes with content applicable to the specific level of end-user. An additional training programme uncovered by the first level of the evaluation procedure is training end-users not only to utilise the transfer object but also to troubleshoot and perform basic maintenance on the transfer object when required.

Finally, it could be argued that the change management required for adoption must be implemented before the actual transfer of the transfer object. However, while the change management phase could be introduced earlier in the framework, the complex and dynamic nature of TT resulted in this framework's step by step approach to improved accessibility and understanding. Additionally, the outcomes of Phase I, Phase II and Phase III will be required before active change management can take place.

Incorporating Phase IV with the early phases may, however, be a feasible alteration depending on the nature of the transfer object, transfer environment and the level of public sector support. When reviewing the case study application of the Safer Deliveries program, it is evident that difficulty associated with ground-level change management with respect to a foreign health technology decreases when the transfer environment's public sector provides a strong push or pull element to the TT venture.

7.1.5 Summary and critical reflection on Phase V of the consolidated conceptual framework

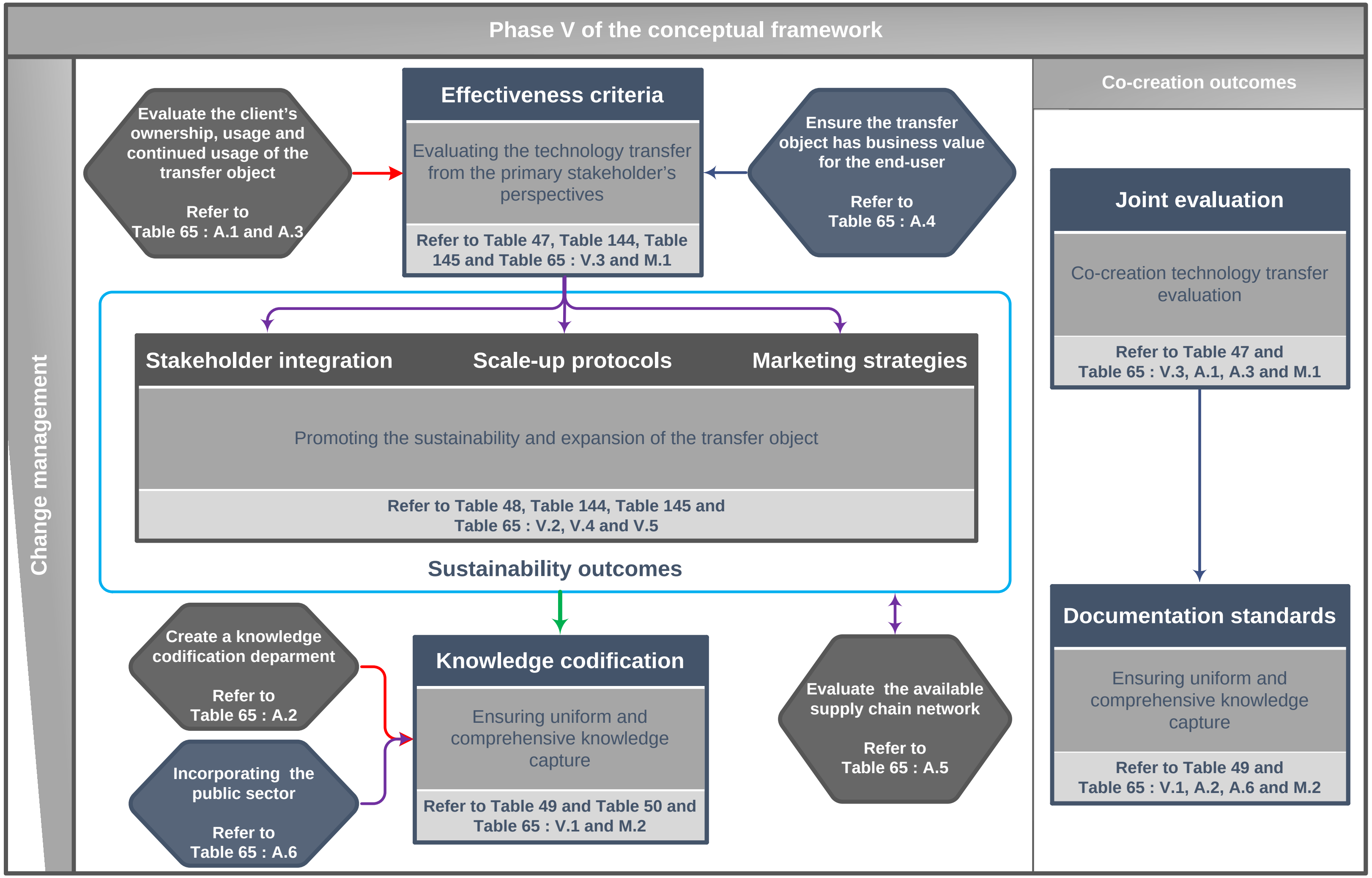


Figure 7-7 - Consolidated version of Phase V of the conceptual framework

Phase V of the consolidated conceptual framework allows the primary TT team to review the relative success of the completed TT venture. Multiple yardsticks and revision criteria are provided, refer to Table 5-25, with which the transferee and transferor may rank the overall success of the TT. The first level of the evaluation procedure outlined that end-user usage and continual usage, represent two additional yardsticks by which the TT may be measured. Another oversight from the original framework was the omission of measuring whether the TT has created market or public value for the end-user, a yardstick deemed critical by the evaluation procedure.

Codification best practices for knowledge documentation and communication standards are also outlined in Phase V. These standards must be applied through the completion of all five phases of the consolidated conceptual framework. Additionally, the first and second levels of the evaluation procedure suggested that an entire department, within the extended TT team, could be created to establish and enforce these standards. While not feasible for all TT ventures, it could be beneficial to lobby the relevant public-sector department to establish nation-wide standards with regards to specific documentation. This will, in turn, also promote compliance amongst the extended TT team and other stakeholders.

As the codification standards must be applied from the commencement of the TT, it could be argued that the knowledge codification node should be implemented in Phase I. However, as a primary goal of this node is to ensure knowledge codification for implementation in future TT ventures, it has been incorporated in Phase V. A feasible alternative would be to include the knowledge codification node into all five phases of the framework, albeit this would add an additional level of complexity to each phase.

An issue exposed by the evaluation procedure is the role of commercialisation in TT ventures. Likewise, it has been a concept that has been rarely incorporated into the identified TT models shown in Appendix A. Thus, the argument could be posed that TT and commercialisation do not overlap. Select interviews in the first level of the evaluation procedure outlined that commercialisation would be attended to by a licensee, rather than the extended TT team. However, when considering the sustainability of a TT, the creation of business value and ensuring market dissemination of the transfer object represent key requirements to ensuring TT sustainability both of which are strongly endorsed by the first and second levels of the evaluation procedure. Thus, the consolidated framework has attempted to incorporate stakeholders such as licensees into the active TT team to aid in the commercialisation and subsequent sustainability and diffusion of the TT venture.

7.2 Chapter 7: Conclusion

Chapter 7 presents the final consolidated TT framework. A complete outline of the entire framework has been illustrated by Figure 7-2 along with the required relationships between the phases and nodes of the framework. Lastly, Figure 7-2 presents all recommended co-creation outcomes as well as highlighting the corresponding co-creation nodes within each phase of the framework.

Chapter 7 also provides an expanded view of the completed framework by presenting each phase individually. These expansions have been shown in Figure 7-3 to Figure 7-7 respectively. Each expanded phase provides a node summary while also highlighting the relationships required between the nodes within a phase. The expanded phases also outline where each node’s corresponding data, both from the framework’s development and the evaluation procedure, has been documented for review and subsequent implementation. Critical reflections on each phase of the consolidated conceptual framework are also provided.

Chapter 8. Conclusions and recommendations

The closing chapter concludes this research study by presenting a concise summary of the conducted research and subsequent research outcomes. This chapter also restates the research aim and objectives as well as providing recommendations for future continuation of the research. Figure 8-1 provides a summary of the outcomes of the concluding chapter.

Key outcomes	Provide a summary of the research study as well as the results obtained
	Present the conclusions of this research study corresponding to the research outcomes
	Provide recommendations for future work relating to the research study

Figure 8-1 - Key outcomes of Chapter 8

8.1 Research summary

The primary aim of this research study has been to contribute to the facilitation of health-related TT ventures both to and from the geographic region of SSA and to this extent a healthcare TT tool has been constructed. The research methodology which enabled the construction of this tool consisted of the following stages:

1. Construction of a problem statement.
2. Completing dual systematic literature reviews.
3. Developing a conceptual framework.
4. Evaluating the conceptual framework through the use of interview, survey and case study outcomes.
5. Consolidating the completed TT tool for healthcare to SSA.

Table 8-1 illustrates how these five key research stages have been completed while highlighting their corresponding chapters within this research document. These five stages represent the methodology outlined in Chapter 2.

Table 8-1 - Research conclusion

Stage	Execution	Chapter
1. Problem statement	- A background has been provided surrounding the healthcare inadequacies of SSA as well as the potential that TT offers to bridge these shortfalls. - The TT perspective was introduced. - The primary research aim, research objectives, scope and limitations of the research study were outlined.	Chapter 1
2. Systematic literature reviews	- Conducted a systematic conceptual literature review surrounding the multiple elements of which TT comprises. The TT process, stakeholders, methods and barriers were all investigated. - Several TT models were identified and outlined for investigation and future use in the conceptual framework's development.	Chapter 3
	- Conducted a systematic comparative literature review to investigate the hard and soft infrastructure requirements and inadequacies of health-related TT to SSA. - The systematic comparative literature review comprised of comparing 51 literature items to extract their TT stakeholders and infrastructure outcomes.	Chapter 4
3. Conceptual framework development	- The conceptual framework was founded upon the outcomes of the systematic literature reviews. - The TT models identified in Chapter 3 were subject to a dual evaluation process to identify models conducive to the research aim of this dissertation. - A detailed outline of the framework's phases and inter-relationships was outlined to provide a framework to guide TT from technology development through to commercialisation.	Chapter 5
4. Conceptual framework validation	- Multiple TT industry experts were interviewed after which the outcomes of these interviews were deductively analysed to determine which areas of the conceptual framework required additions or modifications. - A survey was administered to healthcare TT managers in SSA to determine how the different regions of SSA compared to each other. - The survey also ensured that the conceptual framework's components are easy to implement and useful in promoting the adoption of the transfer object. - The conceptual framework, updated with the outcomes of the interviews and survey, was applied retrospectively to a healthcare TT to SSA to determine were further additions or modifications were required.	Chapter 6
5. Conceptual framework consolidation	- The outcomes of the evaluation procedure completed in Chapter 6 were incorporated into the conceptual framework presented in Chapter 5. - The final consolidated conceptual framework was outlined. This represents the TT tool enabling the transfer of health technologies in SSA.	Chapter 7

8.2 Conclusions pertaining to research objectives

The primary aim of this research paper has been to contribute to the facilitation of health-related TT ventures both to and within the geographic region of SSA. To accomplish this aim, four research objectives were constructed with Section 8.2.1 to Section 8.2.4 discussing the general conclusions relating to each of these research objectives. The four research objectives, and their sub-objectives, first outlined in Section 1.4, have been restated below.

i. Conduct a systematic conceptual literature review to identify key TT characteristics that can be subject to further study in a SSA context.

ii. Conduct a systematic comparative literature review to refine critical factors required for healthcare TT in SSA.

iii. Construct a conceptual framework with maximum efficacy by completing the following sub-objectives:
   a. Deconstruct the critical factors that have been identified during the completion of the systematic comparative literature review.
   b. Synthesise concepts into a conceptual framework.
   c. Evaluate the conceptual framework by implementing a multi-level evaluation procedure consisting of semi-structured interviews, a survey and case study applications.

iv. Evolve the conceptual framework into a TT tool that can be utilised to facilitate healthcare TT ventures to and from SSA.

8.2.1 Conclusions pertaining to research objective i.

The first research objective has been completed by undertaking a detailed systematic conceptual literature review to investigate TT. This literature review was not restricted to a specific geographic area or timeline and was structured to provide comprehension surrounding the process of TT, the evolution of TT, the stakeholders involved in TT, the available TT methods, the role of knowledge transfer, the barriers of TT as well as identifying prominent TT models.

8.2.2 Conclusions pertaining to research objective ii.

The second research objective has been completed by undertaking a systematic comparative literature review to refine literature focus from overall TT to health-related TT in SSA. As such, 51 case-specific literature items were cross-examined to extract data surrounding the TT methods utilised, the TT's stakeholders, the stakeholders' motivations as well as the hard and soft infrastructure requirements and inadequacies of SSA. This data was then codified in the form of various charts to allow for easy interpretation and usage in the research document's subsequent chapters.

8.2.3 Conclusions pertaining to research objective iii.

The third research objective has been completed by instigating the conceptual framework's development. The framework was constructed upon the outcomes delivered by the first two research objectives. The TT models identified in the systematic conceptual literature review were subject to a dual evaluation to extract the most relevant models and model elements for incorporation into the conceptual framework.

The conceptual framework development produced a five-phase framework, aimed at providing a guideline for healthcare TT to SSA. This framework provides a guideline for the technology's development through to the commercialisation of the technology. This five-phase framework was subsequently validated by implementing the outcomes of interview sessions with industry experts in the field of healthcare and TT. A final validation was undertaken by retrospectively applying the updated framework to a healthcare TT undertaken in South Africa.

8.2.4 Conclusions pertaining to research objective iv.

The fourth research objective has been completed by conflating the outcomes of semi-structured interviews and a survey instrument with the conceptual framework development. This consolidated conceptual framework is retrospectively applied to three healthcare TT case studies to highlight the applicability and versatility of the framework. The final consolidated framework provides an evaluated TT tool to facilitate healthcare technologies to SSA.

The final framework guides the TT process from technology development towards commercialisation while emphasising the use of co-creation best practices at each phase. Best practices for the codification and establishment of TT standards have also been outlined. Additionally, the framework provides the user with a detailed guideline for ensuring stakeholder involvement, assigning stakeholder roles and responsibilities, identifying the relevant transfer object and technology environment characteristics, incorporating the appropriate TT method, facilitating the required change management and promoting various best practise to aid the TT's sustainability.

8.3 Recommendations for future research

The recommendations for future research will largely be orientated on the refinement of the consolidated healthcare TT framework shown in Chapter 7. To this extent, the recommendation for future research is to apply the framework to health-related TT case studies. This will allow for refinement of the framework's user interface, flow and focus areas as well as aiding in identifying any additional design-actuality gaps across additional industries. Continuing research into other developing nations may also serve to elucidate SSA specific criteria, while simultaneously identifying additional relevant criteria that may be added to the framework. This will in-turn also broaden the geographic application area of the framework.

The final recommendation surrounds the applicability of the healthcare TT framework with respect to other industries. As universal TT principles account for a substantial portion of the framework's theoretical base, the framework may have applications in other industries or market sectors. Thus, further empirical study into the framework's non-healthcare applicability is also recommended.

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Appendix A - Identified technology transfer models

Appendix A serves to complete research question 5 of the systematic conceptual literature review presented in Chapter 3. All technology transfer models identified during the data collection phase of the conceptual literature review have been presented in Table 3-14, with the individual model expansions provided in Appendix A. These models have subsequently been subjected to a dual evaluation process completed in Section 5.2, the results of which have been presented in Appendix C.

A.1 The Chantramonklasri model (1990)

The Chantramonklasri model represents a revision of the Dahlman Westphal model developed in the 1980s (Chantramonklasri, 1990). The model follows a basic five-stage TT process while highlighting the importance of knowledge assimilation throughout a TT venture. While not a detailed example, the Chantramonklasri model does represent an initial linear TT model (Ramanathan, 2011).

As the model represents an early stage TT model many elements have been vaguely defined or omitted. Research and development of the technology have not been considered an explicit stage of the TT process. Additionally, the model does not provide detail on the constituents required of each phase or dedicate itself to a specific field, industry or geographic region. Similarly, managerial activities have been highlighted as important but little clarification has been provided surrounding the scope of these activities. The model's biggest flaw stems from complete lack of any adoption and integration policies (Ramanathan, 2011)

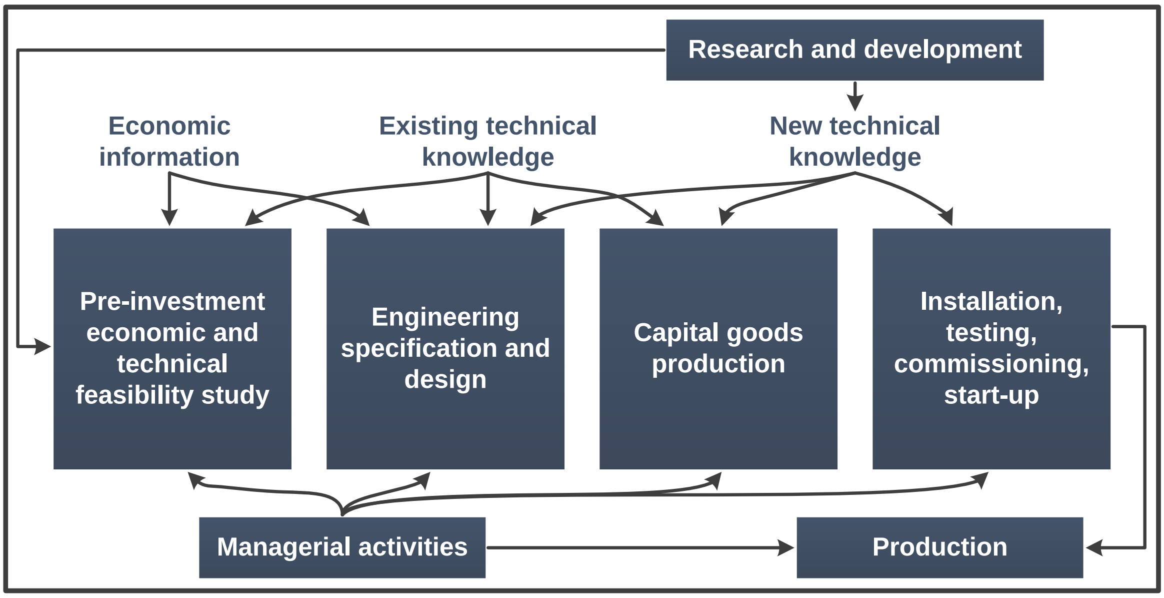

Figure A-1 - The Chantramonklasri technology transfer model (Chantramonklasri, 1990)

A.2 The Levels of Involvement model (1991)

The Levels of Involvement model utilises a technology transfer grid, shown on the right of Figure A-2, to provide management with a tool capable of evaluating a TT venture as well as providing subsequent guidelines depending on the TT's placement on the grid. The TT grid has been derived from three levels of TT, shown on the left of Figure A-2.

The base level, technology development, has been described as the "most fundamental level" for any TT (Gibson *et al.*, 1991). During this level, the transfer will largely function in a passive state while typically being restricted to academic papers, researchers or word of mouth (Gibson *et al.*, 1991). The second level, technology acceptance, entails the collusion between transferor and transferee to ensure that the transferee possesses the knowledge required to utilise the transferred technology (Gibson *et al.*, 1991; Shamsavari *et al.*, 2002; Shamsavari, 2006). The top level, technology application, occurs when the transferee utilises the transfer object either to obtain direct economic benefit or for the aim of supplementing another service which in turn generates an economic benefit (Philip F. Musa *et al.*, 2005; Golob, 2006).

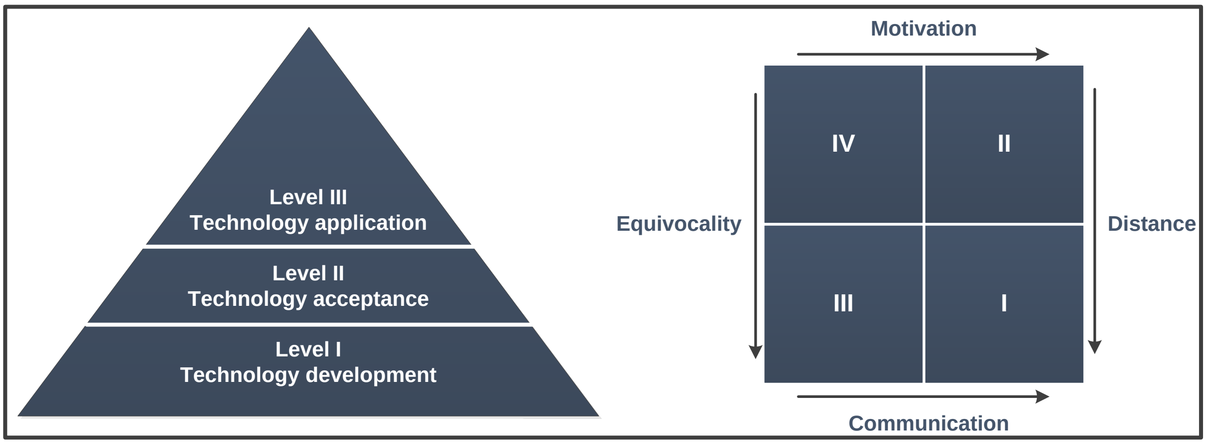

Figure A-2 - The Levels of Involvement pyramid and technology grid (Gibson *et al.*, 1991)

Quadrant one of the transfer grid, shown in Figure A-2, represents the characteristics most favourable to a TT venture, as distance and equivocality between stakeholders will be minimal yet communication and motivation have been prioritised. This model provides several universal managerial best practices in tandem with the transfer grid. These best practices promote the development of support infrastructure aimed at the improvement of the TT at the technology application level (Gibson *et al.*, 1991). The best practices aimed at specifically improving the characteristics shown on the transfer grid have been summarised in Table A-1.

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Table A-1 - Managerial recommendations for the Levels of Involvement model (restated from Gibson & Smilor 1991)

Transfer grid category	Best practices
Communication	- Identify an authority which will be designated to monitor, receive and disseminate new technologies. - Increase the awareness of successful TT cases. - Utilise visible and highly regarded liaisons to champion the transfer. - Emphasise the use of highly interactive communication links throughout the TT process.
Distance	- Expand the diversity of people interacting in the transfer process to increase the mutual level of understanding. - Involve a diverse range of skilled personnel. - Mandate formal TT seminars and workshop training sessions. - Transferors should encourage and fund on-site visits.
Equivocality	- Clarify expectations for research activities and usability criteria. - Encourage collaborative projects to facilitate the sharing of knowledge and research results. - Require projects to have TT objectives. - Develop training programs early in the TT venture. - Encourage on-site demonstrations of the technology.
Motivation	- Provide incentives, rewards and recognition for personnel involved in the transfer process. - Incentives should range from monetary to new funding, to public exposure and internal and external marketing of dedicated personnel.

A.3 The Organisational Capabilities-Based model (1995)

This model has been specifically designed for international joint venture applications (Rebentisch *et al.*, 1995). This model also represents one of the first to be widely utilised in the field of TT (Wahab *et al.*, 2009). The model improved on previous TT models by attempting to provide a guideline for the improvement of the technology and its organisational context rather than explicitly focussing on the transferor and transferee (Wahab *et al.*, 2009).

Table A-2 depicts the four key focus areas of the organisational capabilities model, one of which surrounds the evaluation of the transferee's core capabilities and ability for adoption. The model follows a linear path, first investigating the transfer object's characteristics and subsequently an appropriate method of TT. Lastly, the model evaluates of the transferee's change management ability after which adoption guidelines are provided (Rebentisch *et al.*, 1995).

Table A-2 - The focus areas of the Organisational Capabilities-Based model (restated from Rebentisch & Ferretti 1995)

Category	Description
Transfer scope	The type of technology or knowledge being transferred, focussing on the extent or magnitude of the knowledge being transferred.
Transfer method	The methods, procedures and techniques employed in the TT process, ranging from communication to developing special organisational units for TT.
Knowledge architectures	The forms and functional relationships between the structures and artefacts in which knowledge has been embodied in the organisations.
Organisational adaptive ability	The ability of the organisation to change existing technologies and architectures, to adapt them to the requirements of new technologies.

The model has been structured to emphasise the transfer of hardware and its corresponding knowledge (Rebentisch *et al.*, 1995). The transfer scope explicitly focusses on knowledge transfer and has been divided into impersonal communication, personal communication, group communication, and physical relocation (Rebentisch *et al.*, 1995). This does, however, highlight a potential shortcoming of the organisational capabilities model, as the model inherently assumes that physical artefacts could be transferred without need for a designated and structured transfer method.

As with the transfer scope, knowledge architectures have also been divided into four elements namely; technology hardware, the experience base of the transferee, transfer procedures of the transferee, and the transferee's organisational power structures. The model requires that these elements must be identified to uncover the technology's intricacies, compatibility, cost and the change management required for a successful transfer. Lastly, organisational ability pertains to the transferee's personal and manufacturing abilities needed to adapt to the implementation of the new technology (Rebentisch *et al.*, 1995).

This model can be utilised for any transfer method and has been applied to both physical technology transfer as well as explicit knowledge transfer (Rebentisch *et al.*, 1995). However, the transfer of implicit knowledge may not be appropriate as the model was exclusively developed from the transferor's perspective. Thus, the resulting linear model does not account for the feedback loops between transferor and transferee aside from those established within a pre-existing transfer method (Wahab *et al.*, 2009).

A.4 The Contingent Effectiveness model (2000)

The Contingent Effectiveness focusses on five core areas of TT while simultaneously providing effectiveness criterion for any TT venture. The original model had been designed to instigate university and public research transfers into industry but it has subsequently been successfully utilised in inter-firm TTs as well (Ramanathan, 2011).

As shown in Figure A-3, the model focusses on the transfer agent, media, object, recipient and demand environment. The model also applies constant feedback loops between each focus area to ensure constant communication among stakeholders.

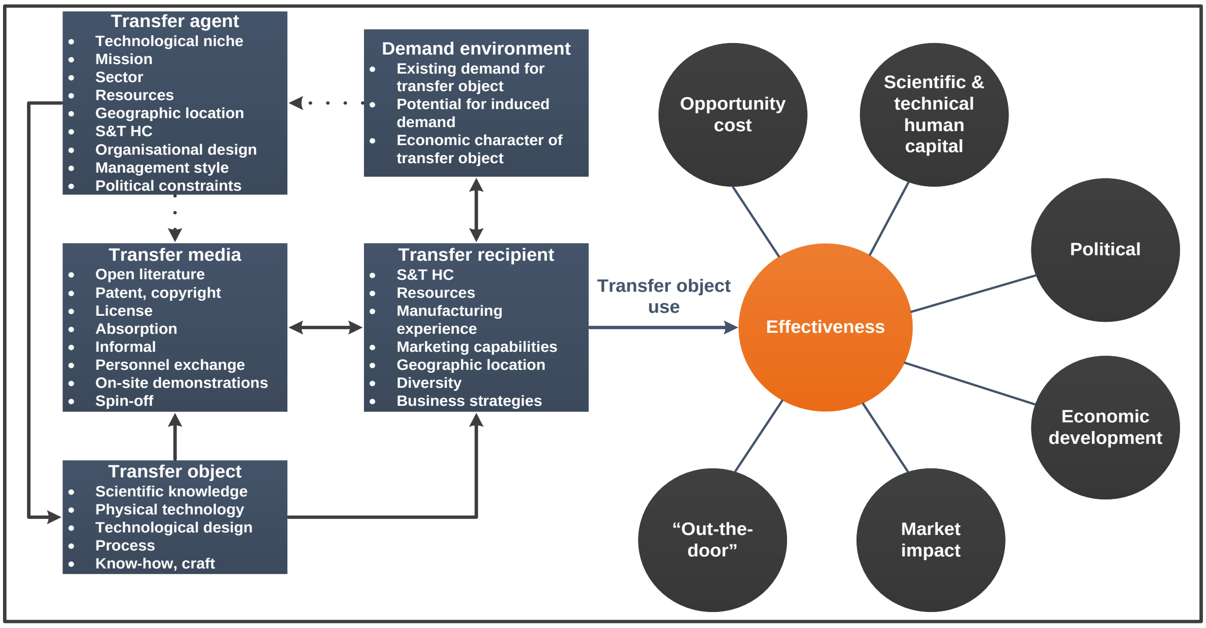

Figure A-3 - The Contingent Effectiveness model (Bozeman, 2000)

Unlike many other models, the Contingent Effectiveness model also provides management with various effectiveness criterion, shown in the right-hand side of Figure A-3. A summary of the individual effectiveness criterion has been provided in Table A-3. Figure A-4 has been directly inserted from the original model development document as it presents the TT management team with various evaluation questions as well as potential benefits and limitations of each effectiveness criterion.

Table A-3 - The Contingent Effectiveness model's effectiveness criteria (derived from Bozeman, 2000)

Effectiveness criteria	Focus
"Out-the-door"	When a technology is transferred between firms with no consideration of its impact. Thus, the transfer itself has been prioritised.
Market impact	Evaluation of the transfer's commercial impact, resulting profit or shift in market share.

Economic development	An expansion of market impact by incorporating regional or national level evaluations.
Political reward	The potential benefits that the public sector could gain from the TT.
Opportunity cost	The cost incurred from implementing the transfer in comparison to other mutually exclusive ventures.
Scientific and technical human capital	The impact of the transfer on knowledge and social capital as well as soft infrastructure improvement in the transferee's environment.

Effectiveness criterion	Key question	Theory base	Major advantage and disadvantage
''Out-the-Door''	Was technology transferred?	Atheoretical or classical organization theory	Advantage: Does not hold transfer agent accountable for factors that may be beyond control. Disadvantage: Encourage cynicism and focus on activity rather than outcome.
Market Impact	Did the transferred technology have an impact on the firm's sales or profitability?	Microeconomics of the firm	Advantage: Focuses on a key feature of technology transfer. Disadvantage: Ignores important public sector and non-profit transfer; must accommodate market failure issues.
Economic Development	Did technology transfer efforts lead to regional economic development?	Regional science and public finance theory.	Advantage: Appropriate to public sponsorship, focus on results to taxpayer. Disadvantage: Evaluation almost always requires unrealistic assumptions.
Political	Did the technology agent or recipient benefit politically from participation in technology transfer?	Political exchange theory, bureaucratic politics models	Advantage: Realistic. Disadvantage: Does not yield to systematic evaluation.
Opportunity Cost	What was the impact of technology transfer on alternative uses of the resources?	Political economy, cost–benefit analysis, public choice	Advantage: Takes into account foregone opportunities, especially alternative uses for scientific and technical resources. Disadvantage: Difficult to measure, entails dealing with the ''counterfactual''
Scientific and Technical Human Capital	Did technology transfer activity lead to an increment in capacity to perform and use research?	Social capital theory (sociology, political science), human capital theory (economics)	Advantage: Treats technology transfer and technical activity as an overhead investment. Disadvantage: Not easy to equate inputs and outputs.

Figure A-4 - The technology transfer's effectiveness criteria (Bozeman, 2000)

A.5 The Traditional Technology Transfer model (2000)

The traditional TT model, shown in Figure A-5, had been designed to enable TTs from public research institutions into the private sector (AUTM, 2000). While this model provides a standard operating procedure for the involved stakeholders, it has little utility in any other TT venture apart from research-based transfers (Bradley *et al.*, 2013).

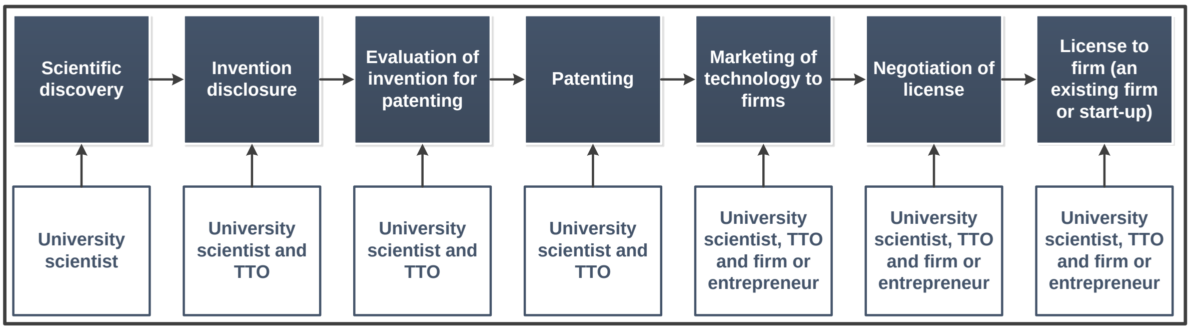

Figure A-5 - AUTM's Traditional Technology Transfer model (AUTM, 2000)

This model utilises licensing as its primary method of TT and requires capable TTOs able to commercialise inventions. The model seeks to take an initial discovery and promote it to an entrepreneur or venture capital firm who will, in turn, be able to profit and subsequently disseminate the innovation (Siegel *et al.*, 2004).

