A Logistic Regression Analysis Model for Predicting the Success of Computer Networking Projects in Zimbabwe

By

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Abstract

Information and communication technology (ICT) greatly influence today's business processes be it in public or private sectors. Everything that is done in business requires ICT in one way or the other. Research in ICTs is therefore critical. So much research was and is still carried out in projects that develop or enhance ICT but it is still apparent that the success rate of these projects is still very low. The extensive coverage of ICTs implies that if the success rate is still that low, many resources are being wasted in the failed projects; therefore, more research is needed to improve the success rate. Previous research has focussed on factors which are critical for the success of ICT projects, assuming that all ICT projects are the same. As a result, literature is full of different suggestions and guidelines of the factors critical to ICT projects' success. This scenario brings challenges to project managers who end up using their own personal judgement to select which factors to consider for any project at hand. The end result is the high failure rate of ICT projects since there is a very high chance of applying the same critical success factors to different types of ICT projects. This research answered the question: which factors are critical to the success of computer networking projects in Zimbabwe and how these factors could be used for building a model that determines in advance the success of such projects?

Literature reviewed indicated that most CSFs were not focused on specific types of ICT projects, hence were generalised. No literature was found on ICT projects' CSFs in Zimbabwe. More so, no CSFs were found for computer networking projects as a specific instance of ICT projects. No model existed that predicts computer networking projects' success. This study addressed the gaps by developing a CSF framework for ICT projects in Zimbabwe, determining CSFs for computer networking projects in Zimbabwe and the development of a logistic regression analysis model to predict computer networking projects' success in Zimbabwe.

Data was collected in Zimbabwe using a unique three-staged process which comprise meta-synthesis analysis, questionnaire and interviews. The study was motivated by the fact that most available research focused on CSFs for general ICT projects and that no research was found on CSFs influencing projects in computer networking. Meta-synthesis analysis was therefore conducted on literature in order to identify CSFs as given in literature. The approach was appropriate since the researcher had noticed that there were extensive ICT projects' CSFs and that no such research has been carried out in Zimbabwe.

These CSFs formed the basis for the determination (using a questionnaire) of ICT projects CSFs for Zimbabwe in particular. Project practitioners' viewpoints were sought through questionnaires. Once CSFs for ICT projects in Zimbabwe were determined, they formed the basis for the determination of unique critical success factors for computer networking projects in Zimbabwe. Interviews were used to get further information that would have been left out by questionnaires. The interview questions were set to clarify some unclear or conflicting responses from the questionnaire and providing in-depth insights into the factors critical to computer networking projects in Zimbabwe. The data i.e. critical success factors for computer networking projects guided the development of the logistic regression analysis model for the prediction of computer networking projects' success in Zimbabwe.

Data analysis from the questionnaire was analysed using SPSS Version 23.0. Factor analysis and principal component analysis were some of the techniques used in the analysis. Interview data was analysed through NVivo Version 10.0. From the results it was deduced that factors critical to ICT project management in Zimbabwe were closely related to those found in the literature.

The only apparent difference was that CSFs for ICT projects in Zimbabwe were more specific thereby enhancing their applicability. Computer networking projects had fewer CSFs than general ICT projects. In addition, CSFs for general ICT projects were different from those critical to computer networking projects in Zimbabwe.

The development of a comprehensive set of general ICT projects' CSFs was the first contribution of this study. This was achieved through meta-synthesis analysis. The other contribution was the development of a CSF framework for ICT projects specific to Zimbabwe and those specific to computer networking projects in Zimbabwe. The major contribution was the development of the logistic regression analysis model that predicts computer networking projects' success in Zimbabwe. These contributions will provide literature on ICT project management in Zimbabwe which will subsequently assist ICT project managers to concentrate on specific factors. The developed prediction model can be used by project managers to determine possible success or failure of ICT projects; thereby possible reducing wastage of resources.

Keywords

Computer networking project; critical success factor; logistic regression analysis model; project success; prediction; meta-synthesis; ICT project; success criteria; principal component analysis; factor analysis.

Declaration

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I declare that the **Logistic Regression Analysis Model for Predicting the Success of Computer Networking Projects in Zimbabwe** is my own work and that all the sources used have been acknowledged and included in the reference list.

This work was not previously submitted, in full or in part, for examination at UNISA for any other qualification or at any other institution.

(T. Masamha) Date: 11 February 2020

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Dedication

This thesis is dedicated to my elder brother Chamunorwa Masamha who selflessly afforded me the opportunity to get this far despite the fact that no one was there for him when he needed the same support. My dear brother I sincerely salute you.

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Acronyms

APM	Association of project management
AU	African Union
CASP	Critical appraisal skills programme
CFA	Confirmatory factor analysis
CHAOS	Comprehensive human appraisal for originating software
CPM	Critical path method
CSF	Critical success factor
DBMS	Database management systems
EFA	Exploratory factor analysis
ERP	Enterprise resource planning
FA	Factor analysis
ICT4D	Information and communication technology for development
ICT	Information communication technology
IDBZ	Infrastructure development bank of Zimbabwe
IRBMS	Integrated results based management system
IS	Information Systems
IT	Information technology
KMO	Kaiser-Meyer-Olkin
KS	Kolmogorov–Smirnov
PERT	Project evaluation and review technique
POTRAZ	Posts and Telecommunications Regulation Authority of Zimbabwe
PMBOK	Project management body of knowledge
PMIZ	Project Management in Zimbabwe
PMSA	Project management of South Africa
PSIP	Public sector investment programme
PSIS	Project investment success
PSMS	Project management success
PSOS	Project ownership success
ROC	Receiver Operating Characteristics
SADC	Southern Africa Development community
SEM	Structural equation modelling
STARLITE	Sampling Strategy, Type of Study, Approaches, Range of years, Limits, Inclusion and exclusion, Terms used in the search and electronic sources used.
USD	United States Dollar
ZINWA	Zimbabwe National Water Authority

Publications from the thesis

1. Masamha, T and Mnkandla, E (2017). Logistic regression analysis of information and communication technology projects: a focus on computer networking projects. IEEE AFRICON 2017 Conference (Cape Town, South Africa).
2. Masamha, T and Mnkandla, E (2017). Mathematical modelling of critical success factors for the management of computer networking projects using logistic regression analysis. SAICSIT M & D Symposium. (Black Mountain, South Africa).

Chapter one: Introduction

1.0 Introduction

Chapter one specifies a summary of the entire research study. It provides the background to the problem, statement of the problem, research questions the researcher set to answer, objectives of the study, importance, threats to validity, ethical considerations of the research study and trustworthiness of the research finding. The chapter ends with a presentation of the chapters in the thesis.

1.1 Background

Information and communication technology (ICT) has brought a new look to the world (Taylor 2015). The most notable change is in data storage, sharing and communication through computer networks. This phenomenon has rendered ICT projects a critical aspect of the project management fraternity.

Literature on ICT project management was centred on ICT projects in general or software-related projects (Ram & Corkingdale, 2014; Ram, Corkingdale & Wu Mong-Lu, 2013; Verburg, Bosch-Sijtsema & Vartiainen, 2013; Ziemba & Oblak, 2013; Ahmad & Cuenca, 2013; Zhang, Kornov & Christensen, 2013; Nethathe, Van Waveren & Chan, 2011). There was no literature on computer networking project management. This research began by reviewing literature on ICT project management in general and used meta-synthesis analysis to build a framework of CSFs for ICT projects in general.

Every aspect of life today is influenced by information and communication technologies (ICTs) in one way or the other (Nawi, Rahman & Ibrahim 2013). This phenomenon renders ICT projects pivotal in modern day research. A project is a means of responding to problems and opportunities found in human life and is carried out in a unique environment (Milis 2002). This suggests that ICT projects, if managed properly, improve livelihoods in many aspects. Responding to business problems and new opportunities in the form of projects can improve, productivity. Therefore, ICT becomes one of the main drivers for the success of modern businesses or enterprises. In other words, ICTs influence many processes in today's private and government sectors of the economy (Ommar, Bass & Lowit 2014: 4).

ICT projects centre on software as their main artefact, therefore, their characteristics are influenced by the properties of software. Software is intangible and controls all ICT systems and gadgets, be it an embedded system, computer network, database, website etc. (Lehtinen, Mantyla, Vanhanen, Itkonen & Lassenius 2014:628). As compared to all other types of projects, ICT projects have increased complexity (Montequin, Cousillas, Ortega & Villanueva 2016:19) and teams that work on them are temporal in their existence with members having few shared experiences, knowledge bases and routines (Reich, Gemino & Sauer 2012).

ICTs have found their way into virtually all human endeavours and in some cases they are embedded in quite a number of gadgets. They offer opportunities that transform livelihoods through increased productivity, competition, economic growth, reducing poverty and creating wealth as well as improving the knowledge economy (Nawi, Rahman & Ibrahim 2013:23). Academics, policy makers and business directors recognise that it is necessary to invest meaningfully in ICTs to gain competitive advantage for organisations and economies to meet their objectives in the global environment (Taylor 2015:4). In recent years, the application of computer systems and internet service (computer networks) have grown rapidly and exponentially. For a stable usage environment, internet service providers have to guarantee that the computer system retains a good quality of service and satisfies their customer needs all the time (Lin & Chang 2012). Attention, therefore, must be paid to improving ICT projects' success rates such that they meet targeted public and private strategic objectives towards effective service delivery (Nawi, Rahman & Ibrahim 2013:8). Technology has great influence in today's business environment that is characterised by competition and it provides direction to businesses (Taylor 2015:16). Therefore, more effort needs to be put in the management of ICT projects (O'Sheedy 2012:34). The researcher was motivated by the fact that ICT projects are an important ingredient to the success of modern business specifically computer networking projects.

Klastonrin (2004) views a project as a finite group of activities that must all be carried out in an effort to achieve set goals. A set of defined activities entails that a project needs a systematic approach to its management i.e. systematic project management. In line with the need for systematic project management, Hall (2012:1) notes a 1000% growth in project management membership in the 15 years leading to 2012. He attributes this growth to the proliferation of a variety of new business systems and processes that are themselves projects. In Zimbabwe, Mbindi (2016) notes that the level of project management training is growing, though slowly.

Modern projects are different from traditional ones in terms of their character with examples in engineering and construction necessitating the development of new techniques to manage the projects (Hall 2012:130). Traditional projects were deterministic whilst modern ones are non-deterministic (Hall 2012:139). Projects therefore, are rendered difficult in terms of scheduling and budgeting. Modern projects lack transparency about their progress and have very short durations especially those that are technology based (Caliste 2012).

It must be noted that the project process does not always proceed as initially planned (Caliste 2012:2). Project management is more difficult due to competition, shortened product useful lives, limited finances, new and emergent systems, international projects and teams (Hall 2012:140). The achievement of any project relies on its scope, duration and cost. However, there is no common agreement on the meaning of project success (Bannerman 2008; Pinto & Slevin 1988; Mohagheghi & Jorgensen 2017; Covarec 2012). According to Milis (2002) and Williams (2016) a successful project, on the one hand, is one that is timeously conveyed, according to the available finances and meeting all set objectives. Conversely, project failure is a notable flop to meet the targeted cost, time line, and worthiness of the project (Lehtinen et al. 2014:624). Williams (2016) notes that a challenged project is the one that has failed in some aspect e.g. not meeting the time constraint, outside the constraint of the budget or with some missing functionality. A project fails if it never gets to completion due to one or more factors and is totally abandoned. It should be noted that challenged projects get to completion and are functional but because they lack in one way or the other, the projects are neither considered to have succeeded nor failed (Mohagheghi & Jorgensen 2017).

The majority of studies on ICT projects simply use the umbrella term ICT without focusing on the individual types of ICT projects. The question was whether computer networking projects' CSFs were similar to other ICT project types e.g. software development or systems upgrade projects. In the same light, Shenhar & Dvir (2004) observe an illusion in project management that 'a project is a project' suggesting the use of same tools to manage all types of project. Successful implementation of ICT projects is predicated on factors which are more influential (critical) (Ugwu 2007). In addition, ICT projects were observed to have a high failure rate partly due to inappropriate or insufficient project design or management (Macapagal 2010).

Despite all these arguments, minimal research focuses on establishing and evaluating ICT projects' CSFs in the third world countries including Zimbabwe (Atsu, Andoh-Baidoo, Osatuyi

& Amoko-Gyampah 2009). In this study, the researcher established many CSFs for ICT projects from literature. Meta-synthesis analysis was then employed to identify common CSFs from various researches (chapter four). The identified CSFs from meta-synthesis analysis were used to develop a questionnaire to ask ICT experts in Zimbabwe on the factors critical to their ICT and computer networking projects. The identified CSFs for computer networking projects laid the foundation for the development of the logistic regression analysis model that predicts computer networking projects' success.

The researcher noted that mathematical modelling techniques including logistic regression analysis were used with success in other fields of study for different purposes e.g. business failure prediction (Jardin (2015); Chen (2015); Wu (2010); software projects (Hu et al. 2015); Cerpa, Bardeen, Astudillo and Verner (2016); project management (Matthew, Shahadat & Lynn (2016); Sebestyen (2017); in health (Santos, Santos, Tavares & Varajao 2014). No mathematical model was found in literature to model the management of computer networking projects. It was, therefore, part of the study to build a logistic regression analysis model to predict computer networking projects' success. The fact that no researcher has tried to isolate the management factors critical to computer networking projects and that no model exists to predict their success provided the impetus for this research.

1.2 Problem statement

Research on critical success factors for information and communication technology (ICT) projects in the past decade mainly focus on ICT projects in general (Ram & Corkingdale, 2014; Ram, Corkingdale & Wu Mong-Lu, 2013; Verburg, Bosch-Sijtsema & Vartiainen, 2013; Ziemba & Oblak, 2013; Ahmad & Cuenca, 2013; Zhang, Kornov & Christensen, 2013; Nethathe, Van Waveren & Chan, 2011). Previous research has focussed on the failure or success of ICT projects. Different researchers isolated different sets of factors critical to the performance of projects. The problem with the resultant lists is that they do not specify the type of ICT project seemingly assuming that all ICT projects are the same. In reality there are many different types.

The types include software development, hardware development, systems development and installations, software upgrades, computer networking, database development, commercial off the shelf system acquisition and cybercrime prevention systems (Tichapondwa & Tichapondwa 2009). If ICT project managers were given the lists of critical success factors for ICT projects, how would they apply them in different types of ICT projects? It is possible that some critical success factors could be applied where they are not appropriate leading to poor performance of some of the projects. This study is a step towards developing insights into taxonomising critical success factors according to ICT project type and building a prediction model that predicts the success of computer networking projects in Zimbabwe since no such model was found in the literature.