This model was constructed after the implementation of the Bayh-Dole Act to provide researchers with an appropriate legal guideline on how to submit new innovations (Siegel *et al.*, 2004; Bradley *et al.*, 2013). However, as TT has evolved this model has become insufficient as no longer represents a relevant procedure for most TT ventures (Link *et al.*, 2016).

As technology is dynamic in nature, TT must inherently also be regarded as dynamic thus rendering this simple linear model obsolete and only useful for the derivation of more elaborate models (Siegel *et al.*, 2004). As such, this model has been included as various other models, investigated in the latter sections of Appendix A, have been founded upon this original linear process.

A.6 The Revised Levels of Involvement model (2000)

The Revised Levels of Involvement model had been updated from its original format to incorporate the effects of commercialisation. However, the technology grid first shown in Figure A-2, has remained unaltered.

As the additional top level has been founded upon the original model, it must be supported by the cumulative success of the base of the pyramid. However, the revised model also acknowledges the prevalence of the technology's market share (Sung *et al.*, 2000). Thus, the top level has been added to provide a quantitative data point that can be utilised to physically measure the success of a TT venture based on its tangible or intangible economic returns.

Literature indicates that return on investment has primarily been utilised to fulfil these data points, however, return on investment may be substituted for other economic indicators (Sung *et al.*, 2000; Golob, 2006). The addition of commercialisation level has been undertaken to ensure that the model has practical application in industrialised industries by presenting physical evidence to the stakeholders that hold influence over the TT and transfer object (Sung *et al.*, 2000).

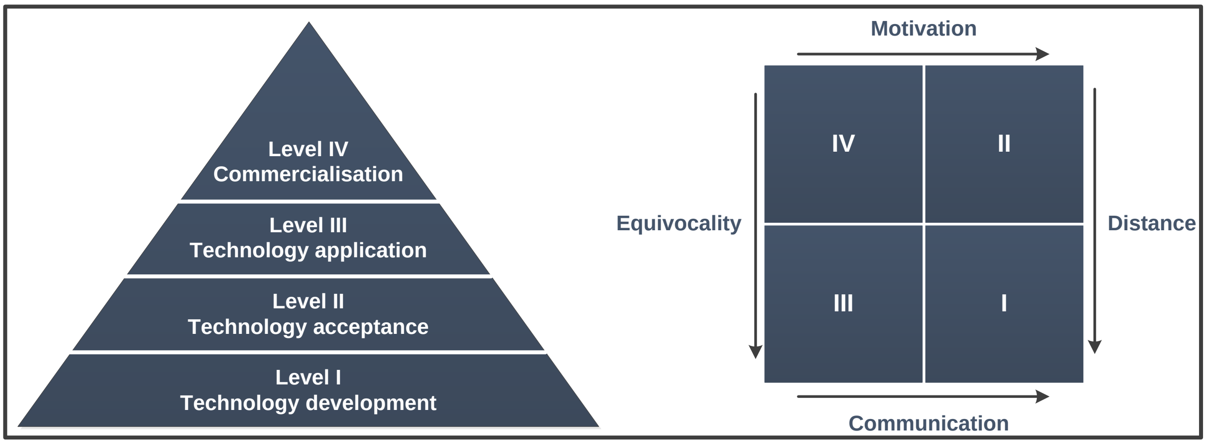

Figure A-6 - The Revised Levels of Involvement pyramid and technology grid (Sung *et al.*, 2000)

A.7 The Interactive Broadcasting model (2002)

The Interactive Broadcasting model, shown in Figure A-7, had been constructed to aid intra-firm TTs. It attempts to classify a technology as 'a broadcast' or a message being sent from one party to another. By holding this broadcast as the nexus, the model guides the method of transfer, actions of the transferor and transferee, and other factors which may influence a TT venture.

The model acknowledges the iterative nature of TT and subsequently provides a feedback loop to enable a communication channel between the transferee and transferor should modifications to the technology be required (Malik, 2002). The model also almost exclusively focusses on the implicit drivers and barriers of the TT process by identifying various intangible characteristics such as 'trust' for management to use for evaluation and decision making. The model thus focusses on stakeholder participation and human capital capabilities (Malik, 2002).

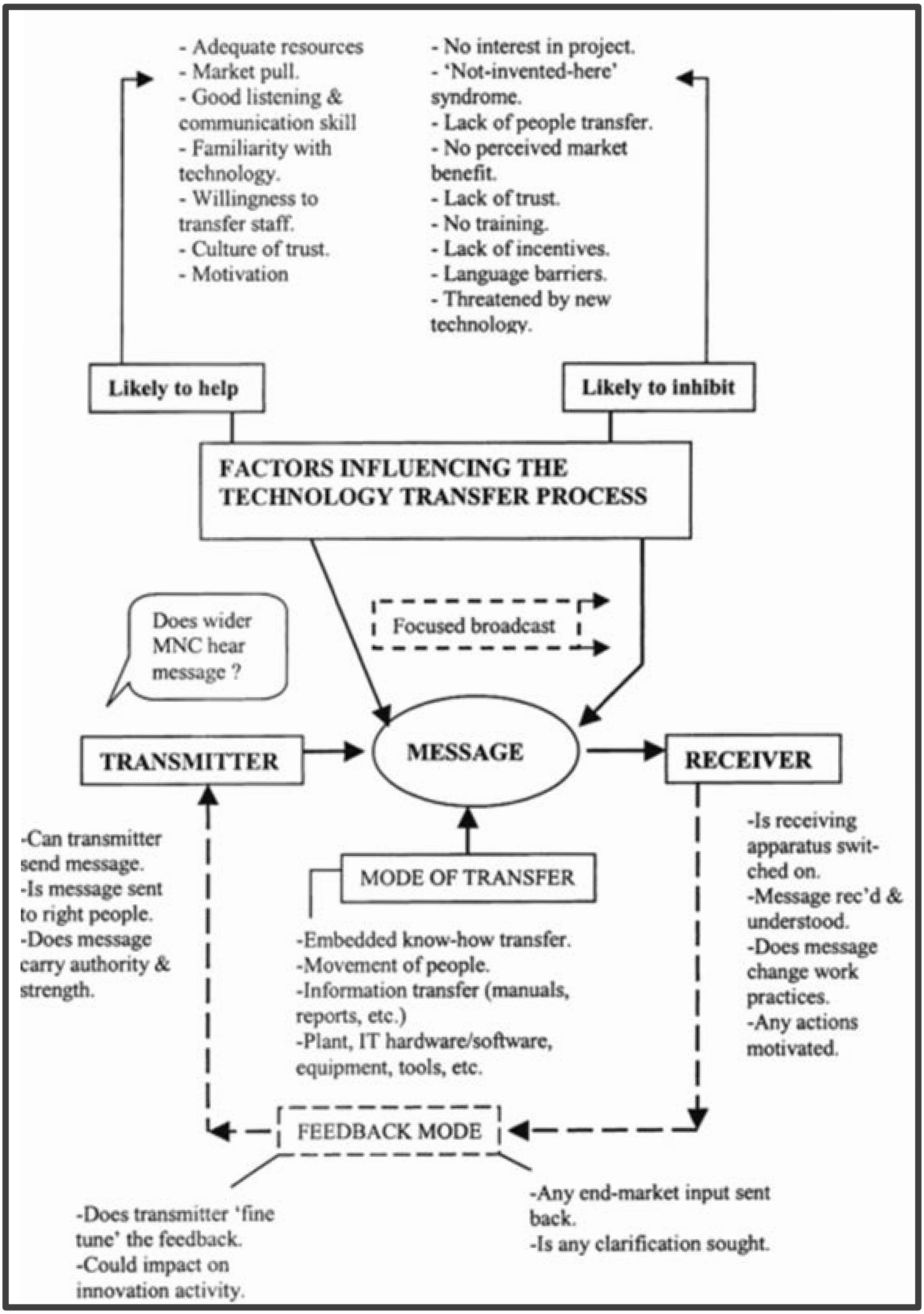

Figure A-7 - The Interactive Broadcasting model (Malik, 2002)

A.8 The Traditional Model of University Technology Transfer (2004)

The traditional model of university TT, shown in Figure A-8, has been founded upon the linear procedure of the traditional model, shown in Figure A-5. However, where the traditional model could be applied to any research-based TT, the model presented in Figure A-8 had been specifically created to accommodate the global influx of TTOs in the early 2000s (Siegel *et al.*, 2004).

This model attempts to effectively monetise scientific discoveries, made by universities or university partners, by implementing licensing or patenting contracts. The model shifts emphasis to the knowledge transfer required rather than the transfer of physical artefacts (Siegel *et al.*, 2004).

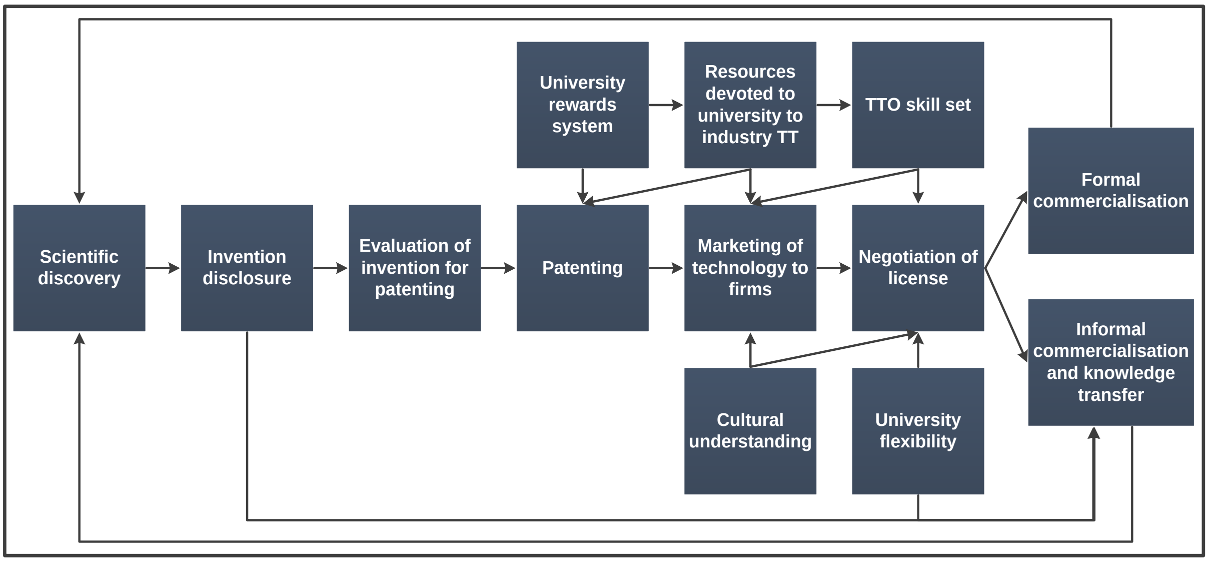

Figure A-8 - The Traditional Model of University Technology Transfer (Siegel *et al.*, 2004)

By incentivising university staff with a rewards system, the model aims at reducing the major barriers in university-based TT ventures. The model also encourages the transferee and transferor to both allocate resources to the TT venture and attempts to accommodate different personalities and cultures in the TT's transfer team. The model also focusses on constantly refining the internal protocols of the relevant TTO, as implicit knowledge documentation and revision will generally be mandated. Financial resources obtained from previous TT ventures will often be allocated to new TT projects currently in their development stage.

A.9 The Stage-Gate model (2010)

Originating in the 19th century, project managers have applied select version of the stage-gate methodology in a formal attempt to manage large and intricate projects (Mazurowski, 2006). Multiple implementations of the stage-gate methodology in the field of TT has produced a refined Stage-Gate model, shown in Figure A-9. This model serves to aid project managers by providing a guideline into the workings of project activities, milestones and decision-point sequences (Jagoda *et al.*, 2005). A summary of the constituents of each phase has been provided in the bottom of Figure A-9.

The model has three overarching phases which guides management through the commencement, planning and execution of a TT venture, while constantly applying a feedback loop to allow for evaluation and revision. The primary benefit of employing this model stems from its ability to identify underperforming projects at multiple points in the TT's life cycle. (Jagoda *et al.*, 2010).

Each stage in the model will be followed by a subsequent gate. If the project does not adhere to a firm's pre-set standards, the project will either be rehabilitated or decommissioned. This simple continuation or decommission decision must be taken at each gate based on the project's status, and in turn, will limit a firm's exposure to future risk. The initiation phase will generally be subject to the judgement of the firm's high-level management, whereas the remaining phases will largely be overseen by "day-to-day" supervisors (Ramanathan, 2011).

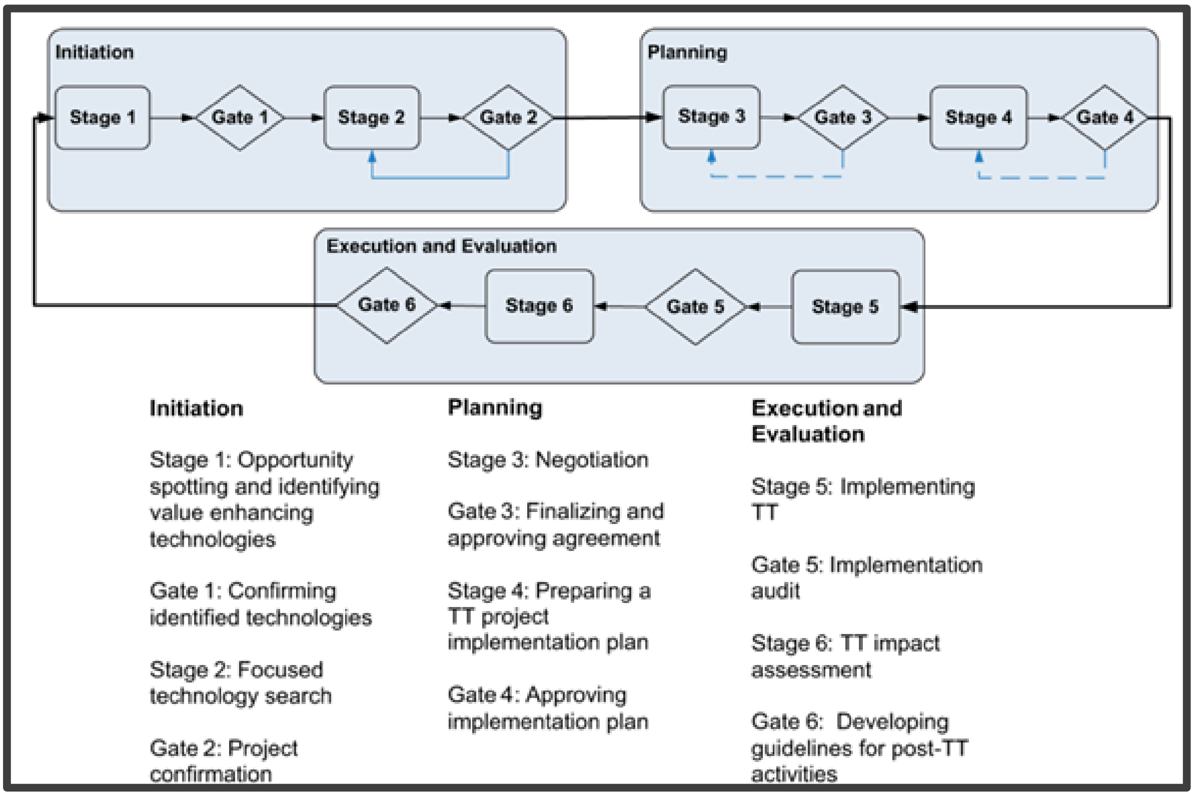

Figure A-9 - The Stage-Gate model (Jagoda *et al.*, 2005)

The Stage-Gate model forces frequent communication between managers of a firm to progress past Stage 1. As a result, the operational, financial and marketing decisions needed for a TT venture will often become streamlined, as stakeholders with decision-making authority must constantly be involved. However, literature does indicate that knowledgeable individuals must be incorporated for a stage-gate TT venture to become successful (Jagoda *et al.*, 2010; Ramanathan, 2011). Lastly, this model argues that the TT process cannot be judged by the outcome of the technology in isolation and that a TT may only be deemed a success if it results in tangible market growth for the firms involved (Ramanathan, 2011).

A.10 The Policy Integration model (2010)

The Policy Integration model, shown in Figure A-10, has specifically been designed to be utilised in conjunction with the FDI TT method. Additionally, the model promotes soft infrastructure development to aid TTs. The model utilises the private sector as its nexus point while providing four key policy development areas to strengthen the transfer environment's TT capabilities (Smith, 2007). While the model does not attempt to directly facilitate a TT, it may be utilised to facilitate the acquisition or development of the foundation required for FDI TTs (Smith, 2007).

FDIs and trade policies have been evaluated based on their contribution to a sector's competitiveness, regional or national, as well as their ability to attract FDIs. This branch of the model places specific emphasis on attracting value-added, technology-based, or efficiency-seeking FDIs. The model provides multiple guidelines to attract these FDIs, such as promotion of free trade policies and selective long-term international mutual partnerships (Smith, 2007).

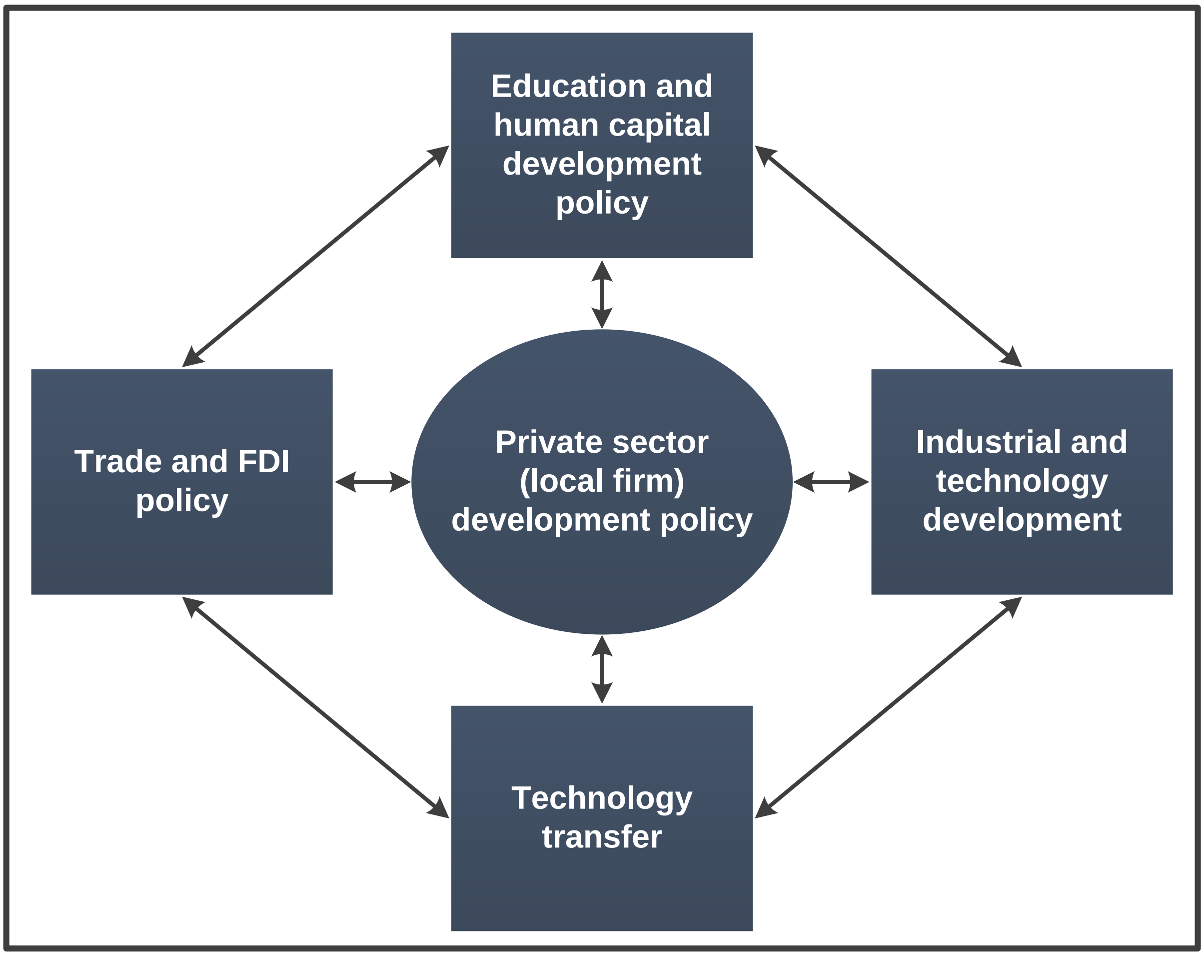

Figure A-10 - The Policy Integration model (Smith, 2007)

The model argues that human capital development policies will remain outside the scope of any TT team and that the public sector will largely be responsible for the education of the workforce. However, guidelines have been provided to allow the transfer team to mitigate this issue, such as expenditure on R&D, implementation of university and firm conjoined research programs and in-house science and technology training courses. The model acknowledges lacking tertiary enrolment statistics worldwide, especially in developing countries, and suggests an ‘integrative policy framework’ between domestic firms and the public sector (Smith, 2007).

Thus, the model has founded industrial and technology development policy guidelines upon human capital policy by arguing that improving human capital automatically improves technological development. TT policies have been formed by amalgamating the other three focus areas (Smith, 2007).

A.11 The Alternative Model of University Technology Transfer (2013)

This model represents a refinement of the traditional model of university TT discussed in Appendix A.8. While the model still focusses on providing research institutions with a concise guideline for monetising research discoveries, the alternative model expands upon the different forms of technology developers. Additionally, the model investigates multiple relationships between the nodes. Possible funding sources for the initial discovery have also been updated in an attempt to ensure that the alternative model serves as a comprehensive framework for research-based TTs (Bradley *et al.*, 2013).

As with other research-based TT models, strong TTO involvement has been promoted throughout the model (Siegel *et al.*, 2004; Bradley *et al.*, 2013). The model encourages research institutions to create any form of incentive scheme, as this greatly improves the participation of TT investors. The alternative flow, from which the model has been named, progresses through informal mechanisms, as shown in Figure A-11. However, the model does concede that the success rate of the informal mechanisms in comparison to formal mechanisms may be less substantial (Bradley *et al.*, 2013).

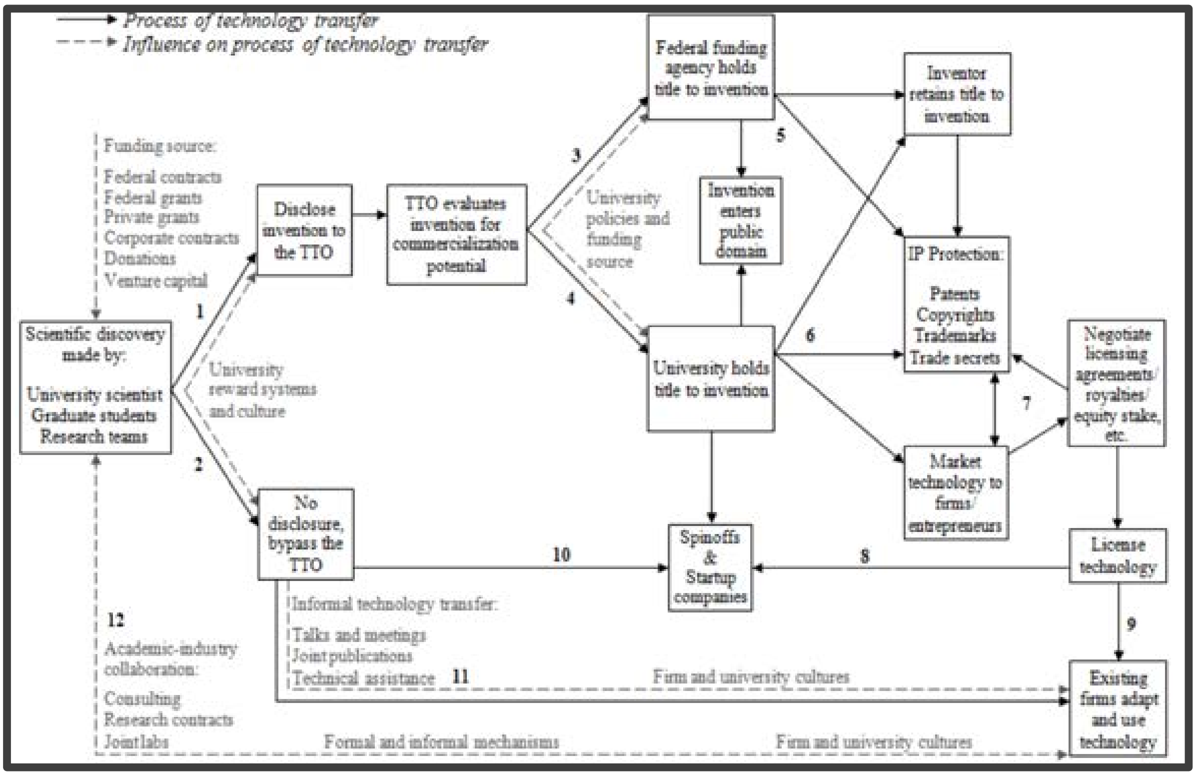

Figure A-11 - The Alternative Model of University Technology Transfer (Bradley *et al.*, 2013)

A significant model improvement stems from the completeness in which it captures the TT process (Bradley *et al.*, 2013). Whereas the traditional model follows a linear path, the alternative model concisely captures the flow of the TT and the various routes that could be possibly followed. Additionally, stakeholders and their influence on the process have also been included (Bradley *et al.*, 2013).

Lastly, the model requires that industry and university cultures must be mindful to the establishment of long-term partnerships. The model states that these partnerships may be maintained by implementing a combination of formal and informal mechanisms, both of which will streamline future TT ventures (Bradley *et al.*, 2013). A summary of such a mutually beneficial collaborative organisation has been illustrated in Figure A-12.

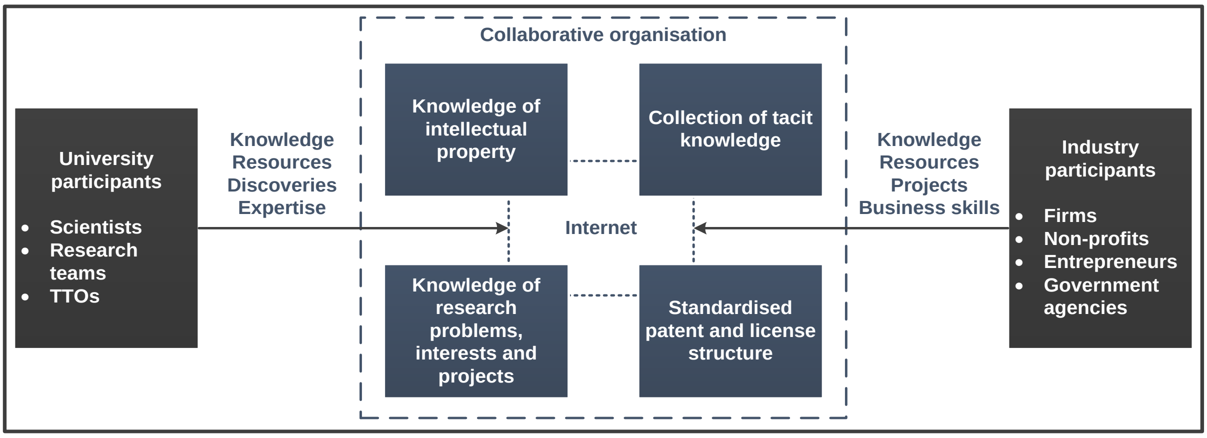

Figure A-12 - A collaborative organisation for the alternative technology transfer model (Bradley *et al.*, 2013)

A.12 The Revised Contingent Effectiveness model (2014)

The Revised Contingent Effectiveness model, shown in Figure A-13, has been updated to include the effectiveness criterion of public value. Bar this change, the model is identical to the one described previously in Appendix A.5. The addition of the public value criterion resulted from an investigation that indicated that organisations' motivations cannot always be categorised in terms of quantifiable results (Bozeman *et al.*, 2015). Actions may often be motivated by public values rather than monetary gain (Golob, 2006; Bozeman *et al.*, 2015).

The inclusion of the public value evaluation also counterpoises the other evaluation criterion which mostly review the economic benefits and limitations of TT. This becomes especially relevant as TT often surrounds the topics of healthcare, public safety, inequality and the general improvement of public quality of life (Bozeman *et al.*, 2015). Thus, even though market growth will always be a prominent indicator for a single TT venture, the inclusion of public value provides another screening criteria by recognising that monetary gain may not consistently represent a suitable primary evaluation criterion (Golob, 2006; Bozeman *et al.*, 2015).

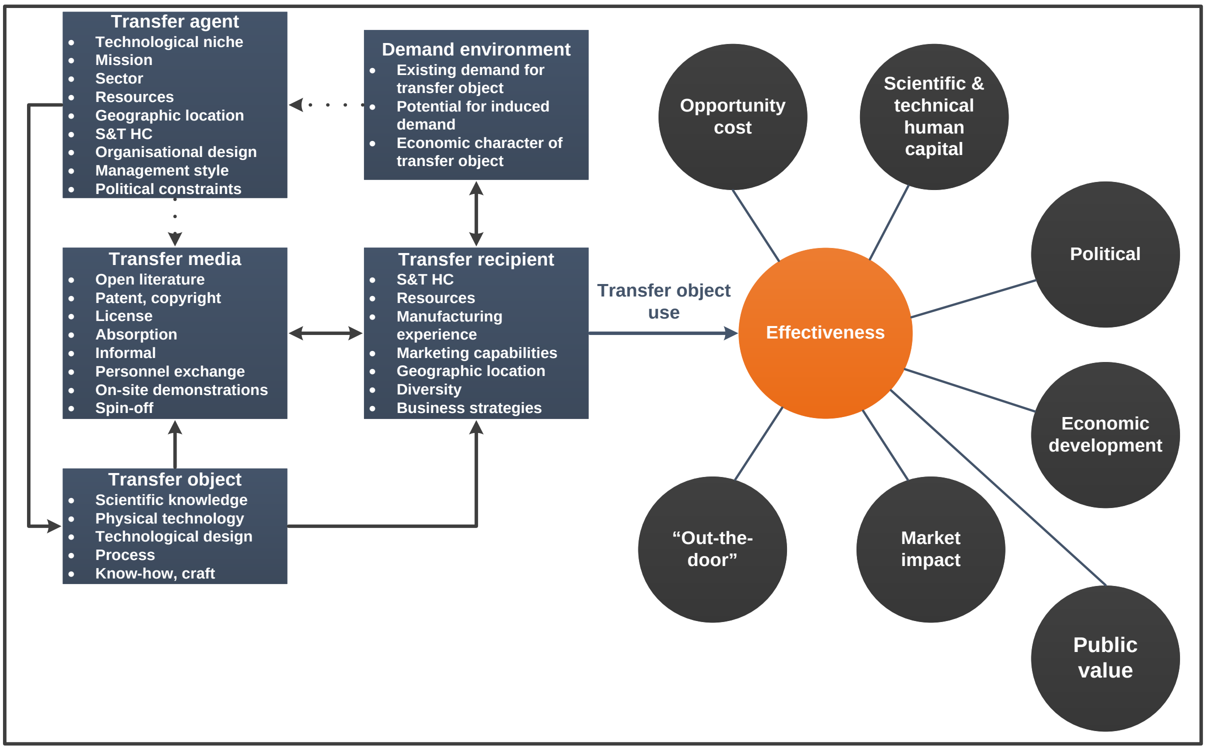

Figure A-13 - The Revised Contingent Effectiveness model (Bozeman *et al.*, 2015)

The inclusion of the public value criteria has ultimately been justified by three major considerations. Firstly, it was suggested that public value will result in a more accurate representation of the public's perception of worth. The second driver has been that public research developed either by universities or by nationally subsidised research units, will be supported through public tax. As a result, the capital expenditure into national R&D must be justified by striving to attain the greatest overall benefit to society. Economic growth, valuable as it may be, will initially only benefit small portions of the public. The final motivation has been that without direct attention to the areas of science, technology and innovation policy, they may easily become overlooked or disbanded (Bozeman *et al.*, 2015).