1.3 Research aim

The research was aimed at building a logistic regression analysis model that predicts computer networking projects' success in Zimbabwe.

1.4 Research Questions

These research questions gave direction to the study:

1. How can a framework for classifying ICT projects' critical success factors be developed?
2. Which are the important mathematical modelling techniques that are useful in developing a logistic regression analysis model for the prediction of computer networking projects' success?
3. Which mathematical simulation techniques are useful in building a logistic regression analysis model that can predict computer networking projects' success?
4. What is the suitable design for a mathematical model to predict the success of a computer networking project?
5. How do you develop a mathematical model that predicts computer networking project success?

1.5 Objectives of the research

The objectives of the research were to:

1. Build a framework for determining ICT projects' and computer networking projects' CSFs in Zimbabwe. The objective was implemented in a process of meta-synthesis analysis of literature, questionnaire administration and follow-up interviews. The questionnaire responses were analysed using SPSS version 23.0 and the interviews by NVivo version 10.0.
2. Examine the important mathematical modelling and simulation techniques useful in developing a logistic regression analysis model to predict computer networking

projects' success in Zimbabwe. This was done through the study of secondary sources of data that included text books and journal articles.

3. Explore suitable designs for a mathematical model that predicts computer networking projects' success. This objective was implemented through studying literature on mathematical modelling techniques and principles.
4. Develop a mathematical model that predicts computer networking projects' success. The objective was implemented using logistic regression analysis.
5. Test and evaluate the mathematical model built to predict the success of computer networking projects. This was achieved through the application of a deep neural network model developed using Python programming language and Jupyter Notebook.

1.6 Assumptions

In carrying out this research study, the researcher upheld the following assumptions:

- ICT projects' CSFs were well researched and documented but no study was done for specific types of ICT projects e.g. for computer networking projects.
- The solution to the project management problems rested with the stakeholders including the entire project team and the project owner.
- There is the need to identify specific CSFs for each type of ICT project if the success rates of these projects was to improve.
- Logistic regression analysis succeeded in many domains of study that include social and natural sciences, so it should also pay dividends in computer networking projects if carefully explored.

1.7 Threats to validity

In as much as care and effort are put in any work, some conditions always exist that limit the success or value of the work. The study was limited by the following:

- The study was limited to one African country. ICT project management practitioners who were respondents in determining CSFs for ICT projects in Zimbabwe were selected randomly. Data to test the usability of the developed model on real life projects were from four companies. The country was experiencing economic and political crisis at the time.
- The final model managed to correctly predict 62.5% of the projects. In addition, some predictions were marginal i.e. around 50 %. Such projects are tricky to handle since

they are likely to succeed or fail. The practitioners may have difficulties in handling them. Hence there is need to improve on this aspect.

- The real life projects on which the model was tested did not have recorded evidence of their success or failure. The stakeholders could have been biased in some cases.
- The country had some salient characteristics that made the results interesting to other African developing countries. By the time of the research the country was characterised by economic challenges. It had poor performance in major economic sectors e.g. mining, tourism and agriculture causing a 12.8% fall in the GDP in 2019 (World Bank 2020). Lack of electricity and foreign currency caused the economic down surge. In 2019 Cyclone Idai negatively impacted on agriculture coupled with prolonged drought and livestock diseases. In addition, currency shortages reduced the availability of agricultural inputs. The new local currency introduced in 2019 following the unpegging of the exchange rate from the USD eroded the exchange rate. As a result inflation rose to over two hundred percent (World Bank, Lloyds Bank 2020). The poverty level rose from twenty nine percent in 2018 to thirty four percent in 2019. This was necessitated by economic shrinkage and sharp rise in food and basic commodities' prices. The unemployment rate approached eighty percent in 2019 with a wide spread informal economy (Lloyds Bank 2020). The country's life expectancy reached close to sixty years in 2017 making it one of the lowest in the world (Lloyds Bank 2020).

These factors limited the generalisation of the model only to Zimbabwe and those African countries experiencing similar economic and political situations.

1.8 Ethical Considerations

Burton and Bartlett (2009) define ethics as proper moralities and values that direct how people perform their activities or tasks. Here the researcher describes what was done to govern the process of this research study. The researcher sought informed consent from the participants which he honoured throughout the study giving evidence that the researcher was obliged to protect the privacy and dignity of all concerned parties. (Knobel & Lankshear, 2004). In this research no names of people were recorded anywhere or by any means so as to protect the privacy of respondents.

The researcher made sure that for every inquiry that was done, permission to do so was obtained in writing from the relevant authorities or individuals. The researcher first obtained ethics clearance from UNISA (the degree awarding institution) according to the University Policy. After such permission was granted, consent was sought from the participants and documented. For the research to progress in a moral way, the researcher was given approval letters by the responsible authorities from which the participants were drawn. The permission letters ensured that no person was unlawfully taken to be part of the research. Everyone who consented to be a respondent in the data collection process read the consent documents after which he/she signed to indicate agreement to participate. A cover letter indicating that responses were to be used solely for academic research purposes accompanied all instruments distributed to respondents. Addresses and mobile phone numbers of the researcher and the supervisors were provided in case the participants want clarification or to ask questions. Participants were explicitly allowed to terminate their participation whenever they needed without any financial or negative implications. All in all no known/intentional harmful practices were exercised in this research.

The risk level was very low since the research did not involve animals, children or any vulnerable groups of people. Naming was strictly limited to pseudo names.

1.9 Integrity and quality of data

Data in any research need to demonstrate quality and integrity which leads to sound inferences from the research. Once the data is questionable, there is no way the results and conclusions of the research will be respected. Questionnaires and interviews together with literature search were the main means by which data was collected. Quantitative and qualitative approaches were also used to balance the data collection as well as analysis. The fact that different methodological aspects were used in the study in a complementary manner meant compensation in terms of weaknesses and shortfalls of each method (Flint, 2009). Different methods and techniques were therefore employed in this study for that same reason.

1.10 Informed purpose of the research

The study was purposed to:

- Add literature on CSFs notably those that relate to computer networking projects' success in Zimbabwe.
- Identify and model computer networking projects' CSFs leading to predicting the success of computer networking projects in Zimbabwe.
- Add new knowledge and insights in the ICT project management body of knowledge.

1.11 Trustworthiness and transferability

Credibility, transferability, dependability and objectivity/confirmability provides a means of measuring trustworthiness of a research study (Korstjens & Moser 2018; Anney 2014). The researcher made efforts to ensure that the study findings were credible, transferable, confirmable/objective and dependable. The following were ensured:

For credibility, the researcher used a unique three staged process of meta-synthesis analysis, questionnaire and interview process. Meta-synthesis analysis was used to determine CSFs for ICT projects from literature, the questionnaire and follow-up interviews were used to determine the CSFs for ICT projects and computer networking projects in Zimbabwe. The results were consistent indicating that the results were credible (Devault 2019; Moon, Brewer, Januchowski-Hartley & Adams 2016).

Transferability is the extent to which results obtained from a study can apply to different situations or environments (Forero et al. 2018; Anney 2014). The data collected for this research is found at:

https://www.dropbox.com/sh/4g4676nlmg0efg4/AABv1FC1nhQxT83zywUpWq0fa?dl=0

The researcher should be clear on the degree to which the research results can or cannot apply to other circumstances (Moon et al. 2016). However, a researcher cannot prove definitely that inferred results from data can be transferred but can only establish the likelihood (Devault 2019; Moon et al. 2016). For transferability, the researcher described the context, nature of the participants and the assumptions central to the research (Korstjens & Moser 2018; Anney 2014). The setting for the research was Zimbabwe which was characterised by economic turbulence at that time. The participants were ICT project practitioners and computer networking project practitioners drawn from different organisations in the country. It was assumed that participants had experience and knowledge in ICT and computer networking projects' management. The researcher ensured that the research findings applied to similar situations, contexts and circumstances by testing the model on real projects and via computer simulations (Korstjens & Moser2018; Forero et al. 2018; Anney 2014).

In qualitative research the assumption is that different researchers come up with different schools of thought to their respective fields of study (Devault 2019). It is critical that different researchers can replicate findings to show that those results were a product of independent research not conscious or unconscious bias (Devault 2019). For this research to be objective or confirmable, all the methods and tools were comprehensively documented. The researcher demonstrated how the conclusions were inferred from the research results in a manner that or replicated by providing a link for other researchers to rerun the developed model. The link directs the researchers to the link function, the logistic regression analysis model developed, all the data and tests done as well as the Python code developed. The essence was to ensure objectivity of the research results. For confirmability the researcher removed researcher bias by highlighting data analysis steps to provide a rationale for all the decisions made from the results. This indicated that findings accurately show the participants' responses (Shenton 2004; Anney 2014; Korstjens & Moser 2018).

Dependability refers to how consistent and reliable the research results were and the extent to which the research process was outlined giving room for the research to be repeated or critiqued (Moon et al. 2016). It is based on replicability or repeatability of that research (Moon et al. 2016). The question is whether or not to get the same findings when one replicates the same study. The thesis recorded the research path for dependability purposes (Korstjens & Moser 2018). The context of the research was Zimbabwe during an economic meltdown where the country had no currency of its own. It was using a bonded currency backed by the United States of America dollar (USD). Repeating this study in Zimbabwe in a changed economic atmosphere may produce slightly different results. Due to that reason, the same results could not be guaranteed if the same study were to be repeated in another country with a different economic climate. However, the researcher developed and validated a questionnaire that can be used in any setting for the same or similar studies. In addition, an interview guide was included in the thesis for replication purposes. The researcher documented the research methodology for the purposes of dependability and credibility of the study.

1.12 Thesis outline

Chapter one presents the introduction to the research. It includes the background to the research, problem statement, objectives and ethical considerations of the research. Chapter two discusses background work to the success of ICT projects and paves the way for success prediction in computer networking projects. Chapter three presents the methodology followed. Chapter four presents meta-synthesis analysis done to identify ICT projects' CSFs.

Chapter five outlines data collection and analysis. Chapter six presents the process employed in building the logistic regression analysis model that predicts computer networking projects' success. Chapter seven presents the simulations and validation done on the developed logistic regression analysis model to test its applicability in predicting the success of computer networking projects. Finally chapter eight presents an evaluation of the research. Conclusions were made from the research and future directions from the research were identified.

1.13 Chapter Summary

ICT is an important driver for the success of modern businesses or enterprises, therefore, it deserves serious research attention. A lot of work was done on the formulation of models for project management (Marques, Varjao, Sousa & Peres 2013; O'Sheedy 2012; Reich, Gemino & Sauer 2012; Jafari, Rezaeenour, Mazden & Hooshmandi 2011; Kukushkin & Zykov 2013). However, ICT projects were characterised by very low success rates and they continue to fail despite many studies carried out to address the situation. (Marques et al. 2013; CHAOS Report 2018). There is need for more work in developing better and more encompassing project management models. Previously much work was generalised to ICT projects' CSFs. The critical success factors were lists which could not be objectively applied to establish possible project success.

Chapter two: Literature review

2.0 Introduction

Here, work related to the current study was interrogated and documented. Topics reviewed include: why ICT projects deserve special attention in research, an exploration of mathematical modelling and simulation techniques, designing and development of mathematical models, ICT projects' CSFs, importance of effective management of ICT projects and their success or failure. The researcher sought to identify gaps in these aspects and pave way for a methodology to provide the means of closing those gaps. Gaps found from this chapter shaped the content of chapter three (methodology).

2.1 Why ICT projects deserve special attention

Information and Communication Technology (ICT) projects centre on software as their main artefact. These projects deserve special attention mainly due to the properties of software and their being important in today's daily life at home and at work. ICTs are a common place at home and in industry (Taylor 2015:4). In Zimbabwe for instance, there are three major cellular service providers, namely, Econet Wireless, TelOne and Telecel. The fact that currently (2020) the country is experiencing a cash crisis in its economy, with banks failing to issue cash to its clients, the cellular service providers developed platforms on which people access their bank accounts and make payments for goods and services. Econet Wireless, TelOne and Telecel developed Ecocash, OneWallet and Telecash respectively, to ease the cash problem. These systems are used in banks, educational institutions, flea markets, wholesale and retail shops, at home and even in the transport sector for paying bus or airfare. The platforms were designed and developed on computer networks, hence the need for research in the management of computer networking projects as part of ICT projects.

A computer networking project involves linking computer devices to share data and support digital communications. In addition it involves scaling hardware and software by giving seamless connection to highly mobile devices. In essence a computer network project aims at providing internet, intranet and extranet services and application. It suffices to differentiate a computer network from a Web Information System (WebiS). The later refers to software systems that run on top of the physical computer network infrastructures e.g. different forms of e-commerce systems. In this study a computer networking project comprise the design, development or upgrade of hardware devices that enable sharing of data and information among compute nodes connected through wired or wireless links.

This research involves prediction of computer networking projects' success. Reich et al. (2012) assert that ICT projects are worked on by teams which are temporal in their existence, members may have few shared experiences, knowledge bases and routines. Therefore, in the management of ICT projects, managers should realise that people working on a project have different experiences, knowledge and ways of doing things. Once heterogeneity is introduced in a project, there is great potential for failure unless adequate management principles are applied. The fact that the teams that work on a project are temporal by nature means that each project is unique. Despite differences in experiences and knowledge among the project team members, the researcher hypothesised that there exist common factors critical to the success of computer networking projects which are different from those commonly referred to in literature as ICT projects' CSFs. So far, literature reviewed did not have any critical success factors specific to computer networking projects.

Taylor (2015:39) identified benefits of ICT which include the following:

1. Provision of a distinctive competitive advantage to business. If an organisation does not use the ICT technologies it would definitely lose out since modern businesses are distributed across national boundaries.
2. Support for strategic thinking. ICTs with their data collection and analysis tools provide a strong base for strategic thinking that leads to concrete decisions.
3. Support for existing business strategies and shaping of new ones. ICTs help to enhance the already available business operations and pave way for the development of new strategies. In Zimbabwe, for example, the new ICT systems are helping people and organisations to carry out their usual business activities cashlessly. The result is convenience in doing business.
4. ICTs catalyse the creation of strategic differentiation and competitive advantage. The way an organisation embraces ICTs determine how it differs from the rest.
5. Since businesses are globalised, definitely an organisation that invests more in ICT is likely to have a competitive edge over others. Globalised business requires a robust network infrastructure for it to be successful.
6. ICTs facilitate effective integration of different business processes. Organisations can connect to their customers, suppliers, contractors and trading partners through a

network facility. The design and management of computer networks, therefore, enhances business activities.