A.13 The Knowledge in Technology Adoption model (2016)

The technology adoption model cannot be considered a complete TT model as it only focusses on the final stage in TT of technology adoption and integration. The model does however still have utility, especially as it focusses on both explicit and implicit knowledge transfer required for a TT to be successfully integrated into its domestic environment (Handoko *et al.*, 2016).

The model, presented in Figure A-14, also provides managerial stakeholders with various indicators to gauge implicit and explicit knowledge transfer as well as the technology's adoption. These indicators have further been strengthened by measurement protocols that can be utilised to ensure that the appropriate knowledge transfer has taken place. These indicators have been summarised in

Table A-4.

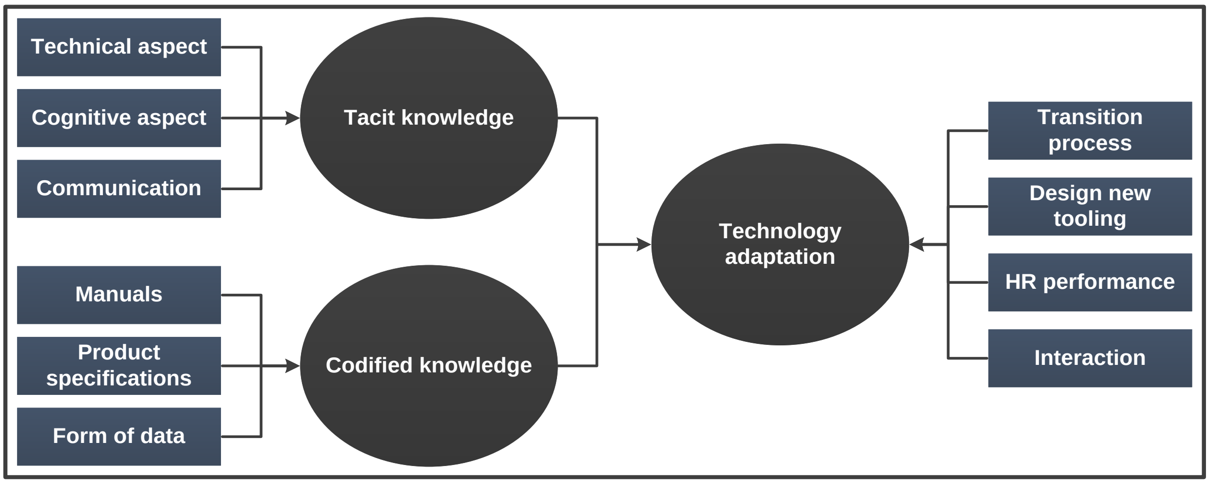

Figure A-14 - The knowledge adoption model (Handoko *et al*., 2016)

Table A-4 - Measurement protocols for the knowledge adaptation model (derived from Handoko et al. 2016)

Constructs	Indicators	Measurement protocols
Implicit knowledge	Technical aspect	- The expertise that has been provided. - The technical exchange during and after the transfer. - The skill exchange between transfer's stakeholders.
	Cognitive aspect	- The stimulation the transferor has received with regards to knowledge transfer. - The level of the transferor's TT experience.

Explicit knowledge	Communication	- The consistency and quality of the communication between transfer team.
	Manuals	- The introduction of technology specification standards. - The blueprint or technical plans of the technology.
	Product specification	- The level of standardisation achieved in the production of the technology.
	Form of data	- The quality and consistency of statistical data. - The type of data presented.
Technology adaptation	Transition process	- The ability to integrate the new technology into existing systems.
	Design new tooling	- The ability to design a new tool.
	Human resource performance	- The ability to adopt the new technology. - The availability of staff to perform skill improvement. - The ability to improve performance to meet the required standardisation levels.
	Transferor interaction	- Capability of the transferee to interact with the transferor.

Appendix B - Case studies of the systematic comparative literature review

Appendix C provides a summary of the healthcare TT to SSA case studies that have been utilised in the systematic comparative literature review shown in Chapter 4. The document title, publishing year and author of the included case studies have been provided in Table B-1.

Table B-1 - Case studies included in the systematic comparative literature review

Author(s)	Title	Year
K. Buse; G. Walt	Global public-private partnerships: Part I - a new development in health	2000
W.E. Ansari; C.J. Phillips	Empowering healthcare workers in Africa: Partnerships in health - beyond the rhetoric towards a model	2001
R. Chanda	Trade in health services	2001
A. Boateng; K.W. Glaister	Performance of international joint ventures: evidence for West Africa	2002
R. Heeks	Information systems and developing countries: failure, success and local improvisations	2002
F.L. Bartels; S.N. Alladina; S. Lederer	Foreign Direct Investment in sub-Saharan Africa: Motivating Factors and policy issues	2003
A. Geissbuhler; O. Ly; C. Lovis; J.F. L'Haire	Telemedicine in Western Africa: lessons learned from a pilot project in Mali, perspectives and recommendations	2003
D.S. Kline	Push and Pull Factors in International Nurse Migration	2003
A.J. Rodrigues; S. Govinda	Towards an integrated management of information system: A case of the University of Mauritius	2003
K. Johnston; C. Kennedy; I. Murdoch; P. Taylor; C. Cook	The cost-effectiveness of technology transfer using telemedicine	2004
J. Braa; E. Monteiro; S. Sahay	Networks of Action: Sustainable health information systems across developing countries	2004
H. C. Kimaro; J. L. Nhampossa	Analysing the problem of unsustainable health information systems in less-developed economies Case studies from Tanzania and Mozambique	2005
O.S. Akinsola; M.E. Herselman; S.J. Jacobs	ICT provision to disadvantaged urban communities: A study in South Africa and Nigeria	2005
P. Meso; P. Musa; V.W.A. Mbarika	Towards a model of consumer use of mobile information and communication technology in lDCs: the case of sub-Saharan Africa	2005
P. Meso; P. Musa; V.W.A. Mbarika	Calling for programmed technology transfer and adoption strategies for sustainable LDC growth	2005
P. Meso; P. Musa; V.W.A. Mbarika	Towards sustainable Adoption of Technologies for Human Development in Sub-Saharan Africa: Precursors, Diagnostics and Prescriptions	2005
E.L Mosse; S. Sahay	The role of communication practices in the strengthening of counter networks: Case experiences from the health care sector in Mozambique	2005

Appendix B - Literature list of case studies included in the systematic comparative literature review

M.Kifle; V.W.A. Mbarika; P.Datta;	Telemedicine in Sub-Saharan Africa: The Case of Teleophthalmology and Eye Care in Ethiopia	2006
C.O. Bagayoko; H. Miller; A. Geissbuhler;	Assessment of internet-based tele-medicine in Africa (the RAFT project)	2006
C. Alden; M. Davies	A profile of the operations of Chinese multinationals in Africa	2006
L. A. Salicrup; L. Fedirkova	Challenges and opportunities for enhancing biotechnology and technology transfer in developing countries	2006
B. Piotti; E. Maome	Public healthcare in Mozambique: Strategic issues in the ICT development during managerial changes and public reforms	2007
S.M. Mutula	Digital divide and economic development: case study of sub-Saharan Africa	2007
J. Ssewanyana; M Busler	Adoption and usage of ICT in developing countries: Case of Ugandan firms	2007
J. Connel; P. Zurn; B. Stilwell; M Awases; J.M. Braichet	Sub-Saharan Africa: Beyond the health worker migration crisis	2007
H. Lucas	Information and communications technology for future health systems in developing countries	2008
C. Fuchs; E. Horak	Africa and the digital divide	2008
H. Munyua; E. Adera; M. Jensen	Emerging ICTs and their potential benefits in revitalising small-scale agriculture in Africa	2008
J. Coloma; E. Harris	Sustainable transfer of biotechnology to developing countries	2008
M. Smith; S. Madon; A. Anifalaje; M. Lazarro-Malecela; E. Michael	Integrated Health Information Systems in Tanzania: Experience and Challenges	2008
T. Schuppan	E-Government in developing countries: Experiences from sub-Saharan Africa	2009
P. Meso; V.W.A Mbarika; S.P Sood	An overview of potential factors for effective telemedicine transfer to sub-Saharan Africa	2009
G. Kariuki	Growth and improvement of information communication technology in Kenya	2009
J.C. Aker; I.M. Mbiti	Mobile Phones and Economic Development in Africa	2010
M. Mars	Health Capacity Development Through Telemedicine in Africa	2010
M.T Latourette; J.E. Siebert; R.J Barto Jr; K.L. Marable; A. Muyepa; C.A. Hammond; M.J Potchen; S.D. Kampondeni; T.E Taylor	Magnetic resonance imaging research in sub-Saharan Africa: Challenges and satellite-based networking implementation	2010
F.C Payton; P. Meso; V.W.A Mbarika	Transfer and Adoption of Advanced Information Technology Solutions in Resource-Poor Environments: The Case of Telemedicine Systems Adoption in Ethiopia	2010
J. Luiz	Infrastructure investment and its performance in Africa over the course of the twentieth century	2010
S.A. Mengiste	Analysing the challenges of IS implementation in public health institutions of a developing country	2010
L. Whittaker; J. van Zyl; A.S. Soicher	What is the point of the point-of-care: A case study of user resistance to an e-Health system	2011
C. Karari; J. Penner; E.A. Bukusi; R. Marima; R. Tittle J. Kulzer; C.R. Cohen	Evaluating the Uptake, Acceptability, and Effectiveness of Uliza! Clinicians HIV hotline: A telephone consultation service in Kenya	2011
M.F. Renard	China's FDI trade in Africa	2011
F. Barthel; M. Busse; R. Osei	The characteristics and determinants of FDI in Ghana	2011

Appendix B - Literature list of case studies included in the systematic comparative literature review

R.M. Coulborn; I. Panunzi; S. Spijker; W.E. Brant; L.T. Duran; C.S. Kosack; M.M Murowa	Feasibility of using teleradiology to improve tuberculosis screening and case management in a district hospital in Malawi	2012
F. Shiferaw; M. Zolfo	The role of information communication technology (ICT) towards universal health coverage: the first steps of a telemedicine project in Ethiopia	2012
E.L Osabutey; Y. A. Debrah	Foreign Direct Investment and technology transfer policies in Africa: A review of the Ghanaian Experience	2012
E. Cleeve	Political and Institutional Impediments to Foreign Direct Investment Inflows to sub-Saharan Africa	2012
A.D. Bakar; Y.H Sheikh; A.B.MD Sultan	Opportunities and Challenges of Open Source Software Integration in Developing Countries: Case of Zanzibar Health Sector	2012
D.S. Wamala; K. Augustine	A meta-analysis of telemedicine success in Africa	2013
C.B Aranda-Jan; N. Mohutsiwa-Dibe; S. Loukanova	Systematic review on what works, what does not work and why of implementation of mobile health (m-Health) projects in Africa	2014
B.A. Jack; J.A. Kirton; J. Downing; K. Frame	The personal value of being part of a tropical health education trust links programme to develop a palliative care degree programme in Sub-Saharan Africa: a descriptive study of the views of volunteer UK health professionals	2015

Appendix C - Evaluation of models

Appendix C comprises of the completed individual evaluations of the TT models identified in Section 3.3.7. This section serves as the foundation for the summary of the analysis done according to both the Dynamic Configuration Criteria and the supplementary criteria stated in Chapter 5.

C.1 Dynamic Configuration Criteria model evaluation outcomes

Appendix C.1 elucidates the analysis done on all models identified by the systematic conceptual literature review. As stated in Section 5.1.1.1, an individual TT model may adhere to multiple sub-sections for each of the general criteria buy may only adhere to a single sub-section for each of the research aim specific criteria. Neither the general nor specific criteria may utilise any half marks.

Table C-1 - The Chantramonklasri model's initial evaluation results

The Chantramonklasri model (1990)							
General criteria	Dimensions	Legal +1	Social +1	~~Economic +1~~	Institutional +1	Political +1	
	Stakeholder involvement	Public sector +1	Transferor +1	Transferee +1	TTO +1	Multi-nationals +1	Domestic firms +1
	Knowledge management	Knowledge production +1	~~Information channel +1~~	~~Consultation channel +1~~	Collaboration channel +1	Capacity building channel +1	
	Innovation management	Multiple research-stakeholder interfaces +1	Development of adaptive capacity +1	Development of an enabling environment +1	Addressing of constraints +1	Adaptive monitoring and strategic adjustment +1	
Research aim specific criteria	Spatial scale	Patch level +0	Landscape level +1	~~Zonal level +2~~	Global level +3		
	Administrative scale	House level +0	Village level +1	~~Municipal level +2~~	Provincial level +2	National level +3	Supra-national level +3
	Stakeholders' relationship	Isolated venture +0	~~Informative relationship +1~~	Advisory relationship +2	Exchange relationship +2	Co-learning relationship +3	Capacity building relationship +3

Appendix C - The initial and supplementary evaluations of the identified technology transfer models

Table C-2 - The Levels of Involvement model's initial evaluation results

The Levels of Involvement model (1991)							
General criteria	Dimensions	Legal +1	Social +1	~~Economic +1~~	~~Institutional +1~~	Political +1	
	Stakeholder involvement	Public sector +1	~~Transferor +1~~	~~Transferee +1~~	TTO +1	Multi-nationals +1	Domestic firms +1
	Knowledge management	Knowledge production +1	~~Information channel +1~~	Consultation channel +1	~~Collaboration channel +1~~	~~Capacity building channel +1~~	
	Innovation management	~~Multiple research-stakeholder interfaces +1~~	Development of adaptive capacity +1	~~Development of an enabling environment +1~~	Addressing of constraints +1	~~Adaptive monitoring and strategic adjustment +1~~	
Research aim specific criteria	Spatial scale	Patch level +0	Landscape level +1	Zonal level +2	~~Global level +3~~		
	Administrative scale	House level +0	Village level +1	Municipal level +2	Provincial level +2	~~National level +3~~	Supra-national level +3
	Stakeholders' relationship	Isolated venture +0	Informative relationship +1	Advisory relationship +2	~~Exchange relationship +2~~	Co-learning relationship +3	Capacity building relationship +3

Table C-3 - The Organisational Capabilities-Based model's initial evaluation results

The Organisational Capabilities-Based model (1995)							
General criteria	Dimensions	Legal +1	Social +1	Economic +1	Institutional +1	Political +1	
	Stakeholder involvement	Public sector +1	~~Transferor +1~~	~~Transferee +1~~	TTO +1	Multi-nationals +1	Domestic firms +1
	Knowledge management	Knowledge production +1	~~Information channel +1~~	~~Consultation channel +1~~	~~Collaboration channel +1~~	Capacity building channel +1	
	Innovation management	Multiple research-stakeholder interfaces +1	~~Development of adaptive capacity +1~~	~~Development of an enabling environment +1~~	~~Addressing of constraints +1~~	~~Adaptive monitoring and strategic adjustment +1~~	
Research aim specific criteria	Spatial scale	Patch level +0	Landscape level +1	~~Zonal level +2~~	Global level +3		
	Administrative scale	House level +0	~~Village level +1~~	Municipal level +2	Provincial level +2	National level +3	Supra-national level +3
	Stakeholders' relationship	Isolated venture +0	Informative relationship +1	Advisory relationship +2	~~Exchange relationship +2~~	Co-learning relationship +3	Capacity building relationship +3

Table C-4 - The Contingent Effectiveness model's initial evaluation results

The Contingent Effectiveness model (2000)							
General criteria	Dimensions	Legal +1	~~Social +1~~	~~Economic +1~~	~~Institutional +1~~	~~Political +1~~	
	Stakeholder involvement	Public sector +1	~~Transferor +1~~	~~Transferee +1~~	TTO +1	Multi-nationals +1	Domestic firms +1
	Knowledge management	Knowledge production +1	~~Information channel +1~~	Consultation channel +1	Collaboration channel +1	~~Capacity building channel +1~~	

Appendix C - The initial and supplementary evaluations of the identified technology transfer models

	Innovation management	~~Multiple research-stakeholder interfaces +1~~	Development of adaptive capacity +1	~~Development of an enabling environment +1~~	~~Addressing of constraints +1~~	Adaptive monitoring and strategic adjustment +1	
Research aim specific criteria	Spatial scale	Patch level +0	Landscape level +1	Zonal level +2	~~Global level +3~~		
	Administrative scale	House level +0	Village level +1	Municipal level +2	Provincial level +2	National level +3	~~Supra-national level +3~~
	Stakeholders' relationship	Isolated venture +0	Informative relationship +1	Advisory relationship +2	~~Exchange relationship +2~~	Co-learning relationship +3	Capacity building relationship +3

Table C-5 - The Traditional Technology Transfer model's initial evaluation results

The Traditional Technology Transfer model (2000)							
General criteria	Dimensions	~~Legal +1~~	Social +1	~~Economic +1~~	Institutional +1	Political +1	
	Stakeholder involvement	Public sector +1	~~Transferor +1~~	~~Transferee +1~~	~~TTO +1~~	Multi-nationals +1	~~Domestic firms +1~~
	Knowledge management	~~Knowledge production +1~~	~~Information channel +1~~	~~Consultation channel +1~~	Collaboration channel +1	Capacity building channel +1	
	Innovation management	~~Multiple research-stakeholder interfaces +1~~	Development of adaptive capacity +1	Development of an enabling environment +1	Addressing of constraints +1	Adaptive monitoring and strategic adjustment +1	
Research aim specific criteria	Spatial scale	Patch level +0	Landscape level +1	~~Zonal level +2~~	Global level +3		
	Administrative scale	House level +0	~~Village level +1~~	Municipal level +2	Provincial level +2	National level +3	Supra-national level +3
	Stakeholders' relationship	~~Isolated venture +0~~	Informative relationship +1	Advisory relationship +2	Exchange relationship +2	Co-learning relationship +3	Capacity building relationship +3

Table C-6 - The Revised Levels of Involvement model's initial evaluation results

The Revised Levels of Involvement model (2000)							
General criteria	Dimensions	Legal +1	Social +1	~~Economic +1~~	~~Institutional +1~~	Political +1	
	Stakeholder involvement	Public sector +1	~~Transferor +1~~	~~Transferee +1~~	TTO +1	~~Multi-nationals +1~~	~~Domestic firms +1~~
	Knowledge management	Knowledge production +1	~~Information channel +1~~	Consultation channel +1	~~Collaboration channel +1~~	~~Capacity building channel +1~~	
	Innovation management	~~Multiple research-stakeholder interfaces +1~~	~~Development of adaptive capacity +1~~	~~Development of an enabling environment +1~~	~~Addressing of constraints +1~~	~~Adaptive monitoring and strategic adjustment +1~~	
Research aim specific criteria	Spatial scale	Patch level +0	Landscape level +1	Zonal level +2	~~Global level +3~~		
	Administrative scale	House level +0	Village level +1	Municipal level +2	Provincial level +2	~~National level +3~~	Supra-national level +3
	Stakeholders' relationship	Isolated venture +0	Informative relationship +1	Advisory relationship +2	~~Exchange relationship +2~~	Co-learning relationship +3	Capacity building relationship +3

Appendix C - The initial and supplementary evaluations of the identified technology transfer models

Table C-7 - The Interactive Broadcasting model's initial evaluation results

The Interactive Broadcasting model (2002)							
General criteria	Dimensions	Legal +1	~~Social +1~~	~~Economic +1~~	Institutional +1	Political +1	
General criteria	Stakeholder involvement	Public sector +1	~~Transferor +1~~	~~Transferee +1~~	TTO +1	Multi-nationals +1	Domestic firms +1
General criteria	Knowledge management	Knowledge production +1	~~Information channel +1~~	Consultation channel +1	~~Collaboration channel +1~~	~~Capacity building channel +1~~	
General criteria	Innovation management	Multiple research-stakeholder interfaces +1	Development of adaptive capacity +1	~~Development of an enabling environment +1~~	~~Addressing of constraints +1~~	~~Adaptive monitoring and strategic adjustment +1~~	
Research aim specific criteria	Spatial scale	Patch level +0	Landscape level +1	Zonal level +2	~~Global level +3~~		
Research aim specific criteria	Administrative scale	House level +0	Village level +1	Municipal level +2	Provincial level +2	~~National level +3~~	Supra-national level +3
Research aim specific criteria	Stakeholders' relationship	Isolated venture +0	Informative relationship +1	Advisory relationship +2	~~Exchange relationship +2~~	Co-learning relationship +3	Capacity building relationship +3

Table C-8 - The Traditional Model of University Technology Transfer's initial evaluation results

The Traditional Model of University Technology Transfer (2004)							
General criteria	Dimensions	~~Legal +1~~	~~Social +1~~	~~Economic +1~~	~~Institutional +1~~	Political +1	
General criteria	Stakeholder involvement	Public sector +1	~~Transferor +1~~	~~Transferee +1~~	~~TTO +1~~	Multi-nationals +1	~~Domestic firms +1~~
General criteria	Knowledge management	~~Knowledge production +1~~	Information channel +1	~~Consultation channel +1~~	Collaboration channel +1	Capacity building channel +1	
General criteria	Innovation management	~~Multiple research-stakeholder interfaces +1~~	Development of adaptive capacity +1	Development of an enabling environment +1	Addressing of constraints +1	Adaptive monitoring and strategic adjustment +1	
Research aim specific criteria	Spatial scale	Patch level +0	Landscape level +1	~~Zonal level +2~~	Global level +3		
Research aim specific criteria	Administrative scale	House level +0	Village level +1	~~Municipal level +2~~	Provincial level +2	National level +3	Supra-national level +3
Research aim specific criteria	Stakeholders' relationship	Isolated venture +0	Informative relationship +1	Advisory relationship +2	~~Exchange relationship +2~~	Co-learning relationship +3	Capacity building relationship +3

Table C-9 - The Stage-Gate model's initial evaluation results

The Stage-Gate model (2010)							
General criteria	Dimensions	~~Legal +1~~	Social +1	~~Economic +1~~	~~Institutional +1~~	Political +1	
General criteria	Stakeholder involvement	Public sector +1	~~Transferor +1~~	Transferee +1	TTO +1	Multi-nationals +1	Domestic firms +1
General criteria	Knowledge management	~~Knowledge production +1~~	~~Information channel +1~~	~~Consultation channel +1~~	Collaboration channel +1	Capacity building channel +1	

Appendix C - The initial and supplementary evaluations of the identified technology transfer models

	Innovation management	Multiple research-stakeholder interfaces +1	Development of adaptive capacity +1	Development of an enabling environment +1	~~Addressing of constraints +1~~	~~Adaptive monitoring and strategic adjustment +1~~	
Research aim specific criteria	**Spatial scale**	Patch level +0	Landscape level +1	~~Zonal level +2~~	Global level +3		
	Administrative scale	House level +0	Village level +1	Municipal level +2	~~Provincial level +2~~	National level +3	Supra-national level +3
	Stakeholders' relationship	Isolated venture +0	Informative relationship +1	~~Advisory relationship +2~~	Exchange relationship +2	Co-learning relationship +3	Capacity building relationship +3

Table C-10 - The Policy Integration model's initial evaluation results

The Policy Integration model (2010)							
General criteria	**Dimensions**	Legal +1	Social +1	~~Economic +1~~	Institutional +1	Political +1	
	Stakeholder involvement	Public sector +1	Transferor +1	Transferee +1	TTO +1	~~Multi-nationals +1~~	~~Domestic firms +1~~
	Knowledge management	Knowledge production +1	~~Information channel +1~~	Consultation channel +1	Collaboration channel +1	~~Capacity building channel +1~~	
	Innovation management	Multiple research-stakeholder interfaces +1	Development of adaptive capacity +1	Development of an enabling environment +1	Addressing of constraints +1	~~Adaptive monitoring and strategic adjustment +1~~	
Research aim specific criteria	**Spatial scale**	Patch level +0	Landscape level +1	Zonal level +2	~~Global level +3~~		
	Administrative scale	House level +0	Village level +1	Municipal level +2	~~Provincial level +2~~	National level +3	Supra-national level +3
	Stakeholders' relationship	Isolated venture +0	Informative relationship +1	Advisory relationship +2	Exchange relationship +2	Co-learning relationship +3	~~Capacity building relationship +3~~

Table C-11 - The Alternative Model of University Technology Transfer's initial evaluation results

The Alternative Model of University Technology Transfer (2013)							
General criteria	**Dimensions**	~~Legal +1~~	~~Social +1~~	~~Economic +1~~	~~Institutional +1~~	Political +1	
	Stakeholder involvement	~~Public sector +1~~	~~Transferor +1~~	~~Transferee +1~~	~~TTO +1~~	Multi-nationals +1	~~Domestic firms +1~~
	Knowledge management	~~Knowledge production +1~~	~~Information channel +1~~	~~Consultation channel +1~~	~~Collaboration channel +1~~	~~Capacity building channel +1~~	
	Innovation management	~~Multiple research-stakeholder interfaces +1~~	Development of adaptive capacity +1	~~Development of an enabling environment +1~~	Addressing of constraints +1	~~Adaptive monitoring and strategic adjustment +1~~	
Research aim specific criteria	**Spatial scale**	Patch level +0	Landscape level +1	~~Zonal level +2~~	Global level +3		
	Administrative scale	House level +0	Village level +1	~~Municipal level +2~~	Provincial level +2	National level +3	Supra-national level +3

Appendix C - The initial and supplementary evaluations of the identified technology transfer models

	Stakeholders' relationship	Isolated venture +0	Informative relationship +1	Advisory relationship +2	Exchange relationship +2	~~Co-learning relationship +3~~	Capacity building relationship +3

Table C-12 - The Revised Contingent Effectiveness model's initial evaluation results

The Revised Contingent Effectiveness model (2014)							
General criteria	**Dimensions**	Legal +1	~~Social +1~~	~~Economic +1~~	~~Institutional +1~~	~~Political +1~~	
	Stakeholder involvement	Public sector +1	~~Transferor +1~~	~~Transferee +1~~	TTO +1	Multi-nationals +1	Domestic firms +1
	Knowledge management	Knowledge production +1	~~Information channel +1~~	~~Consultation channel +1~~	Collaboration channel +1	~~Capacity building channel +1~~	
	Innovation management	Multiple research-stakeholder interfaces +1	Development of adaptive capacity +1	Development of an enabling environment +1	Addressing of constraints +1	Adaptive monitoring and strategic adjustment +1	
Research aim specific criteria	**Spatial scale**	Patch level +0	Landscape level +1	Zonal level +2	~~Global level +3~~		
	Administrative scale	House level +0	Village level +1	Municipal level +2	Provincial level +2	National level +3	~~Supra-national level +3~~
	Stakeholders' relationship	Isolated venture +0	Informative relationship +1	Advisory relationship +2	~~Exchange relationship +2~~	Co-learning relationship +3	Capacity building relationship +3

Table C-13 - The Knowledge in Technology Adoption model's initial evaluation results

The Knowledge in Technology Adoption model (2016)							
General criteria	**Dimensions**	Legal +1	Social +1	Economic +1	Institutional +1	Political +1	
	Stakeholder involvement	Public sector +1	~~Transferor +1~~	~~Transferee +1~~	TTO +1	Multi-nationals +1	Domestic firms +1
	Knowledge management	~~Knowledge production +1~~	~~Information channel +1~~	~~Consultation channel +1~~	~~Collaboration channel +1~~	~~Capacity building channel +1~~	
	Innovation management	Multiple research-stakeholder interfaces +1	~~Development of adaptive capacity +1~~	Development of an enabling environment +1	Addressing of constraints +1	Adaptive monitoring and strategic adjustment +1	
Research aim specific criteria	**Spatial scale**	Patch level +0	Landscape level +1	~~Zonal level +2~~	Global level +3		
	Administrative scale	House level +0	Village level +1	Municipal level +2	~~Provincial level +2~~	National level +3	Supra-national level +3
	Stakeholders' relationship	Isolated venture +0	Informative relationship +1	Advisory relationship +2	Exchange relationship +2	Co-learning relationship +3	~~Capacity building relationship +3~~

C.2 Supplementary criteria model evaluation outcomes

Appendix C.2 presents the evaluation of the four subsequent models that the evaluation in Appendix C.1 indicated was most conducive to the research aim of this document. As before, general TT criteria have again been restricted to a single mark, with an individual TT model able to adhere to multiple sub-sections for each of the general criteria.

Table C-14 - The Revised Levels of Involvement model's supplementary evaluation results

The Revised Levels of Involvement model (2000)					
General criteria	Implicit knowledge	Transfer of personnel	~~Codification of implicit knowledge~~		
	Hard infrastructure	Analysis of transfer environment's physical infrastructure	Identifying hard infrastructure barriers		
	Commercialisation	Technology role out protocols	~~Management of technology for economic profit~~	Marketing of technology to potential funders	
	Soft infrastructure	~~Training programs present~~	~~Incentive programs present~~	~~Collaboration programs present~~	
	TT appraisal methods	~~Managerial checklists for TT process~~	Best practices for individual stages of TT	Revision protocols during and after TT process	
	Marketing and advertising	Marketing of initial discovery or technology	Marketing to potential transferees	Advertising campaigns from start-up transferees	~~Advertising to different stakeholder groups~~
	Change management	Integration protocols	Collaboration between transferor and transferee	Continued involvement of transferor after TT has been completed	Adaptive capability management of transferee

Table C-15 - The Interactive Broadcasting model's supplementary evaluation results

The Interactive Broadcasting model (2002)					
General criteria	Implicit knowledge	~~Transfer of personnel~~	~~Codification of implicit knowledge~~		
General criteria	Hard infrastructure	Analysis of transfer environment's physical infrastructure	Identifying hard infrastructure barriers		
General criteria	Commercialisation	Technology role out protocols	~~Management of technology for economic profit~~	Marketing of technology to potential funders	
General criteria	Soft infrastructure	Training programs present	~~Incentive programs present~~	Collaboration programs present	
General criteria	TT appraisal methods	Managerial checklists for TT process	Best practices for individual stages of TT	Revision protocols during and after TT process	
General criteria	Marketing and advertising	Marketing of initial discovery or technology	Marketing to potential transferees	Advertising campaigns from start-up transferees	Advertising to different stakeholder groups
General criteria	Change management	Integration protocols	Collaboration between transferor and transferee	~~Continued involvement of transferor after TT has been completed~~	Adaptive capability management of transferee

Table C-16 - The Alternative Model of University Technology Transfer's supplementary evaluation results

The Alternative Model of University Technology Transfer (2013)					
General criteria	Implicit knowledge	Transfer of personnel	~~Codification of implicit knowledge~~		
General criteria	Hard infrastructure	Analysis of transfer environment's physical infrastructure	Identifying hard infrastructure barriers		
General criteria	Commercialisation	Technology role out protocols	~~Management of technology for economic profit~~	~~Marketing of technology to potential funders~~	
General criteria	Soft infrastructure	Training programs present	~~Incentive programs present~~	Collaboration programs present	
General criteria	TT appraisal methods	Managerial checklists for TT process	Best practices for individual stages of TT	Revision protocols during and after TT process	
General criteria	Marketing and advertising	~~Marketing of initial discovery or technology~~	~~Marketing to potential transferees~~	Advertising campaigns from start-up transferees	Advertising to different stakeholder groups
General criteria	Change management	Integration protocols	~~Collaboration between transferor and transferee~~	Continued involvement of transferor after TT has been completed	Adaptive capability management of transferee

Table C-17 - The Revised Contingent Effectiveness model's supplementary evaluation results

The Revised Contingent Effectiveness model (2014)					
General criteria	Implicit knowledge	~~Transfer of personnel~~	~~Codification of implicit knowledge~~		
	Hard infrastructure	~~Analysis of transfer environment's physical infrastructure~~	Identifying hard infrastructure barriers		
	Commercialisation	Technology role out protocols	~~Management of technology for economic profit~~	Marketing of technology to potential funders	
	Soft infrastructure	Training programs present	Incentive programs present	~~Collaboration programs present~~	
	TT appraisal methods	~~Managerial checklists for TT process~~	Best practices for individual stages of TT	Revision protocols during and after TT process	
	Marketing and advertising	Marketing of initial discovery or technology	Marketing to potential transferees	~~Advertising campaigns from start-up transferees~~	~~Advertising to different stakeholder groups~~
	Change management	Integration protocols	~~Collaboration between transferor and transferee~~	Continued involvement of transferor after TT has been completed	Adaptive capability management of transferee

Appendix D - Conceptual framework

Appendix D has been included to promote the transparency of the foundations of the conceptual framework presented in Chapter 5. All node and relationships have been restated and supplemented with the references to the corresponding empirical literature sources uncovered during the completion of Chapter 3 and Chapter 4. To improve accessibility, Appendix D has been divided into the five phases corresponding to the five phases of the conceptual framework, shown in Figure 5-9.