7. ICTs and specifically computer networks, help to lower transaction and communication costs between firms. Transactions between firms (ordering, invoicing, payments etc.) are conveniently done at a lower cost with the use of computer networks. No communication can be done without a computer network, hence it is important to engage in research that improves the management of computer networking projects.

Reasons for ICT projects Failure

Factors that cause ICT projects to fail are many and varied (Ebad 2016). Kashiwagi (2014) identified the following as critical performance factors for ICT projects in agreement with Abbasi, Wajid, Iqbal and Zafar (2014):

1. Project planning
2. Project team's capability
3. Unclear project scope
4. Changing project scope
5. Support from senior management.

Ebad (2016:7) asserts that in general, management and organisational culture were the most critical factors in ICT projects. This agrees with Kashiwagi (2014) since all the identified factors fall under management. In Saudi Arabia ICT projects fail due to unclear scope, undefined risks, undefined stakeholders and communication (Ebad 2018:6). These factors are wholly managerial.

Examples of failed ICT projects

One to five billion Euros were wasted in the Netherlands due to ICT project failure (Kashiwagi 2014). In Nigeria over eleven thousand government projects were abandoned from 1971 to 2011 (Okereke 2017:2). The following are a few examples of failed projects:

1. The three hundred million Euro EPD Electronic File system in Netherlands.
2. In Australia the Power and Water Corporation project used over fifty million dollars instead of the expected fourteen million dollars (Kashiwagi 2014).
3. The attempt to replace legacy systems (in Australia) for managing the government's asset management systems was stopped after utilising $70 million (Kashiwagi 2014:15).

4. In the USA, California failed to merge thirteen payroll systems and lost over one billion dollars (Kashiwagi 2014). In addition, the USA government's online healthcare website originally pegged at ninety three million dollars finally consumed six hundred and thirty four million dollars (Kashiwagi 2014:16).
5. The Ghana STX Building project worth one billion dollars failed (Okereke 2017).
6. Egypt's Toshka failed (Okereke 2017).
7. The Microsoft digital villages failed. (Okereke 2017).

From these few examples it is clear that ICT project failure is common. It is therefore imperative for researchers to engage in more research to curb the failures.

In many aspects of business, computer networks play an important role. Many businesses operate with distant customers or trading partners, a situation that dictates the use of a computer network. ICT projects in their varied nature are, therefore, important and need special attention since they are unique and are a backbone to today's business operations.

2.2 Why the interest in computer networking projects

In this section, the researcher highlighted the concepts that portray the reasons why the research focused on computer networking projects. The importance and widespread use of computer networks was discussed. The section comprises communication networks and reliability, the risky nature of networking projects, the importance of computer networks in different fields, monitoring and disaster relief and the influence of technology on computer networks.

The fact that computing power is now everywhere and the prevalence of wired and wireless computer networks enhanced the importance of research in network reliability (Jiang & Hu 2010). A network consists of nodes and the nodes are not equivalent with some being more important than others (Minging & WuXuguang 2011). The researcher noted that for a computer network to be reliable, the planning, installation and upgrade of the network is the starting point. This study did not focus on network reliability per se, but the design, development and installation of a computer network as a project that needs careful management.

2.2.1 Communication networks and Network reliability

A communication network transports data and information between end users reliably and timeously (Neophyton, Stavrou, Vassilion & Pitsillides 2014). As discussed earlier (section 2.1), one of the benefits of ICT projects in business is the lowering of transaction and communication costs between firms. A computer network transmits transaction data from one firm to another and from firms to their customers. A computer network therefore is a collective unit whose services must not only be devoted to the sender and receiver but also many parties during its life span. Computer networks are usually complex. Complex networks have been a heated subject which has brought academics and industrialists to one common cause of research (Minging & WuXuguang 2011). If a project destined to fail is mistakenly perceived as a success or simply not known in advance, the corresponding losses may be immense and irrevocable despite injection of substantial resources, which is indisputably costlier (Hu et al. 2015). This justifies the need for prediction systems.

Minging and WuXuguang (2011) studied the evaluation of node importance in complex networks. They note that a computer network is made up of nodes which do not have the same importance, with some nodes being more important than others. The evaluation of nodes helps to expand the capability of the Internet against virus spasm, augments the strength of power grids etc. (Minging & WuXuguang 2011). From this study, the researcher noted that in a computer networking project, practitioners do not only connect and configure network devices so that they can communicate, but rather there is need to consider the network at node level in order to establish the role each node plays in the network (node evaluation). The process of node evaluation is in itself a computer networking project that requires careful management.

Once network node evaluation is completed, it is critical to consider how these nodes are linked together for effective communication. The links between network nodes have to be evaluated. In this regard, Jiang and Hu (2010) developed a link importance evaluation method built on network communication characteristics. They emphasised the significance of computer network reliability. Jain and Reddy (2013) researched on the importance, applications and advances of node criticality in wireless sensor networks. They noted that a wireless sensor network consists of a dispersed assortment of small resource constrained nodes that are proficient in sensing many types of stimuli from the surroundings (Jing & Hu 2010). Link evaluation is again a computer networking project that needs careful management. It should be emphasised that network nodes are distributed and resource constrained, hence, if not properly managed, the benefits from the network are reduced.

2.2.2 Risky nature of computer networking projects

Hu et al. (2015) note that software development is typically risky and that outsourced projects are exposed to more risk than in-house ones since they entail many different stakeholders. It is critical to point out that all computer networks are hardware and software-driven, and as such they share the same risk levels as software development projects. Preliminary research indicated that in many organisations, computer networks are usually executed by outsourced contractors since it is a highly specialised area. In that case it was hypothesised that computer networking projects are also risky hence require serious attention. From this perspective, the researcher established computer networking projects' CSFs. The identified CSFs formed the foundation of the developed model.

2.2.3 Importance of computer networks in different fields

Several researchers carried out research on computer networking including the importance of computer networks in other fields such as mining, network link importance, mobile networking issues as well as node evaluation in a computer network (Ding, Jing & Zhu 2014; Neophyton et al. 2014; Minging & WuXuguang 2011; Jiang & Hu 2010; Jain & Reddy 2013).

Ding, Jing and Zhu (2014) studied the importance of computer network technology in coal quality inspection. They noted that coal sampling was a function of sample collection, location, safety, time, quality and testing location. Without computer network technology, the collection of samples from various locations, their transportation to testing centres took much time, effort and money (Ding, Jing & Zhu 2014). Human errors were also introduced in the process. Under the support of computer network technology, coal inspection was done safely, there was automatic monitoring and accurate and complete coal detection (Ding, Jing & Zhu 2014). It is clear that computer networks improved the management of the whole process of coal inspection that included the collection of samples and their transportation to testing centres. In computer science and information systems, computer networking is a critical aspect that encompasses the importance of network links, mobile and distributed networks and node evaluation. In all other types of organisations, computer networks aid in effective and efficient sharing of data and information in the form of online advertisements, promotions, lectures, interviews, seminars and collaborations.