D.1 The literature foundation of Phase I

Appendix D.1 depicts the outcomes of the conceptual framework's first Phase, shown in Section 5.4.1. The references and outcomes corresponding to the nodes and relationship flow shown in Figure 5-10 have been restated in Appendix D.1 to highlight the literature foundations.

Table D-1 - Table 5-7's literature foundations

Node: Transferee	
Primary focus	**The transferee's capability to participate in the technology transfer**
Considerations	- The transferee's primary motivations and pulling forces behind the proposed TT (Ramanathan, 2011; Manimala *et al.*, 2013; Handoko *et al.*, 2016). - The economic scale of the transferee and the transferee's available resources that could sustainably be committed to the transfer (Jagoda *et al.*, 2010; Ramanathan, 2011). - The transferee's constituents and the relationships between these constituents if the transferee comprises out of more than a single entity (Bozeman, 2000; Handoko *et al.*, 2016). - The transferee's current experience surrounding TTs and access to codified knowledge of previous transfers of a similar nature (Manimala *et al.*, 2013; Nygaard *et al.*, 2013; Handoko *et al.*, 2016). - The transferee's available personnel capable of TT facilitation, transfer object training and stakeholder communication (Rebentisch *et al.*, 1995; Bozeman, 2000; Handoko *et al.*, 2016). - The scale of the transferee's internal and external marketing department (Bozeman, 2000; Jagoda *et al.*, 2005; Ramanathan, 2011). - The availability of a TTO, either directly or indirectly, in the transferee's setting (Anderson *et al.*, 2007; Ryu *et al.*, 2010; Bradley *et al.*, 2013). - The transferee's opportunity cost of the transfer (Salicrup *et al.*, 2006; Smith, 2007; Bozeman *et al.*, 2015).

Table D-2 - Table 28's literature foundations continued

Node: Transferor	
Primary focus	**The transferor's capability to participate in the technology transfer**
Considerations	- The transferor's primary motivations and pushing forces behind the proposed TT (Ramanathan, 2011; Manimala *et al.*, 2013; Handoko *et al.*, 2016). - The transferor's constituents and the relationships between these constituents if the transferor comprises out of more than a single entity (Jagoda *et al.*, 2010; Ramanathan, 2011). - The transferor's current technology development and TT experience as well as access to codified knowledge of previous transfers of a similar nature (Gibson *et al.*, 1991; Bozeman, 2000; Handoko *et al.*, 2016). - Identifying the transferor's political and social constraints as well as evaluating how these constraints may restrict transferor's ability to perform the proposed TT (Barthel *et al.*, 2008; Mengiste, 2010; Schut *et al.*, 2014). - The transferor's available personnel capable of TT facilitation, transfer object training and stakeholder communication (Rebentisch *et al.*, 1995; Bozeman, 2000; Handoko *et al.*, 2016). - The manner and totality of the transferor's legal ownership of the transfer object (Ryu *et al.*, 2010; Ramanathan, 2011; Chakroun, 2012) - The availability of a TTO, either directly or indirectly, in the transferor's setting (Anderson *et al.*, 2007; Ryu *et al.*, 2010; Bradley *et al.*, 2013). - The transferor's opportunity cost of the transfer (Salicrup *et al.*, 2006; Smith, 2007; Bozeman *et al.*, 2015).

Table D-3 - Table 5-8's literature foundations

Relationship: Transferor and transferee	
Primary focus	**Establishing the required relationship between the primary stakeholders**
Considerations for the initial transfer team	- The potential exists for both a positive and a negative correlation between the geographic distance of the stakeholders and the effectiveness and frequency of their communications (Sung *et al.*, 2000). - The transferee and transferor may adhere to different economic, social and political constraints (Kline, 2004; Lucas, 2008; Andrzejczak, 2014). - The similarities and discrepancies of the legal system in which both stakeholders operate (Kline, 2004; Mars, 2010; Cleeve, 2012). - The mutual communication methods available to the stakeholders (Harris *et al.*, 2000; Siegel *et al.*, 2004; Mosse *et al.*, 2005). - What protocols have been put in place for implicit knowledge transfer (Carley, 1993; Siegel *et al.*, 2004; Handoko *et al.*, 2016). - The feasibility and opportunity cost for co-creation TT considering both stakeholder's perspectives, agendas and available resources (Bozeman, 2000; Golob, 2006; Bozeman *et al.*, 2015).
Managerial best practices for the initial transfer team	- The creation of a strategic business alliance will ensure the promotion of a co-creation TT team (Smith *et al.*, 2008; Wahab *et al.*, 2009). - The magnitude of the difference between the stakeholder's social, economic and political constraints should be counterbalanced by predefined and integrated business strategies from both stakeholders (Bozeman, 2000; Philip F. Musa *et al.*, 2005; Dubickis, 2015). - A predefined communication system should be incorporated along with daily communication between the transferee and transferor (Malik, 2002; Mosse *et al.*, 2005; Manimala *et al.*, 2013). - Both the transferee and transferor should assign dedicated personnel to the TT with the aim of creating a transfer team capable of outlining and achieving the TT's objectives and prerequisites (Harris *et al.*, 2000; Bradley *et al.*, 2013). - The transferor should create training programs for the transferee to accommodate for lacking experience (Harris *et al.*, 2000; Sung *et al.*, 2000). - A managerial hierarchy should be created (Sung *et al.*, 2000). - The managers of this hierarchy should motivate the transfer team through incentives and advertising previous successes (Sung *et al.*, 2000). - Both stakeholders should be actively involved in the design or modification of the transfer object to promote adoption in Phase IV (Nhampossa, 2005; Jesse *et al.*, 2010; Ramanathan, 2011).

Table D-4 - Table 5-9's literature foundations

Node: Transfer object	
Primary focus	**Deconstructing the transfer object's characteristics**
Universal transfer object considerations	
-	The transfer object's ability to be transferred (Rebentisch *et al.*, 1995; Bozeman, 2000; Bradley *et al.*, 2013; Manimala *et al.*, 2013).
-	The industries or sectors in which the transfer object operates (Shamsavari *et al.*, 2002; Johnston *et al.*, 2004; Bozeman *et al.*, 2015).
-	The transfer object's legal protection (Shamsavari *et al.*, 2002; Shamsavari, 2006; Ryu *et al.*, 2010; Bradley *et al.*, 2013).
-	The purpose and utility of the transfer object for both transferee and transferor (Rebentisch *et al.*, 1995; Bozeman, 2000; Sung *et al.*, 2000; Johnston *et al.*, 2004).
-	The transfer object's maturity and total useful life (Ramanathan, 2011; Manimala *et al.*, 2013).
-	The systems, if any, within which the transfer object functions (Rebentisch *et al.*, 1995; Nhampossa, 2005).
-	The sub-systems required, if any, for the transfer object to effectively operate (Rebentisch *et al.*, 1995; Johnston *et al.*, 2004; Kifle *et al.*, 2010; Manimala *et al.*, 2013).
-	The technological complexity of the transfer object in terms of ease of manufacturing, utilisation, modification and maintenance (Bozeman, 2000; Johnston *et al.*, 2004; Nhampossa, 2005; Manimala *et al.*, 2013).
Explicit knowledge considerations	
-	The form or system in which the codified knowledge regarding the transfer object has been stored (Rebentisch *et al.*, 1995; Wahab *et al.*, 2009; Handoko *et al.*, 2016).
-	The complexity of this codified knowledge (Sung *et al.*, 2000; Bradley *et al.*, 2013; Manimala *et al.*, 2013).
-	Any legal constraints preventing access to codified knowledge and its duplication or dissemination (Ryu *et al.*, 2010; Bradley *et al.*, 2013; Handoko *et al.*, 2016).
-	Potential language barriers prohibiting effective explicit knowledge transfer (Shamsavari *et al.*, 2002; Nhampossa, 2005; Handoko *et al.*, 2016).
Implicit knowledge considerations	
-	The form or system in which the implicit knowledge regarding the transfer object has been stored (Wahab *et al.*, 2009; Handoko *et al.*, 2016).
-	The feasibility of effective implicit knowledge transfer through modern communication channels (Rebentisch *et al.*, 1995; Sung *et al.*, 2000).
-	The success of any previous attempts at implicit knowledge codification regarding the transfer object or a transfer object of a similar nature (Bradley *et al.*, 2013; Handoko *et al.*, 2016).
-	The feasibility of the codification of the implicit knowledge regarding the transfer object (Wahab *et al.*, 2009; Bradley *et al.*, 2013; Handoko *et al.*, 2016).
-	The possibility of personnel transfer acquainted with the transfer object characteristics (Rebentisch *et al.*, 1995; Nhampossa, 2005)
-	Cultural or social constraints barring implicit knowledge transfer (Shamsavari *et al.*, 2002; Wahab *et al.*, 2009; Handoko *et al.*, 2016)

D.2 The literature foundation of Phase II

Appendix D.2 depicts the outcomes of the conceptual framework's first Phase, shown in Section 5.4.2. The references and outcomes corresponding to the nodes and relationship flows shown in Figure 5-13 have been restated in Appendix D.2 to highlight the literature foundations.

Table D-5 - Table 5-10's literature foundations

Node: Stakeholder collocation	
Primary focus	**Classification of stakeholders' roles**
Managerial lead	- This role can be appropriated by an individual or by a section of the joint transfer team shown in Figure 5-14 (Martinez, 2003; Siegel *et al.*, 2004; Koefoed *et al.*, 2008; Ryu *et al.*, 2010). - This role will be responsible for championing the TT venture in terms of the transfer environment screening, transfer method selection and the transfer method implementation strategy as well as ensuring overall stakeholder integration (Clarysse *et al.*, 2004; Siegel *et al.*, 2004; Mengiste, 2010). - They may also serve as either the push or pull driver for the TT (Barthel *et al.*, 2008; Luiz, 2010; Osabutey *et al.*, 2012). - This role must actively be integrated into all nodes of the TT framework (Clarysse *et al.*, 2004; Nhampossa, 2005; Meso *et al.*, 2009). - The managerial team will be partly responsible for the revision process and the subsequent continuation or termination decision at both revision nodes (Clarysse *et al.*, 2004; Manimala *et al.*, 2013).
Integration and co-creation lead	- This role will be responsible for stakeholder integration and ensuring collaboration with the appropriate public-sector division (Bassioni *et al.*, 2005; Nhampossa, 2005; Hoekman *et al.*, 2006; Mazurowski, 2006). - A key role will be to ensure co-creation among stakeholders and they should devise a protocol to ensure that a pool of knowledge will be created and documented (Bassioni *et al.*, 2005; Nhampossa, 2005; Mazurowski, 2006; Handoko *et al.*, 2016). - This role will also involve the search for additional stakeholders that may either be a requirement or serve as a benefactor to the TT venture (Bassioni *et al.*, 2005; Mazurowski, 2006). - This role will also be responsible to either directly or indirectly champion the codification of all TT outcomes for future usage (Rebentisch *et al.*, 1995; Malik, 2002; Handoko *et al.*, 2016).
Pull driver	- The pull driver serves as the driving force which brings the transfer object to the transferee and into the transfer environment (Kimaro *et al.*, 2005; Barthel *et al.*, 2008; Munyua *et al.*, 2009). - This role may include supporting the transfer with respect to funding and personnel (Alden *et al.*, 2006; Luiz, 2010; Cleeve, 2012). - The pull driver should focus on exploiting domestic market gaps, easing the healthcare burden and implementing local health initiatives (Kimaro *et al.*, 2005; Shiferaw *et al.*, 2012; Wamala *et al.*, 2013). - This role must strongly promote domestic public-sector collaboration and the establishment or refinement of policy implementations conducive to health-related TT (Chanda, 2002; Wamala *et al.*, 2013; Aranda-Jan *et al.*, 2014). - An important responsibility of this role will be local advertising to promote market-wide adoption after the initial transfer (Mutula, 2008).
Push driver	- The push driver serves as the driving force to push the transfer object from the transferor towards the transferee and into the transfer environment (Alden *et al.*, 2006; Fuchs *et al.*, 2008; Renard, 2011). - This role will often be appropriated by multi-nationals, foreign governments and primary research institutions or a combination of these three stakeholders (Bagayoko *et al.*, 2006; Fuchs *et al.*, 2008; Schuppan, 2009; Renard, 2011). - The primary funding will usually be provided by the stakeholder that fulfills this role (Fuchs *et al.*, 2008; Smith *et al.*, 2008; Renard, 2011). - Market expansion and international research collaborations often serve as the motivation for the push driver. It is thus important to align the improvement of local healthcare infrastructure with these agendas (Fuchs *et al.*, 2008; Kariuki, 2009; Renard, 2011).

Table D-6 - Table 33's literature foundations

Node: Stakeholder collocation	
Primary focus	**Managerial best practices for co-creation responsibilities**
Integration strategy	- It will be imperative that the TT venture has an explicitly defined stakeholder integration strategy accessible by all current and potential stakeholders (Hoppe, 2005; Nhampossa, 2005; Smith *et al.*, 2008; Aranda-Jan *et al.*, 2014). - Each stakeholder must have a single or collection of roles assigned to them based on their individual capabilities and motivations (Ansari *et al.*, 2001; Hoppe, 2005; Schut *et al.*, 2014). - Likewise, all roles shown in Figure 5-14 must have single or multiple stakeholders assigned to it. This ensures that all primary stakeholders will be informed of their requirements and improves accountability and transparency in the subsequent phases of the TT venture (Ansari *et al.*, 2001; Hoppe, 2005; Schut *et al.*, 2014).
Co-creation promotion	- To promote co-creation, the transfer team must aim to adhere to the higher levels of the expanded stakeholder instrument provided in Figure 5-12 (Smith *et al.*, 2008; Wahab *et al.*, 2009; Manimala *et al.*, 2013). - Each stakeholder involved should commit active personnel to the transfer team (Rebentisch *et al.*, 1995; Hoekman *et al.*, 2006; Ryu *et al.*, 2010; Handoko *et al.*, 2016). - In instances where an individual stakeholder's constraints restrict high levels of co-creation, the transfer team must document managerial actions and transfer strategies. This documentation must then be relayed to ensure passive stakeholders have been informed of high-level transfer activities regardless of their individual constraints (Ryu *et al.*, 2010).
Knowledge transfer	- The joint team should adopt a standardised method to codify both explicit and implicit knowledge. Subsequently, training regarding this codification method should be made available to all stakeholders (Rebentisch *et al.*, 1995; Becerra *et al.*, 2008; Nygaard *et al.*, 2013; Handoko *et al.*, 2016). - A document should be constructed that codifies the transfer object's characteristics, sub-system requirements, maintenance schedule and supply chain operations (Rebentisch *et al.*, 1995; Becerra *et al.*, 2008; Nygaard *et al.*, 2013; Handoko *et al.*, 2016). - Personnel that understand both transferee and transferor cultures, politics and languages must be incorporated into the knowledge transfer process (Geissbuhler *et al.*, 2003; Braa *et al.*, 2004; Nhampossa, 2005; Handoko *et al.*, 2016). - When implicit knowledge transfer is required, site visits and temporary personnel transfer must be prioritised (Rebentisch *et al.*, 1995; Bozeman, 2000; Bozeman *et al.*, 2015; Handoko *et al.*, 2016).

Table D-7 - Table 5-13's literature foundations

Node: Stakeholder collocation	
Primary focus	**Managerial best practices for foundation building responsibilities**
Motivation	- If previous successful TT ventures of similar nature are available, the managerial hierarchy should promote these accomplishments to both motivate and educate the transfer team (Sung *et al.*, 2000; Ryu *et al.*, 2010). - The implementation of an intangible rewards system that recognises noteworthy contributions of individual transfer team members should be considered for motivational purposes (Sung *et al.*, 2000; Shiferaw *et al.*, 2012; Bradley *et al.*, 2013).
Funding	- It will be imperative to the TT venture that a funding plan be created, and it must be routinely updated (Akinsola, 2005; Nhampossa, 2005; Jack *et al.*, 2015) - Each stakeholder must be aware of this plan and the expected magnitude and duration of their individual contributions (Ansari *et al.*, 2001; Nhampossa, 2005). - The transfer team must consider funding in conjunction with the transfer environment, infrastructure requirements and transfer object characteristic to establish a detailed budget (Jack *et al.*, 2015). - This responsibility will often be assigned to a combination of the transferor, transferee and the public sector with major contributions from a multi-national expected when present (Chanda, 2002; Geissbuhler *et al.*, 2003; Mutula, 2008; Aker *et al.*, 2010).

Table D-8 - Table 5-13's literature foundations continued

Node: Stakeholder collocation	
Primary focus	**Managerial best practices for foundation building responsibilities**
Incorporating health criteria	- A guideline should be provided by the transfer team that ensures all stakeholders can accommodate the variances between their TT experiences and the implicit requirements of health-related TT. This guideline should be outlined in conjunction with transfer object analysis shown in Table 5-9 (Piotti *et al.*, 2007; Mars, 2010; Karari *et al.*, 2011). - A list must be populated of health-specific requirements, separate of the general TT requirements, for use in the screening of the transfer environment and subsequent evaluation (World Health Organization, 2006; Mengiste, 2010; Shiferaw *et al.*, 2012).
Public liaison	- An individual within the transfer team must explicitly be appointed as the public liaison. This party should ultimately be knowledgeable on the public sector's general procedures and health-related policies. If such an individual does not exist within the transfer team third party consultation must be incorporated (Gibson *et al.*, 1991; Rodrigues *et al.*, 2003; Golob, 2006; Bradley *et al.*, 2013; McKerlich *et al.*, 2013). - An agenda should be constructed by the transfer team outlining the public liaisons objectives as well as a review process to ensure these objectives have been met (Gibson *et al.*, 1991; Bozeman *et al.*, 2015). - It is important for the public liaison to interact with both the transferee's and transferor's governments in instances where they differ (Bagayoko *et al.*, 2006; Salicrup *et al.*, 2006; Connell *et al.*, 2007). - The public liaison is encouraged to populate a list of TT requirements that can only be overcome with aid of the public sector (Lucas, 2008; Kariuki, 2009; Jagoda *et al.*, 2010).

Table D-9 - Table 5-14's literature foundations continued

Node	Transfer environment
Primary focus	**The suitability of the transfer object in the transfer environment**
Transfer environment considerations	- The availability and quality of the required hard and soft infrastructure components (Geissbuhler *et al.*, 2003; Akinsola, 2005; Kariuki, 2009; Latourette *et al.*, 2011). - The variances in the supply, manufacture and maintenance capabilities of the transfer environment and the environment in which the transfer object had originated (Ansari *et al.*, 2001; Kimaro *et al.*, 2005; Bartels *et al.*, 2009). - The economic structure of the transfer environment as well as current and future market situation (Chanda, 2002; Barthel *et al.*, 2008; Cleeve, 2012; Shiferaw *et al.*, 2012). - The appropriateness and marketability of the transfer object in the transfer environment. - Differing user requirements for the transfer object (Chanda, 2002; Akinsola, 2005; Bagayoko *et al.*, 2006; Golob, 2006; Shamsavari, 2006). - Any potential transfer environment alterations required to accommodate the transfer object (Geissbuhler *et al.*, 2003; Akinsola, 2005; Kariuki, 2009; Latourette *et al.*, 2011). - The import duties, quotas or tariffs applicable to the transfer object (Boateng *et al.*, 2002; Alden *et al.*, 2006). - Differences in support or litigation provided by the transferee's public sector when compared to the transferor's public sector (Boateng *et al.*, 2002; Renard, 2011; Bakar *et al.*, 2012).
Managerial best practices	- The transfer team should consist of personnel capable of analysing the transfer environment from multiple perspectives such as economic, social, cultural and political viewpoints (Rebentisch *et al.*, 1995; Bozeman, 2000; Ryu *et al.*, 2010; Manimala *et al.*, 2013). - Designated personnel must be assigned to the evaluation of the transfer environment's market demand and requirements, healthcare system, public sector and the applicable transfer object supply chain. The framework recommends these evaluations be assigned to personnel with experience in these respective fields (Rebentisch *et al.*, 1995; Bozeman, 2000; Ramanathan, 2011). - Specific emphasis must be placed on identifying market conditions as the appropriateness and marketability of the transfer object within the transfer environment will partly determine the commercialisation outcome of the transfer object (Bozeman, 2000; Manimala *et al.*, 2013). - The transfer environment and transfer object considerations should be completed in conjunction with one another. Obstacles created by either may be overcome through alterations to the other. However, the framework encourages the transfer team to alter the transfer object whenever possible due to financial and time implications (Bozeman, 2000; Ramanathan, 2011).

Table D-10 - Table 5-15's literature foundations

Node: Infrastructure requirements	
Primary focus	**Potential hard infrastructure required for health-related TT to SSA countries**
Hard infrastructure requirements	**Managerial mitigation practices**
Internet access and telecommunication infrastructure	- The transfer team should attempt to access the international fibre cables running down the African East and West coast, such as the SEACOM cable. For landlocked countries, this will require government intervention and should be a priority for the public liaison role (Mutula, 2008; Kariuki, 2009; Latourette *et al.*, 2011). - Remote satellite internet access provides the user with stable internet access but requires high capital expenditure and may only be feasible when a multi-national has been incorporated as a stakeholder (Bagayoko *et al.*, 2006; Mutula, 2008; Mars, 2010). - Offline data capture allows users to complete tasks with basic computer or stationary equipment which can, in turn, be transmitted when internet access or telecommunication becomes available. This strategy may be implemented in rural areas after which the data could be transported to an urban centre with improved internet capabilities (Bagayoko *et al.*, 2006; Ssewanyana *et al.*, 2007). - Communication consists of many forms, some which may serve as substitutes for one another. Email, landlines, e-communication, cell phones, faxes should all be compared for individual TT ventures to ascertain which will be the most accessible (Rodrigues *et al.*, 2003; Akinsola, 2005; Philip F Musa *et al.*, 2005; Kariuki, 2009). - Infrastructure development to create internet access points. This will only be economically and politically feasible for either long-term FDIs or major joint ventures with the public sector, but it will result in constant internet access and ICT at lower variable cost than the alternatives (Akinsola, 2005; Mutula, 2008; Kariuki, 2009; Mars, 2010).
Power supply	- For instances where the TT venture has been plagued by unstable electricity, implementing some form of back-up supply that can operate for short periods should be considered. Examples include an uninterrupted power supply, battery systems, fuel-powered generators and even small scale solar panels (Bagayoko *et al.*, 2006; Latourette *et al.*, 2011). - For instances where a TT venture does not have access to a national power grid, the transfer team should consider the power requirements of the transfer and the economic cost of personal power generation. A more economical solution will be the modification of the transfer object to function with smaller amounts of electricity (Geissbuhler *et al.*, 2003; Mengiste, 2010; Latourette *et al.*, 2011; Coulborn *et al.*, 2012). - For larger TT ventures that have long maturities, the transfer team should consider the feasibility of a small-scale electricity generating plant in conjunction with the public sector. Again, the quality of the public liaison role will be of high importance (Mutula, 2008; Renard, 2011).
Healthcare facilitates, services and devices	- Inadequate healthcare infrastructure may represent a substantial barrier as it will typically fall outside of the transfer scope for most TT ventures. Altering the transfer object to operate with the available healthcare infrastructure may often constitute the most feasible solution (Rebentisch *et al.*, 1995; Bozeman, 2000; Ramanathan, 2011). - When the transfer object requires a select healthcare device or system to operate, the transfer team should consider incorporating this sub-device into the overall TT venture. Thus, the transfer object will comprise of both the sub-device and main transfer object (Kifle *et al.*, 2006; Salicrup *et al.*, 2006; Coloma *et al.*, 2008).
Transportation infrastructure	- Transportation infrastructure development would typically be unfeasible for most TT ventures. Mitigation practices should rather focus on eliminating the requirement for frequent transport through communication devices and decentralisation of the transfer object's impact area whenever possible (Mosse *et al.*, 2005; Bagayoko *et al.*, 2006; Munyua *et al.*, 2009).

Table D-11 - Table 5-16's literature foundations

Node: Infrastructure requirements	
Primary focus	**Potential soft infrastructure required for health-related TT to SSA countries**
Soft infrastructure requirements	**Managerial mitigation practices**
Health-related education	- Lacking health-related education presents similar challenges when compared to lacking health-related hard infrastructure. As such, altering the transfer object to operate with the available health-related education may often constitute the most feasible solution (Rebentisch *et al.*, 1995; Kifle *et al.*, 2006). - The framework also encourages the transfer team to facilitate the dissemination of knowledge surrounding the transfer object thus inherently improving the health-related education of the domestic workforce (Ansari *et al.*, 2001; Akinsola, 2005; Osabutey *et al.*, 2012). - Site visits to the transferor, education and training programs may all serve to mitigate inadequate health-related education (Sung *et al.*, 2000; Siegel *et al.*, 2004; Shiferaw *et al.*, 2012).
Integration between stakeholders	- Refer to the integration and co-creation best practices shown in Table 5-12 and Table 5-13.
Digital literacy	- As stated in Phase I, the transferor should implement training programs irrespective of the current level of digital literacy in the transfer environment. These training programs should preferably be completed directly by personnel, however, online training programs will be adequate for most cases (Kifle *et al.*, 2006; Karari *et al.*, 2011; Whittaker *et al.*, 2011; Bakar *et al.*, 2012). - While these training programs may not be tailored specifically to the improvement of digital literacy, the transfer team should include fundamental computer training for all TTs to developing nations (Piotti *et al.*, 2007; Shiferaw *et al.*, 2012).
Political transparency and an established legal framework	- Lack of political transparency in the transfer environment may be mitigated through efforts by the transfer team to incorporate domestic human rights groups currently active in the region. Similar attempts should be made to incorporate non-profit healthcare organisations when political transparency has been deemed an important transfer requirement (Alden *et al.*, 2006; Luiz, 2010; Cleeve, 2012). - When TT occur across borders and involves multiple countries, the transfer team must identify the most politically stable nation with established legal frameworks and utilise this country as the base for the TT to neighbouring regions (Cleeve, 2012). - When the transfer object surrounds e-Health, the transfer team should look to market the potential benefit that e-Government systems such as e-Health may contribute towards political transparency and efficiency (Munyua *et al.*, 2009; Schuppan, 2009). - When the transfer environment has been deemed to possess an insufficient legal framework, the transfer team may utilise licensing agreements and IP to provide international legal protection for the transfer object (Hoekman *et al.*, 2006; Aranda-Jan *et al.*, 2014).
Sustainable technology transfer offices	- The sustainability of TTOs will be heavily reliant on external monetary and personnel support. Thus, when the transfer team incorporates a TTO as a stakeholder protocols should be instated that ensure the TTO has accessed to the necessary resources (Bozeman, 2000; Sung *et al.*, 2000). - TTOs may be strengthened through knowledge sharing with the remainder of the transfer team. Obtaining high levels of co-creation shown in Phase I will thus inherently promote sustainable TTOs (Rogers *et al.*, 2001; Ryu *et al.*, 2010; Link *et al.*, 2016). - When a TTO does not exist in the transfer environment, the transfer team should evaluate the opportunity cost of formulating a TTO. However, the marginal level of output that a newly created TTO provides, may often not justify its monetary start-up cost (Bozeman, 2000; Maredia *et al.*, 2000).

D.3 The literature foundation of Phase III

Appendix D.3 depicts the outcomes of the conceptual framework's first Phase, shown in Section 5.4.3. The references and outcomes corresponding to the nodes and relationship flows shown in Figure 5-16 have been restated in Appendix D.3 to highlight the literature foundations.

Table D-12 - Table 5-18's literature foundations

Node: Collaborative organisation	
Primary focus	**Co-creation best practices to ensure the transfer object's suitability**
Best practices	
- When possible, the transferor and transferee should create a co-creation development team where the transfer object has been jointly created by both parties to function their respective environments (Ramanathan, 2011; Manimala *et al.*, 2013). - When the transfer object already exists, the transferor and transferee should create a co-creation alteration team where both stakeholders attempt to jointly modify the existing transfer object to suit the proposed transfer environment (Jagoda *et al.*, 2010; Ramanathan, 2011; Handoko *et al.*, 2016). - The collaborative organisation should not attempt to ensure transfer object suitability in isolation. The entire transfer team created in previous phases must be consulted (Jagoda *et al.*, 2010; Ramanathan, 2011; Handoko *et al.*, 2016). - As stated in Phase I, the transferor should engage with the transferee to ensure that their motivations, agendas and desired outcomes have been understood and documented (Manimala *et al.*, 2013; Handoko *et al.*, 2016). - The results of the transfer object evaluation, completed in Phase I, should be utilised to create a document of the various transfer object characteristics. These characteristics should be ranked according to the total amount of resources required to alter them (Shamsavari, 2006; Jagoda *et al.*, 2010). - The results of the transfer environment screening, completed in Phase II, should be utilised to create a document of the various transfer environment elements. These elements should be ranked according to the total amount of resources required to alter them (Chandra, 2006; Zhang *et al.*, 2016). - A subsequent document must then be created comparing the required transfer object and transfer environment alterations to ensure suitability will be feasible. The transfer team must consider the varying options and adopt a guideline explicitly dictating which transfer object or transfer environment alterations need to occur (Chandra, 2006; Shamsavari, 2006; Ramanathan, 2011; Manimala *et al.*, 2013) - To aid in the transfer environment alteration, the entire transfer team should continually seek to advertise to additional stakeholders capable of assisting with landscape change. The public liaison role, shown in Figure 5-14, will typically be required to ensure public sector assistance for this process (Shamsavari *et al.*, 2002; Jagoda *et al.*, 2010; Schut *et al.*, 2014).	

Table D-13 represents the complete TT method selection instrument, the summary of which has been shown in Section 5.4.3.2. The instrument provides guidelines with which the transfer team may allocate a TT method suited to a given TT's characteristics.

Table 6-17 also provides the literature foundations utilised in the construction of Table 5-19.

Table D-13 - Technology transfer selection instrument

Node: Transfer method			
Primary focus	Selection of appropriate transfer vehicle		
	Transfer methods		
	Traditional technology transfer	**Foreign direct investments**	**Joint ventures**
Transferor	i. When on a national or global level the transferor will often be a branch of government such as the ministry of health (Karari *et al.*, 2011; Bakar *et al.*, 2012).	i. It is common or the transferor to be a multi-national or foreign government (Alden *et al.*, 2006; Anyanwu, 2012). ii. For health-related TTs, the transferor may also be a foreign university that is supported by a health orientated private or public-sector stakeholders (Bagayoko *et al.*, 2006; Wamala *et al.*, 2013).	i. Generally, a private or public university or research institution will be the transferor in a joint venture (Ansari *et al.*, 2001; Geissbuhler *et al.*, 2003; Braa *et al.*, 2004; Mars, 2010). ii. As with FDIs, the transferor may be a large multi-national corporation, specifically pharmaceutical companies for health-related transfers (Boateng *et al.*, 2002; Kariuki, 2009).
Transferee		i. For health-related TTs, the transferee may often consist of a district hospital, healthcare network or the ministry of health.(Kimaro *et al.*, 2005; Shiferaw *et al.*, 2012; Wamala *et al.*, 2013; Aranda-Jan *et al.*, 2014).	i. For health transfers to SSA, the transferee will either be the local healthcare sector, ministry of health or individual clinics and hospital (Meso *et al.*, 2009; Latourette *et al.*, 2011; Coulborn *et al.*, 2012).
Transfer object	i. The transfer object is often a tangible or intangible service (Heeks, 2002; Kifle *et al.*, 2006, 2010; Karari *et al.*, 2011). ii. While isolated tangible products may still be transferred, this is rare when viewed in a healthcare perspective (Bozeman, 2000). iii. Traditional transfer places strong focus on the implicit knowledge transfer that must accompany the transfer object (Connell *et al.*, 2007; Coloma *et al.*, 2008; Bakar *et al.*, 2012). iv. Personnel transfer may occur to provide a support mechanism for the transfer object (Kline, 2004; Connell *et al.*, 2007).	i. It is common that the transfer object consists of a product or service as well as the required sub-components for the utilisation of the product or service (Alden *et al.*, 2006; Luiz, 2010). ii. The transfer of personnel may occur (Chanda, 2002; Renard, 2011; Shiferaw *et al.*, 2012). iii. A defining characteristic of FDIs is the near absolute level of regulation and influence that the transferor wields over the transfer object (Philip F. Musa *et al.*, 2005; Renard, 2011). iv. Implicit knowledge transfer may occur but is often not explicitly prioritised (Ssewanyana *et al.*, 2007; Fuchs *et al.*, 2008).	i. Joint ventures typically focus on the transfer of a complete system rather than an individual device as emphasis is placed on comprehensive transfer of all required sub-components (Zhang *et al.*, 2016). ii. Typical examples of a health-related joint venture transfer objects would be a telemedicine or health information system (Braa *et al.*, 2004; Mosse *et al.*, 2005; Smith *et al.*, 2008).

Level of stakeholder involvement	i. Universal stakeholder involvement is often poor with limited collaboration (Heeks, 2002; Mengiste, 2010). ii. The transfer is often driven in isolation by either the transferor or transferee (Shamsavari, 2006). iii. The public sector is often passively involved (Mengiste, 2010) iv. It is uncommon for a TTO to be incorporated (Heeks, 2002; Kifle *et al.*, 2010; Karari *et al.*, 2011; Whittaker *et al.*, 2011).	i. FDIs will typically exhibit high levels of stakeholder involvement, with emphasis on the collaboration between the transfer environment's public sector and the transfer team (Wamala *et al.*, 2013; Bozeman *et al.*, 2015). ii. It is uncommon for a TTO to be incorporated (Ssewanyana *et al.*, 2007; Fuchs *et al.*, 2008; Renard, 2011).	i. Of all available transfer methods, joint venture typically exhibits the strongest forms of stakeholder involvement and collaboration (Zhang *et al.*, 2016). ii. The public sector of the transferee is strongly involved in joint venture TT (Smith *et al.*, 2008; Kariuki, 2009; Zhang *et al.*, 2016). iii. It is quite common for a TTO to be incorporated as a stakeholder, particularly when research institutions are involved in the transfer (Geissbuhler *et al.*, 2003; Rodrigues *et al.*, 2003; Mars, 2010).
Pull drivers	i. The primary pull driver is a requirement to fill a market or social gap in the transfer environment (Meso *et al.*, 2005). ii. It is not uncommon for the pull driver to dominate with no explicit push element at all present (Philip F Musa *et al.*, 2005). iii. Favourable domestic conditions and conducive regulatory policies may provide a supporting pull driver (Connell *et al.*, 2007). iv. When health-related transfer to SSA is considered, the disease burden of the transfer environment typically constitutes the primary pull driver (Mengiste, 2010).	i. The resulting capital investment from the transferor into the local economy (Hoekman *et al.*, 2006; Anyanwu, 2012). ii. The international experience introduced into the transfer environment (Arnold *et al.*, 2005; Handoko *et al.*, 2016). iii. The improvement of local infrastructure and health systems in the case of health-related transfers (Alden *et al.*, 2006; Munyua *et al.*, 2009; Shiferaw *et al.*, 2012). iv. A dominated push driver resulting in redundant pull drivers is a recurring theme for FDIs (Akinsola, 2005; Ssewanyana *et al.*, 2007; Renard, 2011).	i. The pull element for most joint ventures is funded by domestic market demand (Rodrigues *et al.*, 2003; Zhang *et al.*, 2016). ii. For health-related transfers, the market demand surrounds the need for health information systems (Rodrigues *et al.*, 2003; Braa *et al.*, 2004; Mosse *et al.*, 2005; Lucas, 2008). iii. Inadequate healthcare systems and the high disease burden in SSA are also recognised pull drivers for joint ventures (Ansari *et al.*, 2001; Johnston *et al.*, 2004; Mars, 2010; Jack *et al.*, 2015).
Push drivers	i. Traditional transfer is often categorised by an insubstantial push driver (Philip F Musa *et al.*, 2005). ii. Economic gain may serve as a push driver (Akinsola, 2005).	i. The primary identification criteria for an FDI is the transferor's motivation which generally revolves around the acquisition of the transfer environment's tangible and intangible resources (Alden *et al.*, 2006; Barthel *et al.*, 2008; Bartels *et al.*, 2009; Anyanwu, 2012; Cleeve, 2012; Osabutey *et al.*, 2012).	i. Joint ventures are often initiated by the transferor to gain access to new market areas, albeit to a lesser extent than FDIs (Boateng *et al.*, 2002; Kariuki, 2009; Zhang *et al.*, 2016). ii. For health-related transfers, these new markets often equate to new medical cases. In terms of SSA, medical staff from developed countries wish to access a disease landscape not found in their own environment (Johnston *et al.*, 2004). iii. Pilot tests are sometimes pushed to serve as validation of future large-scale transfers (Mosse *et al.*, 2005; Lucas, 2008). iv. In select cases, joint ventures are partly motivated to achieve a strategic political advantage (Buse *et al.*, 2000).

Transfer environment	i. Traditional TT often occurs in resource-scarce environments when considering the amount of available capital and value-adding services present (Coloma *et al.*, 2008; Mutula, 2008). ii. In terms of transfer to SSA, the transfer environment often has a low population density with emphasis placed on urban areas (Kifle *et al.*, 2006; Mengiste, 2010).	i. The transfer environment is generally underdeveloped and economically poor with FDIs mostly utilised to facilitate TT to developing nations (Bartels *et al.*, 2009; Luiz, 2010). ii. The domestic public sector is generally amenable to the transfer (Alden *et al.*, 2006; Barthel *et al.*, 2008). iii. FDIs typically transfer products into markets with low competition but entry barriers (Renard, 2011). iv. For health-related transfer, the transfer environment generally consists of inadequate health devices and systems (Chanda, 2002; Aranda-Jan *et al.*, 2014).	i. There are no explicitly defined or universal conditions that exist for the transfer environments in which joint ventures occur after from a define government structure (Zhang *et al.*, 2016) ii. However, for joint ventures in SSA the health landscape is typically defined as one that contains a high disease burden (Smith *et al.*, 2008; Mars, 2010).
Infrastructure concerns	i. Traditional TT often occurs when all basic hard and soft infrastructures are present in some form at an acceptable level (Bozeman, 2000). ii. However, there is generally limited value-adding systems such as ICT and telecommunication infrastructure. When these systems are present they are typically not operational (Mengiste, 2010; Karari *et al.*, 2011).	i. Hard infrastructure inadequacies are considered negligible (Alden *et al.*, 2006; Renard, 2011). ii. Political stability and a base level of workforce education are required by an FDI (Alden *et al.*, 2006; Bartels *et al.*, 2009; Luiz, 2010).	i. Joint ventures typically require fundamental infrastructures such as stable power supply, ICT and internet access and often are decommissioned when these foundations are not in place. (Latourette *et al.*, 2011; Coulborn *et al.*, 2012; Jack *et al.*, 2015).
Scale of transfer	i. Traditional TT is often utilised for large scale projects on a national level due to the simplistic nature of the transfer method (Bozeman, 2000). ii. Traditional transfer may also be utilised for smaller projects that occur on firm-level (Whittaker *et al.*, 2011). iii. However, it is typically difficult to facilitate the scaling of an existing project that utilised traditional transfer (Bakar *et al.*, 2012).	i. FDI TT is exclusively utilised for large scale projects on a national and provincial level (Bozeman *et al.*, 2015). ii. Due to the high resource commitments, FDIs are never utilised to facilitate small scale TT (Renard, 2011; Cleeve, 2012).	i. Joint ventures are mostly utilised for large scale collaboration TTs (Buse *et al.*, 2000; Mosse *et al.*, 2005; Zhang *et al.*, 2016). ii. Instances of smaller joint ventures do exist but are largely designed to be discontinued shortly after commencement (Smith *et al.*, 2008; Zhang *et al.*, 2016).

Table D-14 - Table 5-20's empiric literature foundation

<table>
<tr><th colspan="3">Node: Transfer method</th></tr>
<tr><td>Primary focus</td><td colspan="2">Highlighting best practices for the selected transfer method</td></tr>
<tr><td colspan="3">Universal best practices</td></tr>
<tr><td colspan="3">- The domestic public sector must be incorporated into all TT. This becomes imperative when the scale of the transfer exceeds firm level. Governments must be encouraged to revise free trade policies, infrastructure expansion with focus on ICT and telecommunication and improve digital literacy of the population (Ssewanyana et al., 2007; Schuppan, 2009; Aker et al., 2010; Shiferaw et al., 2012).
- Investment from any source that can be relayed into the transfer environment's healthcare infrastructure will aid in the mitigation of health-related TT in SSA (Chanda, 2002; Geissbuhler et al., 2003; Akinsola, 2005; Aranda-Jan et al., 2014).
- The transfer team must assign roles and responsibilities, refer to Figure 5-14, to the collaborative organisation to ensure communication linkages and aligning motivations (Buse et al., 2000; Boateng et al., 2002; Rodrigues et al., 2003; Mosse et al., 2005).
- All small-scale transfer should be structured to ensure scalability remains feasible. TTs that serve as pilot testing operations should have a predefined document depicting the scaling process (Braa et al., 2004).
- TT methods that require intensive capital funding for results that only benefit a select portion of the population are typically not recommended unless they serve as a foundation for future health projects (Lucas, 2008; Kifle et al., 2010).
- It is imperative that the transfer team consider the gap between the transfer object's design and the transfer environment's reality. The transfer team is encouraged to conduct continual site visits during the transfer process (Heeks, 2002).</td></tr>
<tr><td>Traditional transfer</td><td>Foreign direct investments</td><td>Joint ventures</td></tr>
<tr><td>- When traditional transfer is incorporated, it becomes imperative to ensure the transfer method is supplemented with high levels of collaboration (Shamsavari, 2006).
- Traditional transfer is not recommended when the transfer team does not adhere to a Level III collaboration team or higher as shown in Figure 5-12 (Shamsavari, 2006).
- This framework encourages the user to incorporate the best practices from joint ventures when utilising a traditional transfer method to account for oversights in the transfer method (Shamsavari, 2006; Bozeman et al., 2015).</td><td>- By providing investors with intangible incentive packages the likelihood for capital investment into the transfer environment's is greatly improved. This will also help to negate some existing barriers (Bartels et al., 2009; Munyua et al., 2009; Cleeve, 2012).
- The transfer team must ensure that there are protocols in place that ensure the transferee is able to utilise the transfer object in their own context (Kimaro et al., 2005; Munyua et al., 2009; Luiz, 2010; Aranda-Jan et al., 2014).
- A detailed cost-benefit analysis should be implemented to ensure that the capital investment does not undermine functioning social, cultural and political structures (Meso et al., 2005; Alden et al., 2006; Luiz, 2010; Renard, 2011; Wamala et al., 2013).
- The transfer team must ensure that attracting powerful stakeholders does not become their sole priority. Efforts must also focus on knowledge transfer from the transferor to the transferee (Renard, 2011; Osabutey et al., 2012).</td><td>- For health-related transfers, programs should be in place to stimulated community involvement and participation (Ansari et al., 2001; Smith et al., 2008; Jack et al., 2015).
- Joint ventures between developing SSA countries should be prioritised when possible to ensure maximum knowledge dissemination (Johnston et al., 2004; Mosse et al., 2005).
- For health-related transfer, it is recommended that personnel from the transferor accompany the transfer object for a predetermined period (Coulborn et al., 2012).
- The transfer team is encouraged to present workshops to ensure that all stakeholders are trained to an equivalent level with regards to digital literacy (Piotti et al., 2007).</td></tr>
</table>

Table D-15 - Table 5-21's empiric literature foundation

Node: Transfer method	
Primary focus	Incorporating supporting transfer vehicles
Supporting vehicles	**Best practices**
Licensing	- While licensing negatively impacts total knowledge dissemination through the transfer environment, it may provide funding for a sustainable TT (Maskus, 2000; Arora *et al.*, 2004; Salicrup *et al.*, 2006). - When funding is a key barrier to the transfer, the transfer team is encouraged to peruse licensing options in conjunction with a predefined strategy to relay a percentage of the licensing income into the current or future TTs (Salicrup *et al.*, 2006). - The transfer team is encouraged to develop a document depicting the proposed licensing procedure for the transfer for marketing purposes (Hoekman *et al.*, 2006).
Trade agreements	- All forms of TT benefit from conducive free trade policies. While this may be out of the power of the users of the framework, attempts must be made to collaborate with the public sector to influence policy decisions (Hoekman *et al.*, 2006; Barthel *et al.*, 2008; Bartels *et al.*, 2009). - FDIs are inherently linked with free trade policies and there will be a positive correlation between the transfer team's free trade promotion and the transfer environment's appeal for FDIs (Marcotte *et al.*, 2000; Chanda, 2002; Hoekman *et al.*, 2006; Fuchs *et al.*, 2008).
Spill-overs	- When possible, the transfer object should be made available to all parties in the transfer environment. This includes access to the design and the knowledge required to utilise the transfer object (Bottazzi *et al.*, 2003; Philip F. Musa *et al.*, 2005).

D.4 The literature foundation of Phase IV

Appendix D.4 depicts the outcomes of the conceptual framework's first Phase, shown in Section 5.4.4. The references and outcomes corresponding to the nodes and relationship flows shown in Figure 5-20 have been restated in Appendix D.4 to highlight the literature foundations.

Table D-16 - Table 5-23's literature foundations(Connell *et al.*, 2007; Munyua *et al.*, 2009)

Node: Change management pyramid	
Primary focus	**Change management areas of focus for transferor and transferee**
	Transferee change management
	Deputation
Promote	- After the transferee has taken possession of the transfer object they should designate either an individual or a team to monitor and disseminate the transfer object throughout the transferee's establishment (Ryu *et al.*, 2010; Handoko *et al.*, 2016). - This deputy should be clearly highlighted within the transferee's establishment and been given the authority to implement positive and negative incentive schemes focussed on increasing the transfer object's dissemination (Kline, 2004; Caldera *et al.*, 2010; Shiferaw *et al.*, 2012). - This authority should liaison with the corresponding transferor entity, to determine their best practices for the transfer object's adoption (Bagayoko *et al.*, 2006; Manimala *et al.*, 2013). - This authority should also be familiar with the transferee's previous TTs. A subsequent guideline, which highlights both successful and failed previous best practices, should be created. This authority will also be responsible for documenting current best practices for future use (Alden *et al.*, 2006; Handoko *et al.*, 2016). - When permittable, this authority should incorporate local stakeholders, within the immediate transfer environment, and spread all adoption best practices to promote the TT's dissemination (Braa *et al.*, 2004; Aranda-Jan *et al.*, 2014).
	Equivocality
Mitigate	- The TT's objectives created during Phase I and Phase II must update after the transfer object has been obtained by the transferee. These objectives must be altered to shift focus from acquisition toward sustainability. The continual revision of these objectives throughout the transfer object's maturity cycle will also be highly beneficial (Lucas, 2008; Seuring *et al.*, 2008; Wamala *et al.*, 2013). - At this point of the transfer, the transferee entity to whit the transfer object's knowledge has been provided should create codified documents which can be utilised in training sessions (Ryu *et al.*, 2010; Bradley *et al.*, 2013; Handoko *et al.*, 2016). - The transferee should mandate training and educational sessions to all personnel in the transferee's immediate sphere. Direct training should be utilised whenever possible and on-site demonstrations of the technology should be prioritised (Shamsavari *et al.*, 2002; Alden *et al.*, 2006; Aranda-Jan *et al.*, 2014). - The outcomes of these training sessions should be explicitly stated to all participants. A formal revision protocol should also be created aimed at monitoring the transfer object's adoption rate and documenting identified adoption barriers (Shamsavari *et al.*, 2002; Koefoed *et al.*, 2008).
	Transferor change management
	Motivation
Promote	- After the transferee has taken possession of transfer object, the primary change management best practise for the transferor must be to stimulate continual involvement in the TT. The transferor should thus incorporate an incentive program which rewards the personnel based on their involvement (Bagayoko *et al.*, 2006; Shiferaw *et al.*, 2012; Bradley *et al.*, 2013). - Incentives programs should range from monetary rewards, peer recognition and intangible personnel rewards such as public exposure (McCalman, 2001; Ryu *et al.*, 2010; Shiferaw *et al.*, 2012). - The amount of personnel committed to the TT by the transferor should be reduced, depending on the future requirements of the TT. The smaller active personnel base will, in turn, allow for simplified, and often more economical, incentive reward schemes (Mars, 2010; Bozeman *et al.*, 2015). - The transferor could attempt to obtain funding for continual personnel involvement from both the transferee and the transfer environment's public sector (Malik, 2002; Mars, 2010).
	Knowledge segregation
Mitigate	- The transferor should create a channel aimed at providing transfer object related assistance when required. This channel can range from a dedicated contact person to an active tool depending on the nature of the transfer object (Malik, 2002; Braa *et al.*, 2004; Ryu *et al.*, 2010). - This framework encourages the transferor to hold formal training sessions for the transferee as often as possible. On-site visits by transferor personnel will be highly advantageous to the transfer object's adoption in the transfer environment (Barthel *et al.*, 2008; Karari *et al.*, 2011; Bozeman *et al.*, 2015). - If the transferor has already produced an internal training program surrounding the transfer object, it is recommended that an invitation be sent to the transferee to attend these internal training programs either in person or electronically (Barthel *et al.*, 2008; Koefoed *et al.*, 2008).

Table D-17 - Table 5-24's literature foundations

Node: Adoption best practices	
Primary focus	**Creating an environment capable of sustaining the technology transfer**
Co-creation change management	
Outreach	- After completing the transfer of the transfer object into the transfer environment, multiple stakeholders often disband from the transfer team. The transferor and transferee should thus attempt to retain these stakeholders and assign new stakeholder roles promoting adoption rather than transfer (Ansari *et al.*, 2001; Bakar *et al.*, 2012). - After the transfer has been completed, additional stakeholders should be sought out that may be beneficial to the transfer object's adoption. Often these stakeholders comprise of ground-level health clinics and healthcare professionals as well as domestic non-profit organisations (Ansari *et al.*, 2001; Lucas, 2008; Karari *et al.*, 2011). - Retaining the services of a TTOs, when utilised, must be prioritised as these entities will be skilled at promoting local adoption (Sung *et al.*, 2000; Siegel *et al.*, 2004). - Similarly, retaining the services of the public liaison stakeholder will be critically important (Sung *et al.*, 2000; Shamsavari, 2006; Aranda-Jan *et al.*, 2014).
Training	- The training programs surrounding the transfer object that have been created in the initial phases of the TT must not be discontinued. Instead, the scope of their audience must be altered to also involve the domestic healthcare community rather than the original TT stakeholders (Akinsola, 2005; Nhampossa, 2005; Karari *et al.*, 2011). - The transferor and transferee should conduct local training sessions in tandem (Jagoda *et al.*, 2010; Bozeman *et al.*, 2015). - An important consideration regarding training must be the promotion of knowledge dissemination. To this extent, this framework strongly recommends that transfer object training must be accompanied with the knowledge of how to train others. Thus, training sessions aimed at training local communities on how to train other local communities should be incorporated (Malik, 2002; Martinez, 2003; McKerlich *et al.*, 2013). - Training programs should be extended to administrative staff and not be isolated to healthcare professionals (Schuppan, 2009; Handoko *et al.*, 2016). - The adoption of any healthcare TT will, to some extent, depend on the public sector's ability to train staff. Training programs aimed at promoting adoption should thus be conducted in conjunction with the public sector (Ansari *et al.*, 2001; Hoekman *et al.*, 2006; Piotti *et al.*, 2007). - The transfer team should be encouraged to incorporate different forms of training procedures. For example, an e-Health transfer object will be very conducive to online training and will, in turn, reinforce the digital literacy skills required to utilise the transfer object (Akinsola, 2005; Fuchs *et al.*, 2008; Ramanathan, 2011; Shiferaw *et al.*, 2012).

Table D-18 - Table 5-24's literature foundations continued

Node: Adoption best practices	
Primary focus	**Creating an environment capable of sustaining the technology transfer**
	Co-creation change management
Communication	- The change management best practices shown in Table 5-24 require individual actions from the transferor and transferee. As such, the primary stakeholders much ensure that they re-align their TT agendas after completing their individual change management procedures (Braa *et al.*, 2004). - The communication channels and methods established at the commencement of the TT should be revised. Interacting with local communities in developing nations will often require a different form of communication when compared to stakeholder communication (Harris *et al.*, 2000; Aker *et al.*, 2010; Aranda-Jan *et al.*, 2014). - These revised communication methods should be standardised and documented to ensure uniformity. This will, in turn, simplify training programs (Barthel *et al.*, 2008; Handoko *et al.*, 2016).
Sustainability	- The primary sustainability barrier faced by all TTs has been funding. Thus, it becomes imperative for the transfer team to revise the funding document, established during Phase II, to incorporate new methods of funding. Monetising the transfer object without reducing its adoption capabilities must be prioritised (Swamidass *et al.*, 2009; Aranda-Jan *et al.*, 2014; Bozeman *et al.*, 2015). - The transfer team should reinforce the market analysis division or personnel. Predicting future market needs and supply chain forces will both alleviate funding restraints and allow for marketing campaigns tailored to the market conditions (Chanda, 2002; DeVol *et al.*, 2006; Jesse *et al.*, 2010). - The transfer team should ensure that a high-level co-creation transfer team remains intact (Bozeman *et al.*, 2015; Handoko *et al.*, 2016). - The revision and alteration of the transfer object should be implemented continually to further refine the transfer object and promote adoption. This will greatly rely on the relationship between the transferor and transferee (Shamsavari, 2006; Ann *et al.*, 2008; Bozeman *et al.*, 2015). - The transfer team should continually evaluate new technologies that may be beneficial to the transfer object's impact and adoption (Golob, 2006; Zhang *et al.*, 2016)

D.5 The literature foundation of Phase V

Appendix D.5 depicts the outcomes of the conceptual framework's first Phase, shown in Section 5.4.5. The references and outcomes corresponding to the nodes and relationship flows shown in Figure 5-22 have been restated in Appendix D.5 to highlight the literature foundations

Table D-19 - Table 5-25's literature foundations

Node: Effectiveness criteria		
Primary focus	**Evaluating the technology transfer from the primary stakeholder's perspectives**	
Effectiveness criterion	**Transferee's considerations**	**Transferor's considerations**
Market impact	- Has the transferee been able to utilise the transfer object to the same extent as the transferor (Shamsavari *et al.*, 2002; Shamsavari, 2006)? - Did the transfer object have a tangible impact on the transferee's sales or profitability (Bozeman *et al.*, 2015; Handoko *et al.*, 2016)?	- Did the transferred technology have an impact on the transferor's sales or profitability (Bozeman *et al.*, 2015; Handoko *et al.*, 2016)? - Have new tangible or intangible resources been acquired as a result of the TT (Jagoda *et al.*, 2010; Bozeman *et al.*, 2015)?
Public value	- Aside from monetary objectives, how did the transfer object improve the transfer environment (Jagoda *et al.*, 2010; Bozeman *et al.*, 2015)? - Has the transferee's marketability, public image or social reach improved as a result of the TT (Bradley *et al.*, 2013; Bozeman *et al.*, 2015)?	- Has the transferor's marketability, public image or social reach improved (Bradley *et al.*, 2013; Bozeman *et al.*, 2015)?
Political	- Did the transferee benefit politically from participating in the transfer (Ansari *et al.*, 2001; Bozeman *et al.*, 2015)? - Did the TT result in new healthcare policies for the transfer environment (Braa *et al.*, 2004; Mengiste, 2010)? - Has the TT resulted in the transferee to be noted by the public sector (Ansari *et al.*, 2001; Braa *et al.*, 2004)?	- Did the transferee benefit politically from participating in the transfer (Ansari *et al.*, 2001; Bozeman *et al.*, 2015)? - Has a channel been established between the transferor and the public sector (Braa *et al.*, 2004; Bozeman *et al.*, 2015)?
Human capital	- Did the transfer lead to an increase in the transferee's capacity to conduct or utilise research (World Health Organization, 2006; Bradley *et al.*, 2013; Bozeman *et al.*, 2015)? - Has the educational level of the transferee's personnel increased as a result of the transfer (Shamsavari *et al.*, 2002; Shamsavari, 2006; Bozeman *et al.*, 2015)?	- Did the transferor's human knowledge capital increase as a result of the technology transfer (World Health Organization, 2006; Bradley *et al.*, 2013; Bozeman *et al.*, 2015)? - Have additional training mechanisms been established as a result of the technology transfer (Sung *et al.*, 2000; Barthel *et al.*, 2008; Jagoda *et al.*, 2010)?
Revision nodes	- Has a significant amount of issues been uncovered by the revision nodes? - Could the issues uncovered by the revision nodes have been circumnavigated? - How effectively did the transfer team collaborate to mitigate and red flags uncovered by the revision nodes?	
Economic development	- Did the transfer object lead to additional economic development or serve as the foundation for other products or services (Golob, 2006; Bozeman *et al.*, 2015)? - Have any additional start-ups been created resulting from the TT (Golob, 2006; Handoko *et al.*, 2016)? - Have other firms in the transfer environment implemented the transfer object in their operational activities (Handoko *et al.*, 2016)? - Have other firms in the transfer environment implemented knowledge transferred in their operational activities (Handoko *et al.*, 2016)?	
Opportunity cost	- What other projects were dismissed to pursue the TT (Aker *et al.*, 2010; Bozeman *et al.*, 2015; Link *et al.*, 2016)? - What other knowledge or training opportunity were dismissed to pursue the TT (Bozeman *et al.*, 2015; Link *et al.*, 2016)?	
Healthcare reach	- Did the TT improve the healthcare reach of the transfer environment (Nhampossa, 2005; Karari *et al.*, 2011)? - Did the TT improve the speed or accuracy of healthcare in the transfer environment (Nhampossa, 2005; Piotti *et al.*, 2007; Karari *et al.*, 2011)?	

	Have any health collaborations been established during the transfer (Harris *et al.*, 2000; Wamala *et al.*, 2013)?

Table D-20 - Table 5-26's literature foundations

Node: Sustainability outcomes	
Primary focus	**Promoting the sustainability and expansion of the transfer object**
Stakeholder integration	- The transfer team should continue to implement the extended stakeholder screening instrument shown in Figure 5-12 during the commercialisation process (Malik, 2002; Smith *et al.*, 2008; Bradley *et al.*, 2013; Manimala *et al.*, 2013). - After completing the transfer of the transfer object, stakeholder involvement should be revised as multiple stakeholders may no longer be required (Jagoda *et al.*, 2010; Ramanathan, 2011). - Similarly, additional stakeholders should be incorporated if they could be of potential benefit to the transfer object's dissemination (Jagoda *et al.*, 2010; Ramanathan, 2011). - Depending on the outcome of the selected transfer method in Table 5-20 and Table 5-21, the revised transfer team should actively seek out relevant parties in the public healthcare sector, domestic firms and entrepreneurs capable of establishing spill-overs or start-ups surrounding the transfer object (AUTM, 2000; Sung *et al.*, 2000; Siegel *et al.*, 2004; Ramanathan, 2011).
Scale-up protocols	- As previously noted, commercialisation will tend to lie outside the scope and expertise of the transfer team. Thus, the transfer team should actively incorporate a stakeholder knowledgeable in licensing and commercialisation activities (AUTM, 2000; Sutter *et al.*, 2007; Chakroun, 2012). - It will be the responsibility of the licensee to oversee the commercialisation activities surrounding the transfer object. However, the transfer team should have established pre-defined legal terms to ensure the transfer object's future management aligns with the agenda of the original transfer (Swamidass *et al.*, 2009; Chakroun, 2012). - The commercialisation of a health technology will generally be founded upon two primary business strategies. The technology can be presented to the end-user free of charge and be funded by marketing of the public value of the technology. Alternatively, the technology may be licensed, and service charges will apply to the end-user (Swamidass *et al.*, 2009; Nygaard *et al.*, 2013). - However, the chosen business strategy will be case-specific, and this framework does not promote one above the other. The licensee and transfer team should, however, have a predefined business strategy before the transfer object's expansion may commence (Salicrup *et al.*, 2006; Ann *et al.*, 2008).
Marketing strategies	- The marketing strategy should revolve around the successful outcomes of the TT identified in Table 5-25 (Sung *et al.*, 2000). - The general marketing strategies should be tailored to transfer object in question as well as the business strategy chosen for the transfer object's commercialisation. - It is however important for the transfer team to distinguish between the end-user of the transfer object and the client who commissioned it. For health technologies, these two entities will almost never be the same (Connell *et al.*, 2007; Munyua *et al.*, 2009). - When advertising to potential clients not involved in the creation of the transfer object, the marketing strategy should revolve around how the transfer object will solve the client's problem. How the transfer object will benefit the end-user, typically the patient, should not be prioritised over the client's priorities when dealing with isolated health practitioners (Coloma *et al.*, 2008; Kifle *et al.*, 2010). - However, when advertising to the national public health sector, marketing of the patient's benefits should be prioritised over the health practitioner's benefits (Kifle *et al.*, 2010).

Table D-21 - Table 5-27's literature foundations

Node: Knowledge codification	
Primary focus	**Ensuring uniform and comprehensive knowledge capture**
Best practices for codification	- All documentation captured should be completed in a predefined business language understood by all the primary stakeholders (Malik, 2002; Siegel *et al.*, 2004; Philip F Musa *et al.*, 2005). - All data captured during the TT should be documented in a predefined measurement system, such as SI units (Sutter *et al.*, 2007; Handoko *et al.*, 2016). - All documentation and communication among stakeholders should be completed in a predefined style with stakeholders being encouraged to adopt a universal organisational routine with regards to formalised communication (Hertzfeld, 2002; Malik, 2002; Siegel *et al.*, 2004). - Predefined data capturing should be outlined for various forms of communication along with methods to ensure adherence (Malik, 2002; Mutula, 2008). - Uniformity will be promoted if dedicated personnel have been assigned to the TT's knowledge capturing process. These personnel should preferably be provided by both the transferor and transferee (Rodrigues *et al.*, 2003). - When evaluating the stakeholders in Phase II, care should be given to language barriers. While all stakeholders may understand a language, various levels of comprehension often arise. This has been especially pronounced in SSA countries (Rebentisch *et al.*, 1995; Heeks, 2002; Malik, 2002; Nhampossa, 2005; Ramanathan, 2011). - When possible, translating all codified documentation into a second langue will be highly advantageous (Braa *et al.*, 2004; Nhampossa, 2005; Bagayoko *et al.*, 2006). - Considerations must give to data storage and where possible an electronic system has been recommended. Care should also be taken to ensure duplicates will be removed (Ammenwerth *et al.*, 2006; Mutula, 2008). - With regards to the implicit knowledge of individual stakeholders, the framework recommends developing a standard set of questions to capture the nuances of how stakeholders completed their roles and responsibilities (Carley, 1993; Handoko *et al.*, 2016). - A predefined structure for the documented knowledge base must be outlined before the commencement of Phase I. This structure should be able to accommodate the accumulating knowledge base as the TT progresses (Malik, 2002; Rodrigues *et al.*, 2003; Nygaard *et al.*, 2013).

Appendix E - Semi-structured interviews

The questions posed to the interview candidates have been summarised in Table E-1. The interview candidates have all been subjected to the same sequence of chronological questioning, as depicted in Table E-1.

Table E-1 - Semi-structured interview questions

Semi-structured interview questions
1. How have you attempted to promote adoption amongst the end-users of a transfer object?
2. How have you established a linkage between the high-level stakeholders and ground-level users?
3. Have you encountered a knowledge gap in the end-users with regards to digital literacy or education? If so, how did you attempt to mitigate this knowledge gap?
4. Would you consider a co-creation relationship as a necessity during the entire course of a technology transfer venture? If so, how would you ensure a co-creation relationship existed between the transferee and transferor?
5. Given the phases of technology analysis, development and transfer, would you consider it to be possible to complete these phases in a systematic or sequential manner?
6. With regards to championing a technology transfer, should it be delegated to a single entity or be a collaborative effort between all stakeholders?
7. How would you keep stakeholder involvement high after the transfer object has been transferred? Do you consider high post-transfer involvement as beneficial when considering the additional resource cost?
8. Have you witnessed any specific training procedures that effectively work in the healthcare sector? Can you identify training procedures which typically fail when utilised during a technology transfer venture?
9. Have you ever implemented a training to train policy in addition to training the end user? If so, could you discuss the benefits and obstacles to such a policy?
10. With regards to sub-Saharan Africa's relatively poor infrastructure, how have you circumvented this barrier when conducting a technology transfer venture in this region?
11. Which commercialisation procedures would you recommend for a health technology? Would you consider these procedures to limit the dissemination of the technology or prevent certain users from accessing it?
12. Have you constructed pre-defined documentation and communication standards? If so, can these be regarded as modular and be implemented in future transfers?
13. How have you in the past attempt to manage differing standards, such as compliance, legalisation, technical, and so on?
14. Could you provide any universal yardsticks with which you would typically measure the success of a technology transfer?
15. What are your experiences regarding the implementation of a stage-gate or revision point during a technology transfer?
16. Have you witnessed any additional considerations required when conducting a technology transfer in the healthcare sector when compared with other industry sectors?