2.2.4 Monitoring and disaster relief

Wireless sensor networks evolved as a favourable technology for people to carry out many tasks like car assembling, monitoring children and the elderly, crime prevention, wildlife conservation and so on (Jiang & Hu 2010). As a distributed network, a wireless sensor network's main task is to economically gather data, manipulate it and then transmit the processed information to the anticipated users or base stations, for additional treatment or stored in harmony with the intended purposes (Jain & Reddy 2013). Computer networks of this nature can be used to sense and predict nature's mishaps in order to develop precautionary programmes. In Zimbabwe for instance, house breaking and unlawful entry in homes and shops pose a recurrent problem. Wireless sensor networks that detect and report intrusions are a necessity. This research, though it was not meant to study wireless sensor networks, was concerned with the prediction of success of all computer networking projects including these wireless sensor networks. No work was found in literature that focusses on the management of any type of computer networking projects, let alone the prediction of computer networking projects' success.

2.2.5 The influence of technology on computer networks

ICT may be viewed as an aggregation of all devices and processes used to gather data, store, retrieve, manipulate and disseminate data and information. The computer is the pivotal gadget in this whole process. Every ICT system comprises three main elements, viz., hardware, software and the user. It follows that ICT projects focus on hardware, software and the human element or a combination of these. All the different ICT projects (including software development, hardware development, systems development and installations, software upgrades, computer networking projects, database development, commercial off-the-shelf system acquisition and cyber security systems) fall within these categories. The ensuing sections highlight some hardware and software projects thereby developing a case for this research's focus on computer networking projects.

Mount et al. (2015) proposed a scalable design for an ion trap quantum computer. They argue that any ion trap quantum computer, and specifically the MUSIQC architecture, needs a variety of conventional hardware to energise quantum processes necessary for computation. The project entailed evolving from a small laboratory experiment to a full-fledged system. They presented a scalable hardware to accomplish some of the conventional processes necessary for an ion trap quantum computer. The processes included: continuous wave (CW) laser frequency locking and frequency stabilisation of pulsed laser beams for quantum logic gates (Mount et al. 2015). Each of these components was designed to be cheap, solid, and scalable to allow growth or replication in cases of bigger experiments. Of importance, the researcher noted that this kind of project was done in a laboratory setup and the product was a computer, which could either be used as a standalone computer or as part of a computer network. It was further noted that to bring about utility in the design, some software and human aspects need to be researched on to develop a complete and useful system. In the prevailing global business climate, the full benefits can only be enjoyed if these resources were networked, hence the essence of computer networking projects.

Speedy developments in present computing technologies provided greater usefulness and cost reduction to many fields to do with immense and data-intensive operations. Cloud computing as a unique concept of dispersed task processing was formed as a response to world-wide increasing accessibility and dwindling price-performance ratio of computing resources (Dolezal, Horning, Sobes Lav & Korabecny 2015). As discussed earlier in this research, computing technologies being synonymous with ICTs, are made up of hardware, software and the human element, for this reason, their advancement is through hardware, software and human factor projects. The interplay of these important elements is realised through networking - thus computer networking projects. Cloud computing described here by Dolezal et al. (2015:2) as a paradigm of distributed task processing can only accomplish the distribution if and only if the computing and storage nodes are interconnected, for this reason, there is need for computer networking projects. In Zimbabwe, for instance, there are data centres, for example, TelOne, strategically located in Harare with two backups in Mazowe and Bulawayo for institutional data management based on cloud computing. Organisations including universities, banks and different government departments rent space in these data centres. It was found to be both cheap and convenient for organisations to use these cloud computing services on rental basis.

At the centre of this infrastructure is computer networking otherwise pushing data into the remote centres and accessing it would be difficult and expensive. In addition to the extensive software cloud systems like Dropbox and office 365, crucial influence is probable to other areas that mandates scientific computation (Dolezal et al. 2015:2). The researcher noted that the application of cloud computing in itself is a computer networking issue. People should not be limited to emphasising research on the software and hardware sides of the technology, forgetting the computer networking aspect that makes virtualised technologies a reality. Despite the striking elasticity of cloud computing, a thought-provoking aspect is placing cloud computing at the same scale with High Performance Computing (HPC) which has gained popularity in the recent past (Dolezal et al. 2015). High performance computing (HPC) is a comprehensive technology for making huge and complex computations of persistent data, which may be originated from different places. HPC, just like cloud computing, includes hardware, software and the human factor sides which are driven and necessitated by computer networking.

A classical HPC solution uses computer clusters (Figure 2.1). Challenging computations primary to Virtual Screening in drug discovery had been accomplished mainly through old-fashioned computer clusters (Dolezal et al. 2015). Analogical architecture has been accepted by rationalised HPC resources which mainly comprise potent compute node sphere controlled by a front-server for task scheduling. The compute nodes in HPC structure are interconnected by high-speed network (Dolezal et al. 2015). Of note is the fact that in an HPC solution, a computer network is required to interconnect the different nodes (compute nodes, front-end server etc.). Infrastructure is normally connected to a high performance parallel file system e.g. Lustre for handling data (Dolezal et al. 2015:3). Task distribution, scheduling, queuing, controlling and monitoring over HPC clusters is coordinated by batch systems e.g. SGE.

HPC platforms are used for comprehensive computations provided by scientists and researchers. HPC clusters are compute nodes which normally are standard networked computers with at least one cluster management server (Dolezal et al. 2015:3). The researcher considered the development of an HPC itself as a computer networking project. It is clear that no node can provide a benefit unless a computer network provides a link between that node and the other requiring a service or services. Computing power is a function of the number of connected compute nodes, communication channels, quantity of data transferred and the capability of management computer nodes (Dolezal et al. 2015).

The researcher realised that compute nodes installation in an HPC environment, communication channels, and the capacity of the nodes all fundamentally define the functionality of a computer network. It therefore calls for better ways of managing computer networking projects if all these are to be beneficial to organisations. For an HPC cluster to run, it requires sufficient resources which can only be made available through a computer network. An organisation that utilises HPC infrastructure has to employ specialists for managing the infrastructure, software or hardware and their updates and upgrades. The development of the infrastructure, hardware and software updates and upgrades are all instances of networking projects, which need to be carefully managed for them to succeed.

Research in project management mostly deals with software projects and less is done specifically on the management of computer networking projects. Figure 2.1 shows the traditional computer cluster architecture (Dolezal et al. 2015). The server, router and the compute nodes on Figure 2.1 are all hardware components of the architecture. Further, the development and installation of these and other related components, not necessarily appearing in Figure 2.1, are hardware projects in the ICT domain. The intranet and the Internet shown in Figure 2.1 are software implementations in the architecture. They link communicating parties in a network without which no sharing of resources is possible in real time. The servers, routers and the compute nodes (Figure 2.1) are implemented as both hardware and software which means they can be managed as either hardware or software projects. What this means is that a server can be a specialised hardware equipment in a network infrastructure that is procured for that specific purpose. In a smaller network, any machine can be designated as a server provided it is configured as such. Most importantly, the researcher took the design, development, implementation, installation and upgrade of the entire system (Figure 2.1) as a computer networking project. In other words, it is through computer networking projects that the entire infrastructure brings value to the user community.