Table E-1 does not contain the additional questions posed to individual candidates. When a candidate's initial question response indicated a potentially deeper understanding into the corresponding topic area, this candidate would be posed an additional series of questions. Thus, these additional questions have not been pre-defined or consistently implemented but have rather been raised during an interview. The complete outcomes of the semi-structured interviews have been presented in Section 6.1.

Appendix E - Semi-structured interviews

Appendix F - Survey

F.1 The operational definition of the survey

This survey is administered to respondents with relevant experience in technology management industries. Technology transfer is of specific interest within the wider scope of technology management. The purpose of the survey is to determine the relevance and utility of a technology transfer framework which aims to facilitate the transfer of health technologies in the region of sub-Saharan Africa.

1. Characteristics of interest

The survey aims to gather information on the technology transfer elements of stakeholder co-creation, incorporating legal counsel, implementing standardisation rules, technology transfer methods, revision procedures and adoption and sustainability best practices.

2. Measuring instrument

The survey implements self-administered questions to collect data from respondents. The question set has been split into demographics, primary research and additional correspondence. The measurement scales and items for the demographic and additional correspondence questions are made from a variety of answer types. The primary research questions consistently implement two measurement scales namely perceived ease of us and usefulness. Each of these three measurement scales implements a five-point Likert scale for their measurement items.

3. Method of contact

Respondents will all initially be contacted via email and be presented with a link to the final survey. A follow-up telephone call will be made to all respondents who have not completed the survey within 5 working days after the initial contact email.

4. Terminology utilised in questions

Below is an outline of terminology implemented within the survey instrument. Respondents are advised to have a copy of these terms readily available when completing the survey questions.

The technology - The technology in question being transferred.

Transfer donor- The entity or stakeholder classified as the technology's donor.

Transfer recipient - The entity or stakeholder classified as the technology's recipient.

Additional stakeholders - Additional technology transfer stakeholders not including the technology's recipient or donor.

The technology's intended transfer environment - The final environment in which the technology will be implemented once the technology transfer has occurred.

Revision protocol - A revision process which may terminate all future proceedings if certain criteria are not met.

Case-specific vs standardised - Case-specific refers to the characteristics and decisions required for an individual technology transfer. Standardised refers to selecting characteristics and decisions from a default and predefined framework or guideline.

F.2 The exclusion criteria of the survey

Table F-1 - Exclusion criteria for the projects considered for the survey instrument

Criterion	Description
Geographic region	The project must have been completed within one or more SSA countries.
Healthcare application	The project must surround the implementation of a healthcare initiative
Ethical considerations	The project must be identified using either the CHMI or GHDN databases
Co-creation presence	The case study must involve facets of stakeholder co-creation.
Independence	The projects must be independent from one another and only one project may be included from a single parent organisation.

F.3 Simplified wording structure for survey respondents

Table F-2 outlines specific academic terms which have been replaced within the survey instrument. Although these academic terms have been consistently implemented during this entire research document, alterations are made to ensure that all potential survey respondents may easily comprehend the primary research questions posed within the survey. The definitions of these individual terms are also presented in Table F-2. These terms and definitions are also presented in the operational definition, shown in Appendix F.1 which, is given to each respondent prior to completing the survey.

Table F-2 - Academic vs survey wording implementations and definitions

Survey term	Research term	Definition
The technology	Transfer object	The technology in question being transferred.
Technology donor	Transferor	The entity or stakeholder classified as the transfer object's donor.
Technology recipient	Transferee	The entity or stakeholder classified as the transfer object's recipient.
The technology donor and recipient	Primary stakeholders	The transferor and transferee.
The technology's intended transfer environment	Transfer environment	The final environment in which the transfer object will be implemented once the technology transfer has occurred.
Revision protocol	Stage-gate	A revision process which may terminate all future proceedings if certain criteria are not met.

F.4 Comparison of existing survey instruments

Table F-3 - Comparison of identified survey instruments

Title	Reference	Geographic focus	Survey instrument	Communication method	Response format
Networks of Action: Sustainable health information systems across developing countries	(Braa *et al.*, 2004)	SSA	Not stated	Not stated	Not stated
Towards a model of consumer use of mobile information and communication technology in LDCs: the case of sub-Saharan Africa	(Meso *et al.*, 2005)	Kenya Nigeria	Questionnaire	Hardcopies	Likert scale
Adoption and usage of ICT in developing countries: Case of Ugandan firms	(Ssewanyana *et al.*, 2007)	Uganda	Questionnaire	Not stated	Open-ended
The characteristics and determinants of FDI in Ghana	(Barthel *et al.*, 2008)	Ghana	Not stated	Site visits	Open-ended
Information and communications technology for future health systems in developing countries	(Lucas, 2008)	SSA	Questionnaire	Site visits	Open-ended
Transfer and Adoption of Advanced Information Technology Solutions in Resource-Poor Environments: The Case of Telemedicine Systems Adoption in Ethiopia	(Kifle *et al.*, 2010)	Ethiopia	Questionnaire	Electronic and site visits	Likert scale
Evaluating the Uptake, Acceptability, and Effectiveness of Uliza! Clinicians HIV hotline: A telephone consultation service in Kenya	(Karari *et al.*, 2011)	Kenya	Questionnaire	Site visit	Satisfaction scale
The role of information communication technology (ICT) towards universal health coverage: the first steps of a telemedicine project in Ethiopia	(Shiferaw *et al.*, 2012)	Ethiopia	Questionnaire	Electronic and site visits	Likert scale
The personal value of being part of a tropical health education trust links programme to develop a palliative care degree programme in Sub-Saharan Africa: a descriptive study of the views of volunteer UK health professionals	(Jack *et al.*, 2015)	Uganda	Descriptive survey	Electronic	Open-ended

F.5 Pilot test outcomes

Pilot test	Pilot test employment role	Institute	Recommendations
1	Research team	Refer to Table 6-3	i. Spelling ii. Grammar iii. Compatibility measurement item
2.1	TT licensing manager	CSIR	i. Remove technical writing ii. Add unsure field iii. Change title to role iv. Rephrase legal counsel title v. Rephrase financial motivation
2.2.	Technology manager	CSIR	i. Split intangible and tangible ii. Add technology donor and recipient terminology
3.1	Healthcare technology manager	Broadreach	i. Include SSA regions ii. Add in option not yet available iii. Rephrase prototype question
3.2	Healthcare technology manager	Broadreach	i. Add clinical test and regulatory approval ii. Add both option for motivation iii. Remove 3rd party

F.6 Overview of the determinants influencing the performance of a TT venture.

i. Technology transfer team

The transferor should dedicate the maximum available personnel capable of TT facilitation, transfer object training and stakeholder communication, keeping in mind that the number of required personnel is positively correlated with the scale of the TT (Rebentisch *et al.*, 1995; Bozeman, 2000; Coloma *et al.*, 2008; Bradley *et al.*, 2013; Handoko *et al.*, 2016). However, if the transferor possesses codified knowledge of previous transfers of a similar nature and their current technology development and TT experience is substantial, the number of personnel required will be substantially reduced (Gibson *et al.*, 1991; Bozeman, 2000; Handoko *et al.*, 2016).

It will be imperative to the TT venture that a funding plan be created, and it must be routinely updated (Sung *et al.*, 2000; Smith *et al.*, 2008; Wahab *et al.*, 2009). Each stakeholder must be aware of this plan and the expected magnitude and duration of their individual contributions (Sung *et al.*, 2000; Malik, 2002; Mosse *et al.*, 2005; Manimala *et al.*, 2013). The TT team must consider funding in conjunction with the transfer environment, infrastructure requirements and the technology's characteristic to establish a detailed budget.

After the transferee has taken possession of the technology, they should designate either an individual or a team to monitor and disseminate the technology throughout the technology recipient's establishment (Rebentisch *et al.*, 1995; Bozeman, 2000; Handoko *et al.*, 2016). This deputy should be clearly highlighted within the transferee's establishment and been given the authority to implement positive and negative incentive schemes focussed on increasing the transfer object's dissemination (Sung *et al.*, 2000). This authority should liaise with the corresponding transferor entity, to determine their best practices for the technology's adoption (Malik, 2002; Mosse *et al.*, 2005; Manimala *et al.*, 2013).

Finally, an individual within the TT team must explicitly be appointed as the public liaison. This party should ultimately be knowledgeable on the public sector's general procedures and health-related policies (Bassioni *et al.*, 2005; Kimaro *et al.*, 2005; Hoekman *et al.*, 2006; Mazurowski, 2006). If such an individual does not exist within the TT team third party consultation must be incorporated (Bassioni *et al.*, 2005; Mazurowski, 2006). The public liaison is encouraged to populate a list of TT requirements that can only be overcome with aid of the public sector (Clarysse *et al.*, 2004; Connell *et al.*, 2007; Manimala *et al.*, 2013; McKerlich *et al.*, 2013).

ii. Legal considerations for project components

The transferor is encouraged to explicitly state the manner and totality of their legal ownership of the transfer object to the entire TT team as well as the intended alterations to this legal ownership after the TT has been completed (Ryu *et al.*, 2010; Bradley *et al.*, 2013; Handoko *et al.*, 2016). It will be the responsibility of the licensee to oversee the commercialisation activities surrounding the transfer object. However, the TT team should have established pre-defined legal terms to ensure the technology's future management aligns with the agenda of the original TT (Rebentisch *et al.*, 1995; Becerra-Fernandez *et al.*, 2003; Nygaard *et al.*, 2013; Handoko *et al.*, 2016).

The commercialisation of a health technology will generally be founded upon two primary business strategies. The transfer object can be presented to the end-user free of charge and be funded by marketing of the public value of the transfer object (Swamidass *et al.*, 2009; Nygaard *et al.*, 2013). Alternatively, the transfer object may be licensed, and service charges will apply to the end-user (Swamidass *et al.*, 2009; Nygaard *et al.*, 2013). However, the chosen business strategy will be case specific, and the licensee and TT team should have a predefined business strategy before the transfer object's roll-out may commence (Salicrup *et al.*, 2006; Ann *et al.*, 2008).

iii. Standardisation of project components

With regards to the implicit knowledge of individual stakeholders, it is recommended to develop a standard set of questions to capture the nuances of how stakeholders completed their roles and responsibilities (Bozeman, 2000; Sung *et al.*, 2000; Handoko *et al.*, 2016). A predefined structure for the documented knowledge base must be outlined before the commencement of the TT (Bozeman, 2000; Philip F Musa *et al.*, 2005; Dubickis, 2015). This structure should be able to accommodate the accumulating knowledge base as the TT progresses. Additionally, a list must be populated of health-specific requirements, separate of the general TT requirements, for use in the screening of the transfer environment and subsequent evaluation (Piotti *et al.*, 2007; Mars, 2010; Mengiste, 2010; Karari *et al.*, 2011; Shiferaw *et al.*, 2012).

When evaluating the stakeholders, care should be given to language barriers. While all stakeholders may understand a language, various levels of comprehension often arise (Bozeman, 2000; Philip F Musa *et al.*, 2005). This has been especially pronounced in SSA countries (Philip F Musa *et al.*, 2005). When possible, translating all codified documentation into a second langue will be highly advantageous (Wahab *et al.*, 2009; Bradley *et al.*, 2013; Handoko *et al.*, 2016). It is thus imperative that the TT team acknowledge the gap between the technology's design and the transfer environment's reality when creating standardized protocols. The TT team is also encouraged to present workshops that ensure all stakeholders will be trained to an equivalent level with regards to digital literacy before the TT progresses (Rebentisch *et al.*, 1995; Becerra *et al.*, 2008; Nygaard *et al.*, 2013; Handoko *et al.*, 2016).

All documentation captured should be completed in a predefined business language understood by all the primary stakeholders (Rebentisch *et al.*, 1995; Becerra *et al.*, 2008; Nygaard *et al.*, 2013; Handoko *et al.*, 2016). Similarly, all data captured during the TT should be documented in a predefined measurement system, such as SI units. Lastly, all documentation and communication among stakeholders should be completed in a predefined style with stakeholders being encouraged to adopt a universal organisational routine with regards to formalised communication (Rebentisch *et al.*, 1995; Becerra *et al.*, 2008; Nygaard *et al.*, 2013; Handoko *et al.*, 2016).

iv. Stakeholder co-creation

Both the transferee and transferor should explicitly regard the TT as a business venture and a strategic alliance and should construct and implement protocols which ensure the creation of a joint pool of knowledge surrounding the technology transferred (Smith *et al.*, 2008; Wahab *et al.*, 2009). Additionally, a dedicated incentive scheme should be implemented that involves both monetary and intangible rewards and managers are encouraged to motivate the TT team through advertising previous successes (Sung *et al.*, 2000). Finally, complete co-creation typically occurs when both stakeholders directly influence the technology's primary characteristics and features (Kimaro *et al.*, 2005; Jesse *et al.*, 2010; Ramanathan, 2011).

For health-related transfers, programs should be in place to stimulate community involvement and participation (Kimaro *et al.*, 2005; Shiferaw *et al.*, 2012; Wamala *et al.*, 2013). Additionally, it is recommended that personnel from the transferor accompany the technology for a predetermined period (Bozeman, 2000; Golob, 2006; Bozeman *et al.*, 2015).

v. Project implementation methods

The joint venture method is strongly recommended for all healthcare TTs (Braa *et al.*, 2004; Mosse *et al.*, 2005; Smith *et al.*, 2008; Zhang *et al.*, 2016). The domestic public sector must be incorporated into all TT activities (Meso *et al.*, 2009; Latourette *et al.*, 2011; Coulborn *et al.*, 2012). This becomes imperative when the scale of the transfer exceeds firm level. The public liaison should encourage governments to revise free trade policies and ICT and telecommunication infrastructure expansion in addition to the improvement of the digital literacy of the population (Bagayoko *et al.*, 2006; Salicrup *et al.*, 2006; Connell *et al.*, 2007). Similarly, investment from any source that can be relayed into the transfer environment's healthcare infrastructure will aid in the mitigation of health-related TT barriers in SSA (Boateng *et al.*, 2002; Kariuki, 2009).

The TT team is encouraged to implement a stage-gate during the completion of the TT when feasible (Bozeman, 2000). Multiple stage-gates throughout the TT is however not advisable due to the time and monetary constraints of these revision procedures. The TT must evaluate the following TT features to determine if the TT should be continued, revised or abandoned (Bozeman, 2000; Ansari *et al.*, 2001; Jagoda *et al.*, 2005; Kimaro *et al.*, 2005; Shamsavari, 2006; Bradley *et al.*, 2013; Wamala *et al.*, 2013; Handoko *et al.*, 2016):

- The co-creation team level
- Stakeholders available to complete the required roles and responsibilities
- Market conditions
- Legality
- Availability of infrastructure
- Mitigation practices for lacking infrastructure
- The chosen transfer method
- The suitability off the technology and the transfer environment
- The transfer method application strategy

vi. Project evaluation procedures

The evaluation of TT's impact is primarily to identify topic areas for which best practises can be refined for future TT ventures. It will also allow the TT team to evaluate the general success of the technology's introduction, adoption and integration. It is recommended that the following key areas should be evaluated (Bozeman, 2000; Ansari *et al.*, 2001; Jagoda *et al.*, 2005; Kimaro *et al.*, 2005; Shamsavari, 2006; Bradley *et al.*, 2013; Wamala *et al.*, 2013; Handoko *et al.*, 2016):

- The market impact of the technology
- The addition to the public value in the transfer environment
- The political implications of the TT
- The addition to the human capital base in the transfer environment
- The severity of the alterations required at the stage-gate feature
- The addition to the economic development in the transfer environment
- The opportunity cost for all stakeholders involved
- The technology's improvement of the healthcare reach, cost and effectiveness of the transfer environment

Furthermore, it is recommended that the authority who conducts the evaluation should also be familiar with the technology recipient's previous TTs (Clarysse *et al.*, 2004; Manimala *et al.*, 2013). A subsequent guideline, which highlights both successful and failed previous best practices, should be created. This authority will also be responsible for documenting current best practices for future use (Clarysse *et al.*, 2004; Manimala *et al.*, 2013).

vii. Adoption and sustainability

All small-scale transfers should be structured to ensure that scalability remains feasible. TTs that serve as pilot testing operations should have a predefined document depicting this proposed scaling process and the TT team is encouraged to conduct continual site visits during the transfer process (Bagayoko *et al.*, 2006; Shiferaw *et al.*, 2012; Bradley *et al.*, 2013).

After the transferee has taken possession of transfer object, the primary change management best practise for the transfer donor should be to stimulate continual involvement in the TT (Ryu *et al.*, 2010; Handoko *et al.*, 2016). The transferor is thus encouraged to incorporate an incentive program which rewards the personnel based on their involvement. Incentives programs should range from monetary rewards, peer recognition and intangible personnel rewards such as public exposure (McCalman, 2001; Ryu *et al.*, 2010; Shiferaw *et al.*, 2012). However, the amount of personnel committed to the TT by the transfer donor should be reduced, depending on the future requirements of the TT. The smaller active personnel base will in turn allow for simplified, and often more economical, incentive reward schemes (Mars, 2010; Bozeman *et al.*, 2015).

New stakeholders should be incorporated if they could be of potential benefit to the technology's dissemination (Braa *et al.*, 2004; Aranda-Jan *et al.*, 2014). However, commercialisation will tend to lie outside the scope and expertise of the TT team (Hoekman *et al.*, 2006). Thus, the TT team should actively incorporate a stakeholder knowledgeable in licensing and commercialisation activities (Hoekman *et al.*, 2006; Salicrup *et al.*, 2006). Finally, when permittable, local stakeholders should be incorporated within the immediate transfer environment and spread all adoption best practices to promote the TT's dissemination (Braa *et al.*, 2004; Aranda-Jan *et al.*, 2014).

viii. Training methods for the technology

The transferor is strongly encouraged to create a channel aimed at providing transfer technology-related assistance when required (Bagayoko *et al.*, 2006; Shiferaw *et al.*, 2012; Bozeman *et al.*, 2015). This channel can range from a dedicated contact person to an active tool depending on the nature of the transfer object. It is recommended that the transferor hold formal training sessions for the transferee as often as possible (Barthel *et al.*, 2008; Koefoed *et al.*, 2008). On-site visits by transferor's personnel will be highly advantageous to the technology's adoption in the transfer environment (Barthel *et al.*, 2008; Karari *et al.*, 2011; Bozeman *et al.*, 2015). If the transferor has already produced an internal training program surrounding the technology, it is recommended that an invitation be sent to the transfer recipient to attend these internal training programs either in person or electronically (Carley, 1993; Siegel *et al.*, 2004; Handoko *et al.*, 2016).

The transferee should create codified documents which can be utilised in training sessions (Malik, 2002; Siegel *et al.*, 2004; Handoko *et al.*, 2016). Additionally, the transferee should mandate training and educational sessions to all personnel in the transferee's immediate sphere (Barthel *et al.*, 2008; Karari *et al.*, 2011; Bozeman *et al.*, 2015). Direct training should be utilized whenever possible and on-site demonstrations of the technology should be prioritised (Akinsola, 2005; Kimaro *et al.*, 2005; Karari *et al.*, 2011). The outcomes of these training sessions should be explicitly stated to all participants (Ansari *et al.*, 2001; Hoekman *et al.*, 2006; Piotti *et al.*, 2007). Lastly, a formal revision protocol should also be created aimed at monitoring the technology's adoption rate and documenting identified adoption barriers (Malik, 2002; Martinez, 2003; McKerlich *et al.*, 2013).

ix. Marketing

The general marketing strategies should be tailored to the technology in question as well as the business strategy chosen for the technology's commercialisation (Connell *et al.*, 2007; Munyua *et al.*, 2009). It is however important for the TT team to distinguish between the end-user of the technology and the client who commissioned it (Connell *et al.*, 2007; Munyua *et al.*, 2009). For health technologies these two entities will almost never be the same. When advertising to potential clients not involved in the creation of the technology, the marketing strategy should revolve around how the technology will solve the client's problem (Coloma *et al.*, 2008; Kifle *et al.*, 2010). How the technology will benefit the end-user, typically the patient, should not be prioritised over the client's priorities when dealing with isolated health practitioners (Coloma *et al.*, 2008; Kifle *et al.*, 2010). However, when advertising to the national public health sector, marketing of the patient's benefits should be prioritised over the health practitioner's benefits (Kifle *et al.*, 2010).

F.7 Survey instrument invitation letter

Good day,

I represent a research team at Stellenbosch University in South Africa. We are conducting research into the field of healthcare technology management in sub-Saharan African countries.

To provide an overview of our research:

We are trying to get in touch with technology managers that have conducted healthcare initiatives in sub-Saharan Africa over the last 20 years. We have developed a framework to aid in this process but would like to get the insights of real-world applications to see what works and what doesn't.

Would you be open to completing a 10-minute online survey with questions surrounding your organisation's healthcare initiative as outlined on the Centre for Health Market Innovations or Global Digital Health Network?

Any assistance will be greatly appreciated!

Kind regards

Rian Marais

Health Systems Engineering and Innovation

Stellenbosch University

Healthcare survey link: **Survey link**

F.8 Administration of the survey instrument

Table F-4 - Outline of survey instrument's potential respondents

	Project or parent organisation	Country	Source	Email	Phone
1	PMI AIRS	Angola	GDHN	Yes	
2	PSI/Angola	Angola	CHMI	Yes	Yes
3	Association d'Entraide des Femmes (AssEF)	Benin	CHMI		
4	Benin's National Health Insurance (RAMU)	Benin	CHMI		
5	Gradian Health	Benin	CHMI	Yes	Yes
6	Newborn Health Program	Benin	CHMI	Yes	Yes
7	ProFam	Benin	CHMI	Yes	Yes
8	PSI	Benin	CHMI	Yes	
9	VaxTrac	Benin	CHMI		
10	Africa Teledermatology Project	Botswana	CHMI	Yes	
11	Itekanele Health Scheme	Botswana	CHMI	Yes	
12	Sample Transportation	Botswana	CHMI		
13	Young 1ove	Botswana	CHMI	Yes	Yes
14	CommCare	Burkina Faso	CHMI	Yes	
15	Danish refugee council	Burkina Faso	CHMI	Yes	
16	Gradian Health Systems	Burkina Faso	CHMI	Yes	Yes
17	Marie Stopes	Burkina Faso	CHMI		Yes
18	FrontlineSMS	Burundi	CHMI	Yes	
19	FXB Village model	Burundi	CHMI	Yes	
20	LifeNet International	Burundi	CHMI	Yes	
21	PSI/Burundi	Burundi	CHMI	Yes	
22	Village Health Works (VHW)	Burundi	CHMI	Yes	
23	100% Jeune	Cameroon	CHMI	Yes	
24	Health Sector Support Investment Project	Cameroon	CHMI		
25	Health Unit Database Networking Systems	Cameroon	CHMI	Yes	
26	Danish refugee council	Cameroon	CHMI	Yes	
27	DKT	Cameroon	CHMI	Yes	
28	MTCT Plus Initiative	Cameroon	CHMI		
29	ORBIS Flying Eye Hospital	Cameroon	CHMI	Yes	
30	Réseau ProFam	Cameroon	CHMI		
31	Baptist AIDS Response in Africa	CAR	CHMI		
32	Danish refugee council	CAR	CHMI	Yes	
33	U-Report	CAR	CHMI		
34	Health Services Contracting in Chad	Chad	CHMI		
35	CliniPAK (Clinical Patient Administration Kit)	Comoros	CHMI	Yes	Yes
36	Danish refugee council	Djibouti	CHMI	Yes	
37	Danish refugee council	DRC	CHMI	Yes	
38	DKT Democratic Republic of the Congo	DRC	CHMI	Yes	Yes
39	Healthy Entrepreneurs	DRC	CHMI	Yes	
40	Rebuilding Health in Rwanda	DRC	CHMI		
41	Mobile Information For Maternal Health	DRC	GDHN	Yes	
42	Danish refugee council	Eriteria	CHMI		
43	Alive and Thrive	Ethiopia	CHMI	Yes	
44	APOPO	Ethiopia	CHMI	Yes	Yes
45	Danish refugee council	Ethiopia	CHMI	Yes	Yes
46	Electronic Dispensing Tool by MSH	Ethiopia	CHMI		
47	Enat Messenger for Maternal Health	Ethiopia	GDHN	Yes	
48	Fitun Warmline AIDS Hotline	Ethiopia	CHMI		
49	HHA - Reach Ethiopia	Ethiopia	CHMI	Yes	
50	Innopia Electromechanical Solutions	Ethiopia	CHMI	Yes	Yes
51	Improve Adherence to Antiretroviral Treatment	Ethiopia	CHMI	Yes	Yes
52	Kadisco General Hospital Slide Pathology Program	Ethiopia	CHMI		
53	Marie Stopes	Ethiopia	CHMI	Yes	Yes
54	Medical Biotech Laboratories	Ethiopia	CHMI		

55	Nutrition at the Center	Ethiopia	CHMI		
56	OppiaMobile	Ethiopia	CHMI		
57	Organisation for Women in Self Employment	Ethiopia	CHMI	Yes	Yes
58	Saving Lives with the Neo BVM	Ethiopia	CHMI	Yes	
59	Tebita Ambulance	Ethiopia	CHMI		
60	Telemed Medical Services	Ethiopia	CHMI	Yes	Yes
61	The Last 10 Kilometers	Ethiopia	GDHN	Yes	Yes
62	The Safe Delivery App	Ethiopia	GDHN	Yes	
63	Healthy Entrepreneurs	Gabon	CHMI	Yes	
64	Be Alert	Ghana	CHMI		
65	Breath of Life	Ghana	CHMI		
66	Community Benefits Health	Ghana	CHMI		
67	Community Health Nurse on the Go (CNH)	Ghana	CHMI		
68	DKT Ghana	Ghana	CHMI	Yes	
69	DonKomi	Ghana	CHMI		
70	Early Warning System	Ghana	GDHN	Yes	Yes
71	Empowering and Mobilizing People with HIV/AIDS	Ghana	GDHN	Yes	
72	Global Authentification Network	Ghana	CHMI		
73	HealthKeepers	Ghana	CHMI		
74	HIV/AIDS Prevention Among Plantation Workers	Ghana	CHMI		
75	Improve Adherence to Antiretroviral Treatment	Ghana	CHMI	Yes	
76	Marie Stopes	Ghana	CHMI		Yes
77	MicroClinic International	Ghana	CHMI		
78	Mobile Phone Survey Software for End-Use	Ghana	GDHN	Yes	Yes
79	mPedigree	Ghana	CHMI	Yes	
80	Participatory Monitoring and Evaluation (PartMe)	Ghana	GDHN	Yes	
81	PharmaAccess	Ghana	CHMI	Yes	Yes
82	SafeCare Foundation	Ghana	CHMI	Yes	Yes
83	Tanzania-Ghana Health Partnership (TGHP)	Ghana	CHMI		
84	Texting4Health	Ghana	CHMI		
85	Unite For Sight: Global Health Delivery Programs	Ghana	CHMI	Yes	
86	Viamo	Ghana	CHMI	Yes	
87	Gradian Health	Guinea	CHMI	Yes	Yes
88	HeartString	Guinea	CHMI	Yes	
89	Last Mile Health	Guinea	CHMI	Yes	
90	mHero	Guinea	GDHN	Yes	
91	Informed Push Model (IPM)	Guinea-Bissau	GDHN	Yes	
92	DKT	Ivory Coast	CHMI	Yes	Yes
93	Total Health Village	Ivory Coast	CHMI	Yes	Yes
94	Access Afya	Kenya	CHMI	Yes	
95	Action Network for the Disabled	Kenya	CHMI		
96	Affordable Medicines Facility - Malaria (AMFm)	Kenya	CHMI		
97	Afya Njema Project	Kenya	CHMI		
98	AIDS Barefoot Doctors (ABD)	Kenya	CHMI	Yes	Yes
99	AMD’s Dispatch Case	Kenya	CHMI	Yes	Yes
100	AMUA	Kenya	CHMI	Yes	Yes
101	Anti-Jigger Campaign Program	Kenya	CHMI	Yes	Yes
102	Arogya Parivar	Kenya	CHMI	Yes	
103	Baby Monitor	Kenya	CHMI	Yes	
104	Bambulance Project	Kenya	CHMI		
105	Basic Needs	Kenya	CHMI	Yes	Yes
106	Bike4Care	Kenya	CHMI	Yes	
107	Bima ya Jamii Project	Kenya	CHMI		
108	Born to Live	Kenya	CHMI	Yes	Yes
109	Build Kenya	Kenya	CHMI	Yes	Yes
110	Busia Child Survival Project	Kenya	CHMI		
111	Busia Trailer Park Wellness Centre and Clinic	Kenya	CHMI		
112	Capacity Kenya	Kenya	CHMI	Yes	Yes
113	Carolina for Kibera (CFK)	Kenya	CHMI		Yes
114	Chakruok Interactive Radio Program	Kenya	GDHN	Yes	Yes
115	Changamka Maternal Health Smartcard	Kenya	GDHN	Yes	

116	Child and Family Wellness (CFW) Shops	Kenya	CHMI	Yes	Yes
117	ChildCount+	Kenya	CHMI	Yes	
118	CliniPAK (Clinical Patient Administration Kit)	Kenya	CHMI	Yes	
119	Community Health Promotion Kenya (CHPK)	Kenya	CHMI	Yes	
120	Cyber-Sight	Kenya	CHMI		
121	Cyber-VCT Pilot Program	Kenya	CHMI	Yes	
122	Daktari CD4	Kenya	CHMI	Yes	Yes
123	Danish Refugee Council	Kenya	CHMI	Yes	Yes
124	Diabetes Care in Nairobi slums	Kenya	CHMI	Yes	Yes
125	Diabetic Foot Care, Kenya	Kenya	CHMI	Yes	Yes
126	Donkey Cart Ambulances	Kenya	CHMI		
127	Essential Medicine and for Rural Health	Kenya	CHMI		
128	Essential Obstetrics and Neonatal Care	Kenya	CHMI		
129	FACES	Kenya	CHMI		
130	Fight against AIDS and Tuberculosis	Kenya	CHMI		Yes
131	Global Emergency Care Collaborative	Kenya	CHMI	Yes	
132	Global MamaCare Initiative	Kenya	CHMI		
133	Gradian Health Systems	Kenya	CHMI	Yes	Yes
134	GxAlert	Kenya	CHMI	Yes	Yes
135	Hand to hand renal care	Kenya	CHMI		
136	Health at Home/Kenya	Kenya	CHMI		
137	Health by Motorbike	Kenya	CHMI		
138	Health eVillages	Kenya	CHMI		
139	Health[e]Foundation	Kenya	CHMI	Yes	Yes
140	HealthRight	Kenya	CHMI		Yes
141	Helping Babies Breathe	Kenya	CHMI	Yes	
142	Hope for African Children Initiative (HACI)	Kenya	CHMI		
143	Huduma Poa Health Network	Kenya	CHMI	Yes	
144	I-Care	Kenya	CHMI	Yes	Yes
145	Improving Lutheran Response to HIV/AIDS	Kenya	CHMI		
146	Inrud	Kenya	CHMI	Yes	Yes
147	Jacaranda Health	Kenya	CHMI	Yes	Yes
148	Jaipur Foot	Kenya	CHMI	Yes	Yes
149	Jamii Smart	Kenya	CHMI		Yes
150	Kageno Health Program	Kenya	CHMI		
151	Kangu	Kenya	CHMI	Yes	
152	Kenya Acorn Project (KAP)	Kenya	CHMI		
153	Kenya Partner Ministries Birthing Kits	Kenya	CHMI		
154	K-MET Community Clinics	Kenya	CHMI		
155	Knowledge for Health	Kenya	CHMI	Yes	
156	Korogocho Mathare (KOMA) Network	Kenya	CHMI	Yes	
157	Kutana Cloud	Kenya	CHMI		
158	Lea Toto Community-Based Care Program	Kenya	CHMI		Yes
159	Life	Kenya	CHMI	Yes	
160	Life Wrap	Kenya	CHMI		
161	Living Goods	Kenya	CHMI	Yes	Yes
162	Maasai Dental Clinic	Kenya	CHMI	Yes	
163	Magunga's Baby Bikes	Kenya	CHMI		
164	Mama SASHA Project	Kenya	CHMI	Yes	Yes
165	Mama-Toto Mobile Clinic	Kenya	CHMI		
166	Maternal and Child Health Integrated	Kenya	GDHN	Yes	
167	M-CHANJO	Kenya	CHMI	Yes	Yes
168	Medic Mobile	Kenya	CHMI	Yes	Yes
169	Africa Mobile Telemedicine Clinics Project	Kenya	CHMI		
170	mHBB	Kenya	GDHN	Yes	
171	Micro-Clinic Island Network	Kenya	CHMI		Yes
172	Miti Health	Kenya	CHMI	Yes	Yes
173	Mobile App for HIV in Pregnancy	Kenya	GDHN	Yes	
174	Mobile for Reproductive Health (m4RH)	Kenya	CHMI		
175	Mobile Interactions bringing Hope (MI Hope)	Kenya	CHMI		Yes
176	Mother-Baby Pack	Kenya	CHMI		

177	mSOS	Kenya	GDHN	Yes	
178	M-Vaccine	Kenya	CHMI	Yes	Yes
179	Womens Gender Violence Recovery Center	Kenya	CHMI	Yes	Yes
180	National HIV/AIDS Health Workers Network	Kenya	CHMI		
181	Nex Leaf	Kenya	CHMI	Yes	Yes
182	Roadside Wellness Centres	Kenya	CHMI	Yes	Yes
183	Obstetric Fistula Repair and Care Project	Kenya	CHMI	Yes	Yes
184	OpenHDS	Kenya	GDHN	Yes	
185	Orthopaedic Program	Kenya	CHMI	Yes	Yes
186	PACE Dental Clinic	Kenya	CHMI		
187	Partnership for Maternal and Neonatal Health	Kenya	CHMI	Yes	
188	Peek Vision	Kenya	GDHN	Yes	
189	Penda Health	Kenya	CHMI	Yes	
190	Positive Youth Initiative	Kenya	CHMI	Yes	Yes
191	Powerfree Education Technology	Kenya	CHMI		Yes
192	Right to Care	Kenya	CHMI		
193	Safe Water and AIDS Project (SWAP)	Kenya	CHMI	Yes	Yes
194	SafeTStop	Kenya	CHMI		
195	Sailing Doctors	Kenya	CHMI	Yes	
196	SANA: Open Source Telemedicine	Kenya	CHMI	Yes	
197	Saving Newborn Lives in Kenya	Kenya	CHMI	Yes	
198	Scaling Up Maternal/Postnatal Care	Kenya	CHMI	Yes	
199	Shujaa Program	Kenya	CHMI	Yes	Yes
200	Solar Suitcase	Kenya	CHMI	Yes	Yes
201	Supply chain solution for Essential Care	Kenya	CHMI	Yes	Yes
202	T.E.A.C.H	Kenya	CHMI		
203	Tabasamu Project	Kenya	CHMI	Yes	Yes
204	TEGEMEZA Project	Kenya	CHMI		
205	The Ambulance Project	Kenya	CHMI		
206	The Imani Project	Kenya	CHMI		Yes
207	The Mobile Health Research Lab	Kenya	GDHN	Yes	
208	TropicalClinics Model Health Centers	Kenya	CHMI		
209	Tumutumu Hospital	Kenya	CHMI	Yes	Yes
210	Tunza Family Health Network, Kenya	Kenya	CHMI	Yes	Yes
211	UHAI	Kenya	CHMI		
212	Upperhill Eye & Laser Centre (UHEAL)	Kenya	CHMI	Yes	Yes
213	Viva Afya (formerly Carego Livewell)	Kenya	CHMI	Yes	Yes
214	WelTel	Kenya	CHMI	Yes	
215	Wild4Life	Kenya	CHMI		Yes
216	Wireless Reach Initiative	Kenya	CHMI		
217	World health partners	Kenya	CHMI	Yes	Yes
218	Youth-to-Youth (Y2Y) Initiative	Kenya	CHMI	Yes	Yes
219	ZanaAfrica	Kenya	CHMI	Yes	Yes
220	ZiDi	Kenya	CHMI	Yes	Yes
221	Zingatia Maisha	Kenya	CHMI	Yes	Yes
222	Amref	Kenya	CHMI	Yes	
223	mothers2mothers	Lesotho	CHMI	Yes	Yes
224	Accredited Medicine Store (AMS)	Liberia	CHMI		Yes
225	Adopt-A-Doctor	Liberia	CHMI		
226	Last Mile Health	Liberia	CHMI	Yes	Yes
227	Maternova Obstetric Kit	Liberia	CHMI	Yes	
228	mHero	Liberia	CHMI		
229	SmartChoice Program	Liberia	CHMI	Yes	Yes
230	LAUNCH	Liberia	GDHN	Yes	
231	Affordable Medicines Facility - Malaria (AMFm)	Madagascar	CHMI		
232	BlueStar Madagascar	Madagascar	CHMI		
233	Elimentaire Sarl	Madagascar	CHMI		
234	Marie Stopes	Madagascar	CHMI	Yes	Yes
235	Sexual and Reproductive Vouchers	Madagascar	GDHN	Yes	Yes
236	ProFemina	Madagascar	CHMI		Yes
237	Baobab Health Trust	Malawi	CHMI	Yes	Yes

238	BlueStar Malawi: Banja la Mtsogolo	Malawi	CHMI		
239	Child Status Index (CSI) Mobile App	Malawi	GDHN	Yes	Yes
240	Chipatala Cha Pa Foni	Malawi	GDHN	Yes	
241	CommCare	Malawi	CHMI	Yes	
242	Community IMCI (cIMCI)	Malawi	GDHN	Yes	Yes
243	cStock	Malawi	CHMI	Yes	
244	Emergency Triage Assessment And treatment	Malawi	GDHN	Yes	
245	iCCM	Malawi	GDHN	Yes	
246	Marie Stopes	Malawi	CHMI	Yes	Yes
247	Mobile Clinic in Malawi (PIH and MOH)	Malawi	CHMI		
248	mothers2mothers	Malawi	CHMI	Yes	Yes
249	Mwayi wa Moyo (“A Chance to Live”) Project	Malawi	CHMI	Yes	Yes
250	Tunza Family Health Network, Malawi	Malawi	CHMI		
251	BlueStar Mali	Mali	CHMI		
252	Danish refugee council	Mali	CHMI	Yes	
253	D-tree International	Mali	CHMI	Yes	Yes
254	Mali Health	Mali	CHMI	Yes	Yes
255	Marie Stopes	Mali	CHMI		Yes
256	ProFam	Mali	CHMI	Yes	Yes
257	Project Muso	Mali	CHMI	Yes	
258	Marie Stopes	Mauritania	CHMI	Yes	Yes
259	Jaipur Foot	Mauritius	CHMI	Yes	Yes
260	APOPO	Mozambique	CHMI	Yes	Yes
261	Maternal, Newborn and Child Health	Mozambique	CHMI		
262	DKT Mozambique	Mozambique	CHMI	Yes	Yes
263	Grand Challenge Exploration Phase I	Mozambique	GDHN	Yes	
264	inSCALE	Mozambique	GDHN	Yes	
265	mCenas!	Mozambique	GDHN	Yes	
266	Open Medical Record System (OpenMRS)	Mozambique	CHMI	Yes	
267	Reliefwatch	Mozambique	CHMI	Yes	
268	TB CARE I	Mozambique	CHMI	Yes	
269	VillageReach	Mozambique	CHMI	Yes	
270	Mister Sister Mobile Primary Healthcare Clinics	Namibia	CHMI		
271	Supply Chain Management System (SCMS)	Namibia	CHMI		
272	Danish refugee council	Niger	CHMI	Yes	
273	Marie Stopes	Niger	CHMI		Yes
274	Meningitis Vaccine Project	Niger	CHMI		
275	BlueStar Nigeria	Nigeria	CHMI	Yes	Yes
276	Airtel Insurance with MicroEnsure	Nigeria	CHMI		
277	All Purpose Medical Information System	Nigeria	CHMI		
278	Apollo Telemedicine Networking Foundation	Nigeria	CHMI		
279	Caring palms health care	Nigeria	CHMI	Yes	
280	ChildCount+	Nigeria	CHMI		
281	Deji Clinic	Nigeria	CHMI		
282	DKT Nigeria	Nigeria	CHMI	Yes	Yes
283	DoctorDial	Nigeria	CHMI		
284	DrugStoc	Nigeria	GDHN	Yes	
285	eHealth Africa	Nigeria	CHMI	Yes	
286	Enhancing the Ability of Health Workers	Nigeria	CHMI		
287	Cardiovascular Disease and HIV Integration	Nigeria	CHMI	Yes	Yes
288	Happy Mothers Network	Nigeria	CHMI		
289	Hygeia Community Health Plan (HCHP)	Nigeria	CHMI		
290	Interactive Distance Education Application	Nigeria	GDHN	Yes	
291	Learning About Living	Nigeria	CHMI		
292	mDoc Healthcare	Nigeria	CHMI	Yes	
293	Medpax Disposable Birth Delivery Kit	Nigeria	CHMI		
294	Medplus (Nigeria)	Nigeria	CHMI		
295	Riders for Health	Nigeria	CHMI		
296	Supportive Supervision (SS) for TB	Nigeria	GDHN	Yes	Yes
297	Sure Girl Initiative	Nigeria	CHMI		
298	SUSTAIN cHTC	Nigeria	CHMI	Yes	Yes

299	Technomedics biomedical ltd	Nigeria	CHMI		
300	The 100,000 Smiles Project	Nigeria	CHMI		
301	The River Boat Clinic	Nigeria	CHMI		
302	The SureHealth Plan	Nigeria	CHMI		
303	West Africa Drug Regulatory Authority Network	Nigeria	CHMI		
304	Women and Youths in Empowerment	Nigeria	CHMI	Yes	
305	Y'ello Health Cover	Nigeria	CHMI		
306	Healthcare for Underprivileged Program	Rwanda	CHMI	Yes	Yes
307	Anti-Malaria Micro Project	Rwanda	CHMI	Yes	
308	Centre Dushishoze	Rwanda	CHMI	Yes	Yes
309	Clinique Combiné	Rwanda	CHMI		
310	COMBAR-AIDS	Rwanda	CHMI		
311	Cervical Cancer Prevention Program	Rwanda	CHMI		
312	cStock	Rwanda	CHMI	Yes	
313	Public Health Laboratory Networking Project	Rwanda	CHMI	Yes	Yes
314	Giving Hope program	Rwanda	CHMI	Yes	Yes
315	HDI Medical and Technical Support Program	Rwanda	CHMI	Yes	Yes
316	Health Builders	Rwanda	CHMI	Yes	
317	HIV/AIDS Awareness Program	Rwanda	CHMI		
318	Health Systems Strengthening Project	Rwanda	CHMI		
319	One Family Health	Rwanda	CHMI	Yes	
320	PrePex, Male Circumcision Device	Rwanda	CHMI		
321	Rapid Assessment of Avoidable Blindness	Rwanda	CHMI	Yes	
322	RapidSMS Rwanda	Rwanda	GDHN	Yes	
323	Rwanda Health Enterprise Architecture	Rwanda	CHMI	Yes	Yes
324	Rwanda Performance-Based Financing	Rwanda	CHMI		
325	Strengthening Communities to HIV/AIDS	Rwanda	CHMI	Yes	Yes
326	The Ihangane Project	Rwanda	CHMI	Yes	
327	TRACnet	Rwanda	CHMI		
328	Women's Care and Treatment Program	Rwanda	CHMI	Yes	
329	ARV Inititaive	Sao Tome and Principe	GDHN	Yes	
330	Automated Health Data Exchange System	Senegal	GDHN	Yes	
331	CRS Senegal mHealth Pilot	Senegal	GDHN	Yes	
332	DKT	Senegal	CHMI	Yes	Yes
333	Informed Push Model (IPM)	Senegal	CHMI		
334	IVR for mLearning Platform	Senegal	GDHN	Yes	
335	Ma Sante	Senegal	GDHN	Yes	
336	Automated Health Data Exchange System	Senegal	CHMI		
337	EbolaTXT	Sierra Leone	GDHN	Yes	
338	Essential Newborn Care Corps (ENCC)	Sierra Leone	CHMI		
339	Fistula Hotline	Sierra Leone	CHMI	Yes	
340	Gradian Health Systems	Sierra Leone	CHMI	Yes	Yes
341	iPhones for Malaria Indicator Survey	Sierra Leone	GDHN	Yes	
342	Mobile Phones for ttC/MNCH	Sierra Leone	CHMI	Yes	Yes
343	Quality Circles for Health	Sierra Leone	CHMI		
344	Marie Stopes	Sierre Leone	CHMI	Yes	Yes
345	alcamilabs	Somalia	CHMI	Yes	
346	BulshoKaab Pharmacies Network	Somalia	CHMI	Yes	
347	Danish refugee council	Somalia	CHMI	Yes	
348	PSI	Somalia	CHMI	Yes	
349	Somali Mental Health Foundation	Somalia	CHMI	Yes	
350	Agewell Global	South Africa	CHMI	Yes	
351	AllLife	South Africa	CHMI		
352	ART adherence club	South Africa	CHMI		
353	Aspen Pharmacare	South Africa	CHMI		
354	Autonomous Treatment Center	South Africa	CHMI		
355	Bambisanani Project	South Africa	CHMI		
356	Hospitals Public Private Partnership	South Africa	CHMI		
357	Healthcare Down Referral Model	South Africa	CHMI	Yes	Yes
358	Nurse Initiated Antiretroviral Therapy	South Africa	CHMI		
359	Clinix Health Group	South Africa	CHMI	Yes	Yes

360	ComHealth	South Africa	CHMI		
361	DomestiCare	South Africa	CHMI	Yes	
362	Eskom's HIV/AIDS program	South Africa	CHMI		
363	Etafeni Project	South Africa	CHMI	Yes	
364	Flying for Life	South Africa	CHMI		
365	FoneAstra	South Africa	GDHN	Yes	
366	Hello Doctor	South Africa	CHMI	Yes	
367	HISP	South Africa	CHMI	Yes	
368	Iyeza Express	South Africa	CHMI		
369	Kheth'Impilo	South Africa	CHMI	Yes	Yes
370	Malamulele Onward	South Africa	CHMI	Yes	Yes
371	Marie Stopes	South Africa	CHMI	Yes	Yes
372	Medical Diagnostech	South Africa	CHMI	Yes	Yes
373	MediKredit	South Africa	CHMI	Yes	Yes
374	Men as partners	South Africa	CHMI		
375	Mhealth training for Nurses and Midwives	South Africa	CHMI	Yes	
376	MomConnect	South Africa	CHMI		
377	Netcare Public Private Partnerships	South Africa	CHMI		
378	New Start South Africa	South Africa	CHMI	Yes	Yes
379	OCSA Care	South Africa	CHMI	Yes	Yes
380	Owethu Clinics	South Africa	CHMI	Yes	Yes
381	Pharmacy-in-a-Box	South Africa	CHMI		
382	Phelophepha Healthcare Train	South Africa	CHMI	Yes	Yes
383	Powerfree Education Technology	South Africa	CHMI		
384	Pre-Eclampsia Integrated Estimate	South Africa	GDHN	Yes	
385	Project Khuluma	South Africa	GDHN	Yes	
386	Samsung Solar Powered Health Centre	South Africa	CHMI		
387	Sante Health Platform	South Africa	CHMI		
388	Shonaquip	South Africa	CHMI	Yes	Yes
389	Sizophila Therapeutic Counseling Project	South Africa	CHMI	Yes	
390	South African Business Coalition on HIV/AIDS	South Africa	CHMI		
391	Strait Access Technologies	South Africa	CHMI	Yes	Yes
392	Tateni Home Care Nursing Services	South Africa	CHMI		
393	Teen SMS Helpline to Stop Suicide	South Africa	CHMI	Yes	
394	The CD4 Initiative	South Africa	CHMI		
395	txtAlert for Patient Reminders	South Africa	GDHN	Yes	
396	Umthombo Youth Development Foundation	South Africa	CHMI	Yes	Yes
397	Unjani Clinics	South Africa	CHMI	Yes	
398	Vula Eye Health App	South Africa	CHMI	Yes	
399	ANISA	Sudan	CHMI	Yes	Yes
400	Apollo Telemedicine Networking Foundation	Sudan	CHMI	Yes	Yes
401	Baptist AIDS Response in Africa	Sudan	CHMI		
402	Danish refugee council	Sudan	CHMI	Yes	
403	Sightsavers	Sudan	CHMI	Yes	Yes
404	Child Profiling Survey	Swaziland	GDHN	Yes	Yes
405	A to Z Textiles	Tanzania	CHMI		
406	Accredited Drug Dispensing Outlets (ADDO)	Tanzania	CHMI		
407	Afya (117) AIDS Helpline	Tanzania	CHMI		
408	Afya Mtandao	Tanzania	CHMI		
409	Aga Khan eHealth Resource Centre	Tanzania	CHMI	Yes	Yes
410	Association of Private Health Facilities	Tanzania	CHMI		Yes
411	BasicNeeds	Tanzania	CHMI		
412	Philanthropies Maternal Health Initiative	Tanzania	CHMI		
413	Boma la Mama	Tanzania	CHMI		
414	CCBRT	Tanzania	CHMI	Yes	Yes
415	CliniPAK (Clinical Patient Administration Kit)	Tanzania	CHMI	Yes	
416	CommCare for Home-Based Care	Tanzania	GDHN	Yes	Yes
417	EngageTB	Tanzania	GDHN	Yes	
418	eNUT	Tanzania	GDHN	Yes	
419	eNutrition	Tanzania	GDHN	Yes	Yes
420	FACES	Tanzania	CHMI	Yes	Yes

421	Familia	Tanzania	CHMI		
422	Fistula Surgery Wing	Tanzania	CHMI		
423	Foundation for African Medicine & Education	Tanzania	CHMI	Yes	Yes
424	Helping Babies Breathe	Tanzania	CHMI		
425	International Quality Short Messaging System	Tanzania	GDHN	Yes	
426	Joining Hands Initiative	Tanzania	CHMI		
427	KNCU Health Plan	Tanzania	CHMI		
428	Maternal Health	Tanzania	GDHN	Yes	Yes
429	MEDA Bednet	Tanzania	CHMI	Yes	Yes
430	mHealth for Community Family Planning	Tanzania	GDHN	Yes	
431	mHealth for Safe Deliveries	Tanzania	GDHN	Yes	Yes
432	EZY Pesa Mobile Banking Service	Tanzania	GDHN	Yes	
433	Mobile Phone Microscopy	Tanzania	GDHN	Yes	
434	MobyApp	Tanzania	GDHN	Yes	
435	OppiaMobile	Tanzania	GDHN	Yes	
436	Pona Na Tigo Bima	Tanzania	GDHN	Yes	
437	Safer Deliveries	Tanzania	CHMI		
438	SMS For Life	Tanzania	CHMI		
439	Tabasamu Project	Tanzania	CHMI	Yes	
440	Tanzania National eVoucher Scheme	Tanzania	GDHN	Yes	
441	The National Fistula Program	Tanzania	CHMI		
442	Transport My Patient by CCBRT	Tanzania	CHMI	Yes	
443	Wazazi Nipendeni	Tanzania	CHMI		
444	Wired Mothers	Tanzania	GDHN	Yes	
445	Hang-Up and Track	Tanzania	GDHN	Yes	
446	Hope Through Health	Togo	CHMI	Yes	
447	Long Lasting Insecticide-treated Nets	Togo	CHMI		Yes
448	POMEFA	Togo	CHMI		Yes
449	Act For Birth	Uganda	GDHN	Yes	
450	Action for Community Development (ACODEV)	Uganda	CHMI		
451	AOET Rural Health Initiative	Uganda	CHMI	Yes	
452	BanaPads	Uganda	CHMI		
453	Bike4Care	Uganda	CHMI		
454	BlueStar Healthcare Network	Uganda	CHMI	Yes	Yes
455	BRAC Essential Health Care Programme	Uganda	CHMI	Yes	Yes
456	Charis International Medical Centre	Uganda	CHMI	Yes	Yes
457	Clear Seven	Uganda	CHMI		
458	Clinic Africa	Uganda	CHMI		
459	Clinic Communicator	Uganda	CHMI		
460	COHRE Training Program	Uganda	CHMI		
461	Combating Child Mortality among Batwa	Uganda	CHMI		
462	Comboni Hospital Health Plan	Uganda	CHMI		
463	Community Empowerment in Health	Uganda	CHMI	Yes	Yes
464	Prevention of Mother To Child HIV Transmission	Uganda	CHMI	Yes	Yes
465	Community-Based Family Planning Program	Uganda	CHMI		
466	ePartogram	Uganda	GDHN	Yes	
467	eQuality Health Bwindi	Uganda	CHMI	Yes	Yes
468	Contracting in Uganda	Uganda	CHMI		
469	FINCA Uganda-NHHP health insurance scheme	Uganda	CHMI		
470	FXBVillage Model	Uganda	CHMI		
471	Global Emergency Care Collaborative	Uganda	CHMI		
472	Global Health Network	Uganda	CHMI	Yes	Yes
473	Gradian Health Systems	Uganda	CHMI	Yes	Yes
474	Hands of Help Community Health Project	Uganda	CHMI		
475	Happy Health Insurance Scheme Clinic	Uganda	CHMI		
476	Health Child - Uganda	Uganda	CHMI	Yes	Yes
477	Health[e]Foundation	Uganda	CHMI	Yes	
478	Inrud	Uganda	CHMI		Yes
479	International Medical Group	Uganda	CHMI		
480	Ishaka Hospital Health Insurance Scheme	Uganda	CHMI		
481	Kadama Caring Community Project (KCCP)	Uganda	CHMI		

482	Kadic Health Services	Uganda	CHMI		
483	Kangu	Uganda	CHMI		
484	Kisiizi Community Health Insurance Scheme	Uganda	CHMI		
485	Kitanga Health Insurance Scheme	Uganda	CHMI		
486	Kitovu Community Health Insurance Scheme	Uganda	CHMI	Yes	Yes
487	Kitovu Mobile	Uganda	CHMI	Yes	Yes
488	Kiwoko Hospital Community-Based Health	Uganda	CHMI		
489	Kyetume Community Health Care Programme	Uganda	CHMI		Yes
490	LifeNet International	Uganda	CHMI		
491	Mama Rescue	Uganda	CHMI	Yes	
492	Market Vendors AIDS Project (MAVAP)	Uganda	CHMI		
493	Maternova Obstetric Kit	Uganda	CHMI		
494	mHealth for Safer Deliveries	Uganda	GDHN	Yes	Yes
495	Microcare	Uganda	CHMI		
496	Mobile Male Circumcision Clinic	Uganda	CHMI	Yes	Yes
497	Mobile Pharmacy in Northern Uganda Project	Uganda	CHMI		
498	Mobiles for Quality Improvement	Uganda	GDHN	Yes	Yes
499	Mother Child Rescue Project (MCRP)	Uganda	CHMI		
500	mTrac: Monitoring Essential Medicine Supply	Uganda	GDHN	Yes	Yes
501	Munno Mu Bulwadde Microinsurance	Uganda	CHMI		
502	Mutolere Community Health Insurance Scheme	Uganda	CHMI		
503	Mwenya Uganda Mobile Clinic	Uganda	CHMI	Yes	
504	National Health Insurance Fund	Uganda	CHMI		
505	Nyakibale Hospital Health Plan	Uganda	CHMI		
506	NCBHIS	Uganda	CHMI		
507	ORBIS Flying Eye Hospital	Uganda	CHMI		
508	Orthopaedic Program	Uganda	CHMI		
509	Patient Satisfaction Survey Mobile Program	Uganda	CHMI		
510	ProFam, Uganda	Uganda	CHMI	Yes	Yes
511	Project Bumwalukani	Uganda	CHMI	Yes	Yes
512	Radio Apac	Uganda	CHMI	Yes	Yes
513	Reach Out Mbuya Parish HIV/AIDS Initiative	Uganda	CHMI	Yes	Yes
514	Reduction of Maternal Mortality through ICT	Uganda	GDHN	Yes	
515	Roads to a Healthy Future	Uganda	CHMI		
516	Safe Mothers, Safe Babies	Uganda	CHMI	Yes	Yes
517	Safe Water and AIDS Project (SWAP)	Uganda	CHMI	Yes	Yes
518	SafeBoda	Uganda	CHMI	Yes	Yes
519	Scaling Up Microinsurance in East Africa	Uganda	CHMI		
520	School Health Made Easy	Uganda	CHMI	Yes	
521	Securing Ugandans' Right for Essential Medicines	Uganda	CHMI		
522	Smartphone Thyroid Disease Management	Uganda	CHMI	Yes	Yes
523	Soft Power Health (SPH)	Uganda	CHMI	Yes	
524	Health Care Services Community Programme	Uganda	CHMI		
525	Stop Malaria Project (SMP)	Uganda	CHMI		
526	Strengthening TB and AIDS Response	Uganda	CHMI		
527	STRIDES for Family Health	Uganda	CHMI		
528	Sustainable Drug Seller Initiatives (SDSI)	Uganda	CHMI		
529	TeleMedicine Project	Uganda	CHMI		
530	Teso Safe Motherhood Project (TSMP)	Uganda	CHMI	Yes	
531	The AIDS Support Programme (TASO)	Uganda	CHMI		
532	The Initiative to End Child Malnutrition (IECM)	Uganda	CHMI		
533	The Medical Concierge Call Centre and Service	Uganda	CHMI	Yes	
534	The Youth Truck	Uganda	CHMI		
535	The Zambulance	Uganda	CHMI		
536	Tobacco Kills: Say No & Save Lives	Uganda	GDHN	Yes	
537	Total Health Village	Uganda	CHMI		
538	TTC: SMS to improve HIV awareness	Uganda	CHMI		
539	Uganda Cares	Uganda	CHMI		
540	Uganda Hearing Health Care Program	Uganda	CHMI		
541	Uganda Private health units association	Uganda	CHMI	Yes	
542	Uganda Private Midwives Organisation	Uganda	CHMI		

543	Uganda Rural Fund (URF)	Uganda	CHMI	Yes	Yes
544	Uganda Village Project	Uganda	CHMI	Yes	
545	Human Resources for Health Information System	Uganda	CHMI		
546	Vine Pharmacy	Uganda	CHMI		
547	Wayo-Nero Strategy	Uganda	CHMI		
548	Winsenga eFHR	Uganda	CHMI		
549	Yer Yotkom	Uganda	CHMI		
550	ColaLife	Zambia	CHMI	Yes	Yes
551	Communications Support for Health	Zambia	CHMI		
552	Community COMPACT	Zambia	CHMI		
553	Corridors of Hope	Zambia	CHMI		
554	ELMIS	Zambia	CHMI		
555	Gradian Health Systems	Zambia	CHMI	Yes	Yes
556	iAfya Mobile health Application	Zambia	CHMI	Yes	
557	Marie Stopes	Zambia	CHMI	Yes	Yes
558	One Family Health	Zambia	CHMI	Yes	Yes
559	Society for Family Health	Zambia	CHMI	Yes	Yes
560	The Zambulance	Zambia	CHMI	Yes	Yes
561	Vision Centers	Zambia	CHMI		Yes
562	Automating Data Collection for HIV Services	Zimbabwe	GDHN	Yes	Yes
563	Mobile HIV and Malaria Reporting System	Zimbabwe	GDHN	Yes	

F.9 Parent organisations of survey respondents

Table F-5 - Parent organisations of survey respondents

Parent organisations			
1	AEDES	46	Ministry of Health - Tanzania
2	Agewell	47	Ministry of Health - Zambia
3	AIDSFree	48	MAHSRA
4	Anova Health Institute	49	mTrac
5	Aurum institute	50	National Agency for the Control of AIDS
6	Avallain Foundation	51	NPOKI
7	Babyl Rwanda	52	Nutrition International
8	Banda Health	53	One Family Health
9	Broadreach	54	PATH
10	Catholic relief services	55	Pathfinder International
11	CHN	56	PharmAccess Group
12	Clinton health access initiative	57	PNMLS
13	DAPP	58	Policy
14	Desmond Tutu HIV Foundation	**59**	**Prefer not to say**
15	Digital African Health Library	**60**	**Prefer not to say**
16	Dimagi	61	Program for Appropriate Technologies in Health
17	DKT International	62	PSI
18	DSW	63	Reach Ethiopia
19	D-tree International	64	RIIO
20	FHI 360	65	Rosalia Health Innovation Team
21	FIMRC	66	Safe Water and AIDS Project
22	Foundation for African Medicine and Education	67	Sightsavers
23	FrontlineSMS	68	SystemOne LLC
24	Ghana Health Service	69	Tanzanian Training Centre for International Health
25	Global health network Uganda	70	TB program
26	Health[e]Foundation	71	The Ihangane Project
27	Hello Doctor	72	The Medical Concierge Group
28	Human Network International	73	The SMH foundation
29	Innovations for Poverty Action Kenya	74	UCOP+
30	Inrud	75	Uganda Village Project
31	IntraHealth International	76	Ugandan Academy for Health Innovations and Impact
32	John Snow Inc	77	UNICEF
33	JSI	78	University of Toronto
34	KNCV Tuberculosis Foundation	79	Uphealth foundation
35	Last Mile Health	80	US Aid
36	Makerere University Joint Aids Program	81	VecnaCares
37	Management Sciences for Health	82	Village Reach
38	Masinde muliro university of science and technology	83	Voltamac Home Health Services
39	mDoc	84	We Care Solar
40	MEDA	85	WelTel International mHealth Society
41	Medic Mobile	86	World Education, Inc.
42	Ministry of Health - Kenya	87	Young 1ove Organisation
43	Ministry of Health - Mali	88	ZanaAfrica
44	Ministry of Health - Nigeria	89	Zimbabwe civil liberties and drug network
45	Ministry of Health - South Africa		

Appendix F - Survey

F.10 Final survey instrument

Thank you for participating in this survey!

This survey is being administered to collect primary data on healthcare technology transfer and technology management in the geographic region of sub-Saharan Africa. The collective data findings will provide an overview of how healthcare technology transfer is conducted in the region as well as highlighting the challenges faced by health technology users, managers and administrators.

This survey has 23 questions in total and should take between 8 and 12 minutes to complete.

Respondents with any inquiries are invited to contact us:

Primary researcher: **Rian Marais**
Contact email: **16963989@sun.ac.za**

Consent to use survey data

Please find a copy of this survey's electronic consent form using the link provided. By completing this survey the participant consents to the use their data. No primary data will ever be released and all published work will only contain aggregate and anonymous research findings from this survey instrument.

Consent form information

I confirm that I have read and understood the information provided for the current study.

Tick box: Yes or No

I agree to take part in this survey.

Tick box: Yes or No

Section 1: Demographic questions

1. Which fields of healthcare, if any, does your organisation conduct operations in?

Tick boxes with the following options:

e-Health, Telemedicine, Health information systems, Medial devices, Patient care, Facility management, Maintenance, Research and development, Improving patient reach and supply chain, Ensuring Compliance, Public liaison with government healthcare, Healthcare services

2. What is the name of the organisation?

Open-ended text box

3. What is your official title within this organisation?

Open-ended text box

4. Which sub-Saharan countries, if any, does your organisation most frequently conduct operations in?

Tick boxes with the following options:

Angola; Benin; Botswana; Burkina Faso; Burundi; Cameroon; Cape Verde; Central African Republic; Chad; Comoros; Congo (Brazzaville); Congo (Democratic Republic); Côte d'Ivoire; Djibouti; Equatorial Guinea; Eritrea; Ethiopia; Gabon; Gambia; Ghana; Guinea; Guinea-Bissau; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Mauritius; Mozambique; Namibia; Niger; Nigeria; Réunion; Rwanda; Sao Tome and Principe; Senegal; Seychelles; Sierra Leone; Somalia; South Africa; Sudan; Swaziland; Tanzania; Togo; Uganda; Western Sahara; Zambia; Zimbabwe; None; Western Africa, Central Africa, Eastern Africa, Southern Africa

5. Which technology management markets does your organisation most frequently conduct operations in?

Dropdown list with following options:

Developing new products or processes; R&D environmental monitoring, Technology strategy development; R&D portfolio management; IP management; Post-project evaluation; Technology road mapping; Product line planning; Product portfolio management; Feasibility evaluation; Project execution, Technology transfer; Post-project support; Environmental monitoring; Technology needs assessment; R&D funding; New business development, Other

6. Which fields of technology transfer, if any, does your organisation conduct operations in?

Tick boxes with the following options:

Post technology transfer evaluation; Technology transfer offices; Licensing, Joint ventures, Foreign Direct Investments, Start-up or spin-off business development, Stakeholder integration, Public liaison, Transfer object development, Transfer object management, Technology transfer consultation, Market screening and evaluation, Transfer environment screening, Legal, Other

7. Which fields of healthcare, if any, does your organisation conduct operations in?

Tick boxes with the following options:

e-Health, Telemedicine, Health information systems, Medial devices, Patient care, Facility management, Maintenance, Research and development, Improving patient reach, Compliance officer, Public liaison

Section 2: Evaluation questions

1. In what year was your organisation's health initiative initiated?

Open-ended text box limited to 4 numerical characters

2. What was the motivation of the healthcare initiative

Dropdown list with following options:

Commercial drive and market gain; Social impact; A combination of both

3. To what extent was the health initiative adopted by the intended end-user group?

Dropdown list with following options:

Technology was not adopted at all; Technology was poorly adopted; Technology was marginally adopted; Technology was mostly adopted; Technology was wholly adopted;

4. To what extent did the health initiative experience diffusion into other groups (beyond the intended end-user group) after it was implemented?