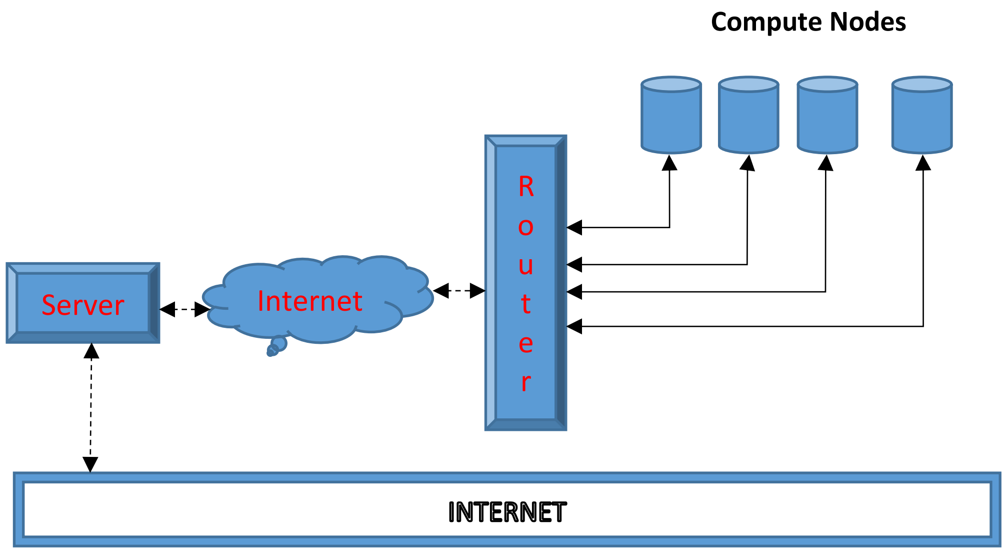


Figure 2. 1 Traditional computer cluster architecture

Nencini (2015:1) presented a prior art analysis on DYNAMAP monitoring network hardware systems and described DYNAMAP sensors' technical specifications. DYNAMAP was built as a prototype system for city councils and was built on pervasive and cheaper hardware for noise measurement as well as artificial intelligence algorithm to create real time noise maps automatically. A dynamic noise mapping system capable of detecting and representing in real time the acoustic effect due to road infrastructures was developed (Nencini 2015:1). The researcher managed to identify three basic facets of hardware, software and networking in DYNAMAP. Management of this type of project requires knowledge of software, hardware and computer networking project management. The low cost hardware network is both a computer hardware project and a computer networking project.

2.3 Distributed monitoring systems as examples of computer networking projects

The projects to be discussed in this section are examples of computer networking projects involving distributed monitoring systems as identified by Nencini (2015). Their discussion was aimed at showing how critical computer networking projects are in different spheres of organisational mandates.

SENSEable Pisa - This project began in 2011 aimed at interconnecting noise sensors accommodated at the residences of volunteers to produce a comprehensive acoustic image of the region in real time. The whole idea of the system was to provide security for the home. This project was similar to the installation of CCTV systems at premises so that intruders can be identified and reported in real time for action to be effected in time. Such systems improve on the recovery of stolen goods. The provision of real time data is very important in security systems especially from distributed environments in making crucial decisions. No matter how good the software used in the system, the system is of limited use if there is poor networking.

NoiseTube – The work was done at Sony Computer Science Lab in Paris. It proposed a collaborative process of checking noise pollution by including the public. The NoiseTube was a portable application that turned mobile phones into noise sensors that enabled people to measure the sound experience in their everyday life (Nencini 2015). This system was both a software project and a computer networking project. The NoiseTube itself was a mobile application, hence, its development was a software project. Deploying it to the community for the citizens to use and benefit was a networking project since the people do not stay in one place. The management of such systems requires that specific factors be taken into consideration if the entire project is to succeed.

Smart Citizens - Smart Citizens was a program used to produce collaborative developments by people in their respective cities (Nencini 2015). It did that by linking data, humans and knowledge. The goal of the program was to act as a node for building fruitful and open indicators, and dispersed tools, and later the collaborative building of the city for its occupants. Just like the Noise Tube, this system is a software platform whose development is a software project and its deployment is a networking project.

IDEA - The work focused specifically on environmental stressors having a very local character like fine particulate material and noise (Nencini 2015). The crucial purpose of IDEA was constructing a measurement network of cheaper sensors that used bio-stimulated intelligent applications to diminish the loss of worthy universal data. The project was heavily networking. The bio-inspired intelligent system was a software issue. Even if the sensor development, choice or upgrade was a hardware initiative and the bio-inspired intelligent systems and their upgrade were purely software, their deployment and installation was purely a networking issue. Therefore, the management of such projects requires paying attention to computer networking as a project.

Bartneck, Soucy, Fleuret & Sandoval (2015) developed the robotic engine (TRE) from Unity 3D Game Engine. From this robotic engine they developed the LEGO Fireman and InMoov.

Bartneck et al. (2015) noted that there existed many middle-ware software for robots e.g. the Robot Operating System. These structures provide libraries and tools to assist developers produce robot coordinated systems (Bartneck et al. 2015).

The TRE project had several components that included: The Main Script that managed the rest of the scripts, units and graphical user interface elements. It (de)activated units e.g. the computer vision unit. The Model Script managed the motorised components of the robot related to the Game Objects. The primary purpose of the Model Script was to change the absolute location of the Game Objects into the relative locations required for the robot. The Animator Script managed the animator part of the Unity 3D's Mecanim Animation System. It managed the movement of the Game Objects and relays the locations and angles of the Game Objects to the Model Script.

Robot development requires several hardware components such as 3D printers and micro controllers e.g. Arduino boards (Bartneck et al. 2015:2). The emergence of open source hardware heralded the development of several robotic open source hardware platforms e.g. 3D printable robot, Jimmy by the Intel Company and the InMoov robot. It is one thing to develop a robot as a physical system of hardware components and another thing to develop the software system that controls the actions of the robot. The development of a robotic system of any kind is a 'portfolio' of projects. This meant the construction of the systems entails the construction of sub-systems which include the:

1. robotic hardware sub-system (hardware project)
2. software controlling the robot (Software project)
3. development and installation of a network of the robots as a working system (networking project).

Computer networks were found to be everywhere, heterogeneous and need careful planning, installation and upgrading for them to be reliable. Computer networks are software-driven and outsourced, hence, risky. This was due to the risky nature of software as a consequence of its intangibility and complexity. Computer networks are usually installed by outsourced contractors with different stakeholders involved and this makes them risky as well. This calls for rigor in their management as projects. If the management of computer networking projects improves, there would be evident ripple effects in the associated benefits to organisations that use them.

2.4 The concept of project management

A project is commenced to develop a distinctive product or service, and consists of a set of tasks or activities (Hall 2012:137). It is an outlay of capital in a time-framed mandate to build fruitful assets (Cusworth & Frank (2013) or as an initiation to cause change, undertaken in an effort to realise unique goals in a certain period and setting (Tichapondwa & Tichapondwa 2009:12). From the PMBOK, a project is viewed as a temporary endeavour undertaken to create a unique product or service. From these definitions a project is allocated a budget and has a duration which is marked by a *start time* and an *end time*. That on its own is a challenge to project managers. All project tasks must be completed under constraints that include budget, time and resources (Hall 2012; Salamah & Alnaji 2014; Mohagheghi & Jorggensen 2017; Bannerman 2008). As such, managers need to use principles and methods that ensure the successful completion of tasks within the given constraints. The researcher deduced that processes to ensure that the project is successful under given limitations are the hallmark of project management. As a result, project management is important in that it effectively controls change, giving room to introduce unique products and services.

Project management is viewed as the application of knowledge, skills, tools and techniques to project activities to meet projects requirements (PMBOK 2015). Tichapondwa and Tichapondwa (2009:25) view project management as the enablement of planning, scheduling and controlling of all activities carried out to attain project goals. Many organisations worldwide practise project management as a way to survive competitively in the global market (Carey 2011:2). Projects are increasingly becoming more complex as attested by their different characteristics (Hall 2012:140). Project management as a profession, therefore, enables effective management of projects in an ever-changing environment. Projects produce, over the project duration, assets, and systems etc. which remain in use and produce a flow of advantages after the project has been accomplished (Cusworth & Frank 2013:15).

Project practitioners should note that a project is an investment, has different activities involved, is expected to provide benefits, and has to be executed under constraints that differ from one project to the other and from one organisation to the other. From this perspective, this research took any computer networking project as a unique endeavour that provides services according to different organisational requirements.

The uniqueness of a computer networking project requires special attention since different situations require different management techniques for the project to succeed. The identification of critical success factors for computer networking projects was a step towards identifying factors that need priority for the successful implementation of the project.

2.4.1 The history of ICT Project Management in Zimbabwe

Zinyama and Nhema (2016:1) define e-governance as the utilisation of ICT designed to enhance the efficiency, effectiveness, transparency and accountability of government operations. E-governance creates a technology-enabled transformation of government operations into one that focuses on the reduction of costs and the promotion of economic development and improvement in public sector service delivery. Computer networks thus enable the communication among different government ministries and their departments. Every province and every district has government departments that include the Passport and Immigration, Police Services and Health. All these departments need to share data and information enabled by the existence of computer driven networks.

Networks are set up and implemented as computer networking projects. Zinyama and Nhema (2016) note that advancement in e-governance in African countries continues to be comparatively low and irregular. In accordance with the regional E-Government Development Index (EGDI 2014), among the 54 African nations, sixteen were at the lower 10% of the global standing (United Nations, 2014). Tunisia, Mauritius, Egypt, Seychelles, Morocco and South Africa were included. The highest ranked African country (EGDI) was Tunisia with a world ranking of 75 (by 2014), followed by Mauritius and Egypt with rankings of 76 and 80, respectively. Zimbabwe and its neighbours South Africa and Botswana were ranked 126, 93 and 112, respectively. The researcher noted that these rankings show that Zimbabwe required much effort if it were to improve on its position. Though many factors come into play e.g. economic and political, ICT infrastructure development which rests on computer networking infrastructure plays a huge part. In Africa, most of the internet activity and infrastructure was found in South Africa, Morocco, Egypt, Mauritius and Seychelles. The researcher deduced that Zimbabwe had to improve on its computer networking infrastructure for its regional ranking to improve.

2.4.1.1 Background of ICTs in Zimbabwe

Project management existed for many years, dating as far back as to the Egyptian epoch (Tichapondwa & Tichapondwa 2009:16) and the background of ICTs in Zimbabwe can be traced back to the 1970s when ICTs were accessible by the public through the Central Computing Services (CCS) (Zinyama & Nhema 2016). The Integrated Results Based Management System (IRBMS) was adopted in 2005. In the same year, the government embarked on an e-readiness survey that gave birth to the first national ICT Policy and e-strategy which provided the road map leading to a knowledge community. From 2009, the Government, guided by the ZimConnect, developed the digital access and e-government agenda in the country (Zinyama & Nhema 2016:2). ZimConnect was meant to connect the government and its people. The focus was on infrastructure, capacity building and systems applications. Connecting the government to the people required a comprehensive network and communications infrastructure.

ZimConnect moved with the mission "To deliver unified e-services to the inhabitants, business and government via an interlocked public service assimilating humans, systems and technology". It is clear from the mission statement that the mission could only be achieved by developing a network infrastructure that links the government, business, people and processes. Computer networking projects and the associated software development projects took centre stage. The implementation of these projects therefore, became critical. Zinyama and Nhema (2016:3) note that in terms of technology, the country stood very low in the global ranking. It should be acknowledged that the correct application and management of technology provides great stimuli to the four traditional factors of economic growth (land, labour, capital and education). ICTs, driven by computer networks and software were critical in driving the country's economic through the stimulation of land, labour, capital and education. To achieve meaningful economic development through ICT infrastructural development, there was need for more investment in the computer networking infrastructure which in turn could be achieved through the careful management of computer networking projects.

At the regional level a lot of efforts were made by the Heads of government to improve the member countries' ICT developments. Of note was the SADC Declaration on ICT of 2001 in Malawi which included the development of Infrastructure for ICT developments and emphasised the role of ICT in business as priority areas of action.

Zimbabwe as a member state relied on the government to adhere to the declaration by rolling out programmes that aimed at ICT infrastructural development. The efforts did not end at the SADC level but were also complemented by the African Union (AU). In 2010 the Heads of

State and Government of the African Union (AU) considered telecommunication and ICT infrastructure and services as a basic public utility infrastructure. It was noted in the previous section that the country ranked very low in terms of ICT in the world. It was ranked number 126 as compared to its neighbour South Africa ranked 93 (United Nations, 2014). Tunisia, Mauritius, Egypt, Seychelles, Morocco and South Africa were part. This remains true for most African Countries (e.g. Algeria 150, Angola 142, Botswana 113, Burundi 173, Cameroon 155, DRC 180, Zambia 132, Malawi 166, Mozambique 172, South Africa 76, Tanzania 130, Kenya 119 and Lesotho 134 - EGDI 2016 figures). It would thus only be fair and rational for the AU Heads of State and Government to prioritise telecommunications and ICT infrastructure and services.

2.4.1.2 Zimbabwe National Association for Project Management Practitioners

Project management is relatively young as a formal management discipline (Sherhar & Dvir 2004:2; Carey 2011). It began in the 1950s marked with the Program Evaluation and Review Technique (PERT) charts (Sherhar & Dvir 2004:2). This agrees with Tichapondwa and Tichapondwa (2009) who assert that formal project management tools began in the 1950s marking the start of the current project management epoch. The country adopted the use of ICTs in the 1970s (Zinyama & Nhema 2016) coinciding with the emergence of project management as a formal speciality.

Zimbabwe joined the rest of the world in formalising project management as a discipline. Formed in 2009, the Zimbabwe National Association for Project Management Practitioners was registered as a trust in 2010 and named the Project Management Institute of Zimbabwe (PMIZ). From 2009 its membership grew to 150 by 2011. The PMIZ had centres in Harare, Bulawayo, Mutare, Midlands and Masvingo. PMIZ in 2009 noted that there was unclear discourse on the project management discipline in public business and political forums in relation to how the career was being advocated internationally. Mbindi (2016) notes that in many sub-Saharan African countries, the extent of project management education and accreditation was growing, although slowly, noting that the nations undertook enormous infrastructural development projects.

The success of the Fifa World Cup in South Africa (2010) was an example of good project management in Africa. The establishment of PMIZ aimed at providing appropriate education and endorsement which substantially minimise project failure risks since accredited experts were expected to have the comprehension to overcome hindrances and accomplish projects within the desired durations and financial constraints.

The PMIZ is affiliated to the Association of Project Management (APM) in the United Kingdom and the Project Management South Africa (PMSA). The organisation engages the public and private sectors in the country for career respect and appreciation of project management in local and international economic growth