Dropdown list with following options:

Technology did not experience any diffusion; Technology diffusion was limited; Technology experienced marginal diffusion; Technology experienced diffusion; Technology was widely diffused

5. How would you rank your organisation's satisfaction level regarding the health initiative's success when considering monetary and time input versus the project's outcomes?

Drop-down lists with following options:

Completely unsatisfied; Unsatisfied; Somewhat satisfied; Satisfied; Completely satisfied

Appendix F - Survey

Section 3: Primary research questions

The following section will require respondents to evaluate the perceived ease of use and usefulness of various healthcare implementations throughout the life cycle of a healthcare initiative.

Perceived ease of implementation of factor:
The degree to which the respondent believes that using this factor would be free of effort considering time and monetary requirements.

Usefulness of factor:
The degree to which the respondent believes that using this factor would enhance their job performance or project success, considering time and monetary requirements.

Please refer to the terminology below for all future questions:

Project - refers to the healthcare initiative of your organisation.
Technology - refers to the healthcare technology implemented.
Standardised - refers to a predefined list of items that can be implemented in any project regardless of its individual characteristics.
Technology donor - The individual or team behind the development of the project.
Technology recipient - The end-users of the project.

Technology transfer team (TTT)

Action statements	*SCC*	Perceived ease of use	Usefulness
Relationship between technology recipient and donor - Conducting preliminary screening of the technology recipient and donor's abilities in order to allocate initial technology transfer tasks.	*1*		
Constructing a detailed co-creation tool - Constructing a dedicated technology transfer team from members of both the technology recipient and donor. - Implementing a managerial hierarchy within this team, i.e. where all team members, except one, is supervised and directly managed by another. - Implementing a tangible or intangible incentive scheme for team members. - Continual and scheduled on-site demonstrations from the technology donor.	*2a* *2b* *2c* *2d*		
Improving the technology transfer team's outreach - Routinely identifying and removing stakeholders with limited future utility regarding the technology transfer.	*3a*		

Stakeholder co-creation (SCC)

Action statements	*SCC*	Perceived ease of use	Usefulness
Constructing a detailed co-creation tool - Defining the technology transfer as a profitable business venture or a strategic alliance. - Allowing end-users to participate in the project's creation and implementation. - Sharing existing knowledge and experience with other project team members.	*1a* *1b* *1c*		

Legal considerations for project components (LC)

Action statements	*LC*	Perceived ease of use	Usefulness
Legally binding stakeholders - Legally binding the technology donor to the technology transfer over its entire lifecycle.	*1*		
Incorporating legal counsel - Incorporating legal advice into the technology's design. - Incorporating legal advice into the completed technology transfer strategy.	*2a* *2c*		

Standardisation of project components (STD)

Action statements	*STD*	Perceived ease of use	Usefulness
A universal starting point - Creating a universal technology transfer starting point regardless of the initiator.	*1*		
Establishing a standardised stakeholder tool - Assigning standardised, not case-specific, roles or responsibilities to individual stakeholders. - Creating a stakeholder tool which identifies individual stakeholder capabilities and assigns data and tasks accordingly.	*2a* *2c*		
Codification standards - Implementing and maintaining a standardised and continual form of communication between all stakeholders throughout the technology transfer. - Documenting all outcomes throughout the technology transfer into standardised tables. - Allowing future technology transfers to access documentation of completed technology transfers.	*3a* *3b* *3c*		

Project implementation methods (PIM)

Action statements	*PIM*	Perceived ease of use	Usefulness
Screening the transfer environment - Screening the infrastructure components of the technology's intended transfer environment and categorising available and missing components. - Selecting infrastructure mitigation practices from a standardised technology transfer list for case-specific technology transfers. - Identifying tailor-made solutions for missing infrastructure components.	*1a* *1b* *1c*		
Selecting a transfer method			

- Implementing a joint venture technology transfer method in favour of other methods.	*2a*		

Project evaluation procedures (PEP)

Action statements	*PEP*	Perceived ease of use	Usefulness
Internal revision procedures - Using a standardised revision protocol tool to review the status of the technology transfer.	*1a*		
Reviewing the completed technology transfer - Compiling revision feedback from multiple stakeholder perspectives into a standardised table. - Using standardised and pre-defined evaluation criteria for the revision process. - Allowing future technology transfers access to revision documents of completed technology transfers.	*2a* *2b* *2c*		

Training methods for the technology (TM)

Action statements	*TM*	Perceived ease of use	Usefulness
Training ground level users			
- Constructing training methods based on the user's existing internal training policies.	*1a*		
- Implementing on-site transfer object training.	*1b*		
- Training end-users to train future users of the technology.	*1c*		
- Identifying end-users' capabilities and constructing training programs accordingly.	*1d*		

Adoption and sustainability (AS)

Action statements	*AS*	Perceived ease of use	Usefulness
Promoting future adoption			
- Constructing a prototype of the technology.	*1a*		
- Incorporating and incentivising early adopters into the technology transfer team.	*1b*		
Decentralizing authority			
- Recruiting ground-level members to champion the project's adoption or diffusion.	*2*		

Marketing (M)

Action statements	*M*	Perceived ease of use	Usefulness
Promoting sustainability			
- Marketing the technology to additional public-sector stakeholders, not in the original transfer team.	*1a*		
- Marketing the technology to additional private sector stakeholders, not in the original transfer team.	*1b*		

Section 4: Additional correspondence

The research team would greatly appreciate if you could please forward the names or contact details of any healthcare management implementations you have previously worked on

Comment box

If you are interested in the findings of this doctoral study, please provide us with your email address below and an executive summary of the survey's outcomes will be forwarded once they have been completed.

Comment box

Thank you for your time and help in making this study valuable to healthcare technology transfer development in sub-Saharan Africa!

F.11 Data tables

Table F-6 - Mean analysis data summary for perceived ease of use

Perceived ease of use				
Indicator	**Managerial best practices**	**Foundation**	**Phase**	**$\bar{x}$**
X_1 ease of use	Conducting preliminary screening of the project recipient and donor's abilities in order to allocate initial tasks.	Technology transfer team	I	3.449
X_2 ease of use	Constructing a dedicated project team from the project recipient, donor and additional stakeholders.	Technology transfer team		3.202
X_3 ease of use	Implementing a managerial hierarchy within this team, i.e. where all team members, except one, is supervised and directly managed by another.	Technology transfer team		3.303
X_4 ease of use	Outlining a monetary incentive scheme for team members.	Technology transfer team		**2.596**
X_5 ease of use	Outlining a non-monetary incentive scheme for team members.	Technology transfer team		3.146
X_6 ease of use	Legally binding the technology donor to the technology transfer over its entire life-cycle.	Legal considerations for project components		2.663
X_7 ease of use	Creating a universal project starting point regardless of the initiator.	Standardisation of project components		2.989
X_8 ease of use	Sharing existing knowledge and experience with other project team members.	Stakeholder co-creation	II	3.337
X_9 ease of use	Defining the project as a profitable business venture or a strategic alliance.	Stakeholder co-creation		**2.573**
X_{10} ease of use	Incorporating legal advice into the health technology's design.	Legal considerations for project components		2.685
X_{11} ease of use	Incorporating legal advice into the project's implementation strategy.	Legal considerations for project components		2.831
X_{12} ease of use	Assigning standardised tasks to individual team members.	Standardisation of project components		3.236
X_{13} ease of use	Identifying team members' capabilities using standardised criteria.	Standardisation of project components		3.326
X_{14} ease of use	Screening the infrastructure components of the project's intended environment and categorizing available and missing components.	Project implementation methods		3.034
X_{15} ease of use	Selecting infrastructure mitigation practices from a standardised list.	Project implementation methods		2.775
X_{16} ease of use	Identifying tailor-made solutions for missing infrastructure components.	Project implementation methods		2.685
X_{17} ease of use	Allowing end-users to participate in the project's creation and implementation.	Stakeholder co-creation	III	3.191
X_{18} ease of use	Implementing a joint venture project between two or more stakeholders.	Project implementation methods		2.708
X_{19} ease of use	Using a standardised tool to periodically review the project.	Project evaluation procedures		3.270
X_{20} ease of use	Constructing a prototype of the technology to improve adoption among end-users.	Adoption and sustainability		2.629
X_{21} ease of use	Incorporating and incentivising early adopters into the project team.	Adoption and sustainability		2.854
X_{22} ease of use	Routinely evaluating team members and removing members with limited future use for the project.	Technology transfer team	IV	**2.562**

X_{23} ease of use	Implementing and maintaining a communication channel between all stakeholders throughout the project	Standardisation of project components		2.933
X_{24} ease of use	Constructing training methods based on the user's existing internal training policies.	Training methods for the technology		3.135
X_{25} ease of use	Implementing on-site training.	Training methods for the technology		3.483
X_{26} ease of use	Training end-users to train future users of the project.	Training methods for the technology		3.124
X_{27} ease of use	Identifying end-users' capabilities and constructing training programs accordingly.	Training methods for the technology		3.000
X_{28} ease of use	Recruiting ground-level members to champion the project's adoption or diffusion.	Adoption and sustainability		2.876
X_{29} ease of use	Documenting all project outcomes into standardised tables.	Standardisation of project components		2.787
X_{30} ease of use	Allowing future projects to access documentation of completed projects.	Standardisation of project components		3.135
X_{31} ease of use	Compiling project feedback from multiple stakeholder perspectives into a standardised table.	Project evaluation procedures		3.022
X_{32} ease of use	Using standardised evaluation criteria for the final project revision.	Project evaluation procedures	V	3.472
X_{33} ease of use	Allowing future projects access to revision documents of completed projects.	Project evaluation procedures		3.180
X_{34} ease of use	Marketing the project to additional public-sector stakeholders, not in the original team.	Marketing		2.921
X_{35} ease of use	Marketing the project to additional private sector stakeholders, not in the original team.	Marketing		2.618

Table F-7 - Mean analysis data summary for usefulness

Usefulness				
Indicators	**Managerial best practices**	**Foundation**	**Phase**	**$\bar{x}$**
X_1 usefulness	Conducting preliminary screening of the project recipient and donor's abilities in order to allocate initial tasks.	Technology transfer team	I	4.337
X_2 usefulness	Constructing a dedicated project team from the project recipient, donor and additional stakeholders.	Technology transfer team		4.382
X_3 usefulness	Implementing a managerial hierarchy within this team, i.e. where all team members, except one, is supervised and directly managed by another.	Technology transfer team		3.910
X_4 usefulness	Outlining a monetary incentive scheme for team members.	Technology transfer team		**3.157**
X_5 usefulness	Outlining a non-monetary incentive scheme for team members.	Technology transfer team		3.551
X_6 usefulness	Legally binding the technology donor to the technology transfer over its entire life-cycle.	Legal considerations for project components		3.607
X_7 usefulness	Creating a universal project starting point regardless of the initiator.	Standardisation of project components		3.584
X_8 usefulness	Sharing existing knowledge and experience with other project team members.	Stakeholder co-creation	II	4.539
X_9 usefulness	Defining the project as a profitable business venture or a strategic alliance.	Stakeholder co-creation		**3.416**
X_{10} usefulness	Incorporating legal advice into the health technology's design.	Legal considerations for project components		3.573
X_{11} usefulness	Incorporating legal advice into the project's implementation strategy.	Legal considerations for project components		3.708
X_{12} usefulness	Assigning standardised tasks to individual team members.	Standardisation of project components		3.854
X_{13} usefulness	Identifying team members' capabilities using standardised criteria.	Standardisation of project components		4.315
X_{14} usefulness	Screening the infrastructure components of the project's intended environment and categorizing available and missing components.	Project implementation methods		4.112
X_{15} usefulness	Selecting infrastructure mitigation practices from a standardised list.	Project implementation methods		**3.416**
X_{16} usefulness	Identifying tailor-made solutions for missing infrastructure components.	Project implementation methods		3.506
X_{17} usefulness	Allowing end-users to participate in the project's creation and implementation.	Stakeholder co-creation	III	4.573
X_{18} usefulness	Implementing a joint venture project between two or more stakeholders.	Project implementation methods		4.022
X_{19} usefulness	Using a standardised tool to periodically review the project.	Project evaluation procedures		4.258
X_{20} usefulness	Constructing a prototype of the technology to improve adoption among end-users.	Adoption and sustainability		4.225
X_{21} usefulness	Incorporating and incentivising early adopters into the project team.	Adoption and sustainability		4.090
X_{22} usefulness	Routinely evaluating team members and removing members with limited future use for the project.	Technology transfer team	IV	3.697
X_{23} usefulness	Implementing and maintaining a communication channel between all stakeholders throughout the project	Standardisation of project components		4.584
X_{24} usefulness	Constructing training methods based on the user's existing internal training policies.	Training methods for the technology		4.067

X_{25} usefulness	Implementing on-site training.	Training methods for the technology		4.472
X_{26} usefulness	Training end-users to train future users of the project.	Training methods for the technology		4.315
X_{27} usefulness	Identifying end-users' capabilities and constructing training programs accordingly.	Training methods for the technology		4.449
X_{28} usefulness	Recruiting ground-level members to champion the project's adoption or diffusion.	Adoption and sustainability		4.247
X_{29} usefulness	Documenting all project outcomes into standardised tables.	Standardisation of project components		4.112
X_{30} usefulness	Allowing future projects to access documentation of completed projects.	Standardisation of project components		4.135
X_{31} usefulness	Compiling project feedback from multiple stakeholder perspectives into a standardised table.	Project evaluation procedures		4.191
X_{32} usefulness	Using standardised evaluation criteria for the final project revision.	Project evaluation procedures		4.045
X_{33} usefulness	Allowing future projects access to revision documents of completed projects.	Project evaluation procedures		4.169
X_{34} usefulness	Marketing the project to additional public-sector stakeholders, not in the original team.	Marketing		3.944
X_{35} usefulness	Marketing the project to additional private sector stakeholders, not in the original team.	Marketing		3.730

F.12 Content validity of latent variables

Table F-8 - Content validity overview of latent variables

Latent variable	Node	Content validity overview
Phase I: Technology development	The technology donor	The technology donor should dedicate the maximum available personnel capable of TT facilitation, transfer object training and stakeholder communication, keeping in mind that the number of required personnel is positively correlated with the scale of the TT. However, if the technology donor possesses codified knowledge of previous transfers of a similar nature and their current technology development and TT experience is substantial, the number of personnel required will be substantially reduced. The technology donor is encouraged to explicitly state the manner and totality of their legal ownership of the technology to the entire TT team as well as the intended alterations to this legal ownership after the TT has been completed. Lastly, the technology donor should attempt to identifying their political and social constraints as well as evaluating how these constraints may restrict their ability to perform the proposed TT.
	The technology recipient	It will be highly beneficial to the latter stages of the TT if the economic scale of the technology recipient as well as their available resources, that could sustainably be committed to the transfer, have been documented. Additionally, capturing the technology recipient's current experience surrounding TTs and access to codified knowledge of previous transfers of a similar nature, will be imperative when assigning stakeholder roles in the transfer method application phase of this framework. Lastly, the technology recipient should take care evaluating the opportunity cost of the all potential TTs, both ensuring the correct TT is chosen and that any potential TT will not present a substantial business risk to the technology recipients normal operations.
	The transfer object	The TT team must consider the following aspects of the technology being transferred: - The transfer object's maturity and total useful life. - The systems, if any, within which the transfer object functions. - The sub-systems required, if any, for the transfer object to effectively operate. - The transfer object's legal protection. - The technological complexity of the transfer object in terms of ease of manufacturing, utilisation, modification and maintenance.
	The co-creation TT team	Both the technology recipient and donor should explicitly regard the TT as a business venture and a strategic alliance and should construct and implement protocols which ensure the creation of a joint pool of knowledge surrounding the technology transferred. Additionally, a dedicated incentive scheme should be implemented that involves both monetary and intangible rewards and managers are encouraged to motivate the TT team through advertising previous successes. Finally, complete co-creation typically occurs when both stakeholders directly influence the technology's primary characteristics and features.
Phase 2: Technology analysis	Stakeholder collocation	It will be imperative to the TT venture that a funding plan be created, and it must be routinely updated. Each stakeholder must be aware of this plan and the expected magnitude and duration of their individual contributions. The TT team must consider funding in conjunction with the transfer environment, infrastructure requirements and the technology's characteristic to establish a detailed budget. A list must be populated of health-specific requirements, separate of the general TT requirements, for use in the screening of the transfer environment and subsequent evaluation. Finally, an individual within the TT team must explicitly be appointed as the public liaison. This party should ultimately be knowledgeable on the public sector's general procedures and health-related policies. If such an individual does not exist within the TT team third party consultation must be incorporated. The public liaison is encouraged to populate a list of TT requirements that can only be overcome with aid of the public sector.
	The transfer environment	The TT team should consist of personnel capable of analysing the transfer environment from multiple perspectives such as economic, social, cultural and political viewpoints. When feasible, designated personnel must be assigned to the evaluation of the transfer environment's market demand and requirements, healthcare system, public sector and the applicable transfer object supply chain. If possible, the framework recommends these evaluations be assigned to personnel with experience in these respective fields. Specific emphasis must be placed on identifying market conditions as the appropriateness and marketability of the technology within the transfer environment. Additionally, the transfer environment and technology's considerations should be completed in conjunction with one another. Obstacles created by either may be overcome through alterations to the other. However, the framework determinately encourages the TT team to alter the technology whenever possible due to financial and time implications of transfer environment alterations.

	Hard infrastructure requirements	The TT team should attempt to access the international fibre cables running down the African East and West coast, such as the SEACOM cable. For landlocked countries, this will require government intervention and should be a priority for the public liaison role. Remote satellite internet access provides user with stable internet access but requires high capital expenditure and may only be feasible when a multi-national has been incorporated as a stakeholder. Offline data capture allows users to complete tasks with basic computer or stationary equipment which can in turn be transmitted when internet access or telecommunication becomes available. This strategy may be implemented in rural areas after which the data could be transported to an urban centre with improved internet capabilities. For instances where the TT venture has been plagued by unstable electricity, implementing some form of back-up supply that can operate for short periods should be considered. Examples include an uninterrupted power supply, battery systems, fuel powered generators and even small scale solar panels. Inadequate healthcare infrastructure may represent a substantial barrier as it will typically fall outside of the transfer scope for most TT ventures. Altering the technology itself to operate with the available healthcare infrastructure may often constitute the most feasible solution. When the technology requires a select healthcare device or system to operate, the TT team should consider incorporating this sub-device into the overall TT venture. Thus, the technology will comprise of both the sub-device and main technology object.
	Soft infrastructure requirements	Lacking health-related education presents similar challenges when compared to lacking health-related hard infrastructure. As such, altering the technology itself to operate with the available health-related education may often constitute the most feasible solution. The framework also encourages the TT team to facilitate the dissemination of knowledge surrounding the technology thus inherently improving the health-related education of the domestic workforce. Additionally, the TT team should implement training programs irrespective of the current level of digital literacy in the transfer environment. These training programs should preferably be completed directly by personnel, however online training programs will be adequate for most cases. While these training programs may not be tailored specifically to the improvement of digital literacy, the TT team should include fundamental computer training for all TTs to developing nations. Lack of political transparency in the transfer environment may be mitigated through efforts by the TT team to incorporate domestic human rights groups currently active in the region. Similar attempts should be made to incorporate non-profit healthcare organisations when political transparency has been deemed an important transfer requirement. Lastly, when TT occurs across borders and involves multiple countries, the TT team must identify the most politically stable nation, with established legal frameworks, and utilize this country as the base for the TT to neighbouring regions.
Phase 3: **Transfer method application**	The TT method	The joint venture method is strongly recommended for all healthcare TTs. The domestic public sector must be incorporated into all TT activities. This becomes imperative when the scale of the transfer exceeds firm level. The public liaison should encourage governments to revise free trade policies and ICT and telecommunication infrastructure expansion in addition to the improvement of the digital literacy of the population. Similarly, investment from any source that can be relayed into the transfer environment's healthcare infrastructure will aid in the mitigation of health-related TT barriers in SSA. All small-scale transfers should be structured to ensure that scalability remains feasible. TTs that serve as pilot testing operations should have a predefined document depicting this proposed scaling process and the TT team is encouraged to conduct continual site visits during the transfer process. For health-related transfers, programs should be in place to stimulated community involvement and participation. Additionally, it is recommended that personnel from the transfer donor accompany the technology for a predetermined period. The TT team is also encouraged to present workshops that ensure all stakeholders will be trained to an equivalent level with regards to digital literacy before the TT progresses. Lastly, it will be imperative that the TT team acknowledge the gap between the technology's design and the transfer environment's reality.
	Stage-gate implementation	The TT team is encouraged to implement a stage-gate after the completion of the third phase of the TT when feasible. Multiple stage-gates throughout the TT is however not advisable due to the time and monetary constraints of these revision procedures. The TT must evaluate to following TT features to determine if the TT should be continued, revised or abandoned: - The co-creation team level - Stakeholders available to complete the required roles and responsibilities - Market conditions - Legality - Availability of infrastructure - Mitigation practices for lacking infrastructure - The chosen transfer method - The suitability off the technology and the transfer environment - The transfer method application strategy
Phase 4:	Technology recipient	After the technology recipient has taken possession of the technology, they should designate either an individual or a team to monitor and disseminate the technology throughout the technology recipient's establishment. This deputy should be clearly highlighted within the transferee's establishment and

Change management	change management	been given the authority to implement positive and negative incentive schemes focussed on increasing the transfer object's dissemination. This authority should liaison with the corresponding transfer donor entity, to determine their best practices for the technology's adoption. This authority should also be familiar with the technology recipient's previous TTs. A subsequent guideline, which highlights both successful and failed previous best practices, should be created. This authority will also be responsible for documenting current best practices for future use. When permittable, this authority should incorporate local stakeholders, within the immediate transfer environment, and spread all adoption best practices to promote the TT's dissemination. At this point of the transfer, the technology recipient should create codified documents which can be utilised in training sessions. Additionally, the transfer recipient should mandate training and educational sessions to all personnel in the transfer recipient's immediate sphere. Direct training should be utilized whenever possible and on-site demonstrations of the technology should be prioritised. The outcomes of these training sessions should be explicitly stated to all participants. Lastly, a formal revision protocol should also be created aimed at monitoring the technology's adoption rate and documenting identified adoption barriers.
	Technology donor change management	After the technology recipient has taken possession of transfer object, the primary change management best practise for the transfer donor should be to stimulate continual involvement in the TT. The transfer donor is thus encouraged to incorporate an incentive program which rewards the personnel based on their involvement. Incentives programs should range from monetary rewards, peer recognition and intangible personnel rewards such as public exposure. However, the amount of personnel committed to the TT by the transfer donor should be reduced, depending on the future requirements of the TT. The smaller active personnel base will in turn allow for simplified, and often more economical, incentive reward schemes. The transfer donor is strongly encouraged to create a channel aimed at providing transfer technology related assistance when required. This channel can range from a dedicated contact person to an active tool depending on the nature of the transfer object. This framework encourages the transfer donor hold formal training sessions for the transfer recipient as often as possible. On-site visits by transfer donor personnel will be highly advantageous to the technology's adoption in the transfer environment. If the transfer donor has already produced an internal training program surrounding the technology, it is recommended that an invitation be sent to the transfer recipient to attend these internal training programs either in person or electronically.
Phase 5: Commercialization	Evaluation of the TT impact	The evaluation of TT's impact is primarily to identify topic areas for which best practises can be refined for future TT ventures. It will also allow the TT team to evaluate the general success of the technology's introduction, adoption and integration. It is recommended that the following key areas should be evaluated: - The market impact of the technology - The addition to the public value in the transfer environment - The political implications of the TT - The addition to the human capital base in the transfer environment - The severity of the alterations required at the stage-gate feature - The addition to the economic development in the transfer environment - The opportunity cost for all stakeholders involved - The technology's improvement of the healthcare reach, cost and effectiveness of the transfer environment
	Sustainability of the TT	New stakeholders should be incorporated if they could be of potential benefit to the technology's dissemination. However, commercialisation will tend to lie outside the scope and expertise of the TT team. Thus, the TT team should actively incorporate a stakeholder knowledgeable in licensing and commercialisation activities. It will be the responsibility of the licensee to oversee the commercialisation activities surrounding the transfer object. However, the TT team should have established pre-defined legal terms to ensure the technology's future management aligns with the agenda of the original TT. The commercialisation of a health technology will generally be founded upon two primary business strategies. The technology can be presented to the end-user free of charge and be funded by marketing of the public value of the technology. Alternatively, the technology may be licensed, and service charges will apply to the end-user. However, the chosen business strategy will be case specific, and this framework does not promote one above the other. The licensee and TT team should however have a predefined business strategy before the transfer object's expansion may commence. The general marketing strategies should be tailored to technology in question as well as the business strategy chosen for the technology's commercialisation. It is however important for the TT team to distinguish between the end-user of the technology and the client who commissioned it. For health technologies these two entities will almost never be the same. When advertising to potential clients not involved in the creation of the technology, the marketing strategy should revolve around how the technology will solve the client's problem. How the technology will benefit the end-user, typically the patient, should not be prioritised over the client's priorities when dealing with isolated health practitioners. However, when advertising to the national public health sector, marketing of the patient's benefits should be prioritised over the health practitioner's benefits.

Appendix G - SUREC documentation

UNIVERSITEIT
STELLENBOSCH
UNIVERSITY

REC Humanities New Application Form

10 September 2017

Project number: ING-2017-1168

Project title: Constructing a framework that facilitates technology transfer to sub-Saharan Africa

Dear Mr Rian Marais

Your REC Humanities New Application Form submitted on 31 August 2017 was reviewed by the REC: Humanities and approved with stipulations.

Ethics approval period: 11 September 2017 - 10 September 020 REC STIPULATIONS:

The researcher may proceed with the envisaged research provided that the following stipulations, relevant to the approval of the project are adhered to or addressed.

Some of these stipulations may require your response. Where a response is required, you must respond to the REC within six

(6) months of the date of this letter. Your approval would expire automatically should your response not be received by the REC within 6 months of the date of this letter. If a response is required, please respond to the stipulations in a separate cover letter titled "Response to REC stipulations".

The researcher is required to remove the guide text from the informed consent form before it is presented to participants. The researcher is requested to submit the final version of the informed consent form to the REC for approval. [RESPONSE REQUIRED]

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

If the researcher deviates in any way from the proposal approved by the REC: Humanities, the researcher must notify the REC of these changes.

Please use your SU project number (ING-2017-1168) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

FOR CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD

Please note that a progress report should be submitted to the Research Ethics Committee: Humanities before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further year (if necessary)

If you have any questions or need further help, please contact the REC office at cgraham@sun.ac.za.

Sincerely, Clarissa Graham

REC Coordinator: Research Ethics Committee: Human Research (Humanities)

National Health Research Ethics Committee (NHREC) registration number: REC-050411-032.

The Research Ethics Committee: Humanities complies with the SA National Health Act No.61 2003 as it pertains to health research. In addition, this committee abides by the ethical norms and principles for research established by the Declaration of Helsinki (2013) and the Department of Health Guidelines for Ethical Research: Principles Structures and Processes (2nd Ed.) 2015. Annually a number of projects may be selected randomly for an external audit.

UNIVERSITEIT
STELLENBOSCH
UNIVERSITY

REC Humanities New Application Form

6 August 2018

Project number: ING-2018-7493

Project title: Technology transfer healthcare survey in sub-Saharan Africa

Dear Mr Rian Marais

Your REC Humanities New Application Form submitted on 29 June 2018 was reviewed by the REC: Humanities and approved with stipulations.

Ethics approval period:

Protocol approval date (Humanities)	Protocol expiration date (Humanities)
6 August 2018	5 August 2021

REC STIPULATIONS:

The researcher may proceed with the envisaged research provided that the following stipulations, relevant to the approval of the project are adhered to or addressed:

The researcher is reminded that permission must be obtained from Center For Health Market Innovations before data collection may commence. Proof of permission should be uploaded to this REC application once available. [ACTION REQUIRED]

The researcher is also asked to confirm that his data collection method is a questionnaire and not an interview (as indicated in section 7: Data collection Methods). [ACTION REQUIRED]

HOW TO RESPOND:

Some of these stipulations may require your response. Where a response is required, you must respond to the REC within six

(6) months of the date of this letter. Your approval would expire automatically should your response not be received by the REC within 6 months of the date of this letter.

Your response (and all changes requested) must be done directly on the electronic application form on the Infonetica system: https://applyethics.sun.ac.za/Project/Index/9261

Where revision to supporting documents is required, please ensure that you replace all outdated documents on your application form with the revised versions. Please respond to the stipulations in a separate cover letter titled "Response to REC stipulations" and attach the cover letter in the section Additional Information and Documents.

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

If the researcher deviates in any way from the proposal approved by the REC: Humanities, the researcher must notify the REC of these changes.

Please use your SU project number (7493) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

FOR CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD

Please note that a progress report should be submitted to the Research Ethics Committee: Humanities before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further year (if necessary)

If you haveany questions or need further help, please contact the REC office at cgraham@sun.ac.za.

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Investigator Responsibilities
Protection of Human Research Participants

Some of the general responsibilities investigators have when conducting research involving human participants are listed below:

1. Conducting the Research. You are responsible for making sure that the research is conducted according to the REC approved research protocol. You are also responsible for the actions of all your co-investigators and research staff involved with this research. You must also ensure that the research is conducted within the standards of your field of research.
2. Participant Enrollment. You may not recruit or enrol participants prior to the REC approval date or after the expiration date of REC approval. All recruitment materials for any form of media must be approved by the REC prior to their use.
3. Informed Consent. You are responsible for obtaining and documenting effective informed consent using only the REC-approved consent documents/process, and for ensuring that no human participants are involved in research prior to obtaining their informed consent. Please give all participants copies of the signed informed consent documents. Keep the originals in your secured research files for at least five (5) years.
4. Continuing Review.The REC must review and approve all REC-approved research proposals at intervals appropriate to the degree of risk but not less than once per year. There is no grace period. Prior to the date on which the REC approval of the research expires, it is your responsibility to submit the progress report in a timely fashion to ensure a lapse in REC approval does not occur. If REC approval of your research lapses, you must stop new participant enrollment, and contact the REC office immediately.
5. Amendments and Changes.If you wish to amend or change any aspect of your research (such as research design, interventions or procedures, participant population, informed consent document, instruments, surveys or recruiting material), you must submit the amendment to the REC for review using the current Amendment Form. You may not initiate any amendments or changes to your research without first obtaining written REC review and approval. The only exception is when it is necessary to eliminate apparent immediate hazards to participants and the REC should be immediately informed of this necessity.
6. Adverse or Unanticipated Events.Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research-related injuries, occurring at this institution or at other performance sites must be reported to Malene Fouche within five (5) days of discovery of the incident. You must also report any instances of serious or continuing problems, or non-compliance with the RECs requirements for protecting human research participants. The only exception to this policy is that the death of a research participant must be reported in accordance with the Stellenbosch University Research Ethics Committee Standard Operating Procedures. All reportable events should be submitted to the REC using the Serious Adverse Event Report Form.
7. Research Record Keeping. You must keep the following research-related records, at a minimum, in a secure location for a minimum of five years: the REC approved research proposal and all amendments; all informed consent documents; recruiting materials; continuing review reports; adverse or unanticipated events; and all correspondence from the REC
8. Provision of Counselling or emergency support. When a dedicated counsellor or psychologist provides support to a participant without prior REC review and approval, to the extent permitted by law, such activities will not be recognised as research nor the data used in support of research. Such cases should be indicated in the progress report or final report.
9. Final reports. When you have completed (no further participant enrollment, interactions or interventions) or stopped work on your research, you must submit a Final Report to the REC.
10. On-Site Evaluations, Inspections, or Audits. If you are notified that your research will be reviewed or audited by the sponsor or any other external agency or any internal group, you must inform the REC immediately of the impending audit/evaluation.
11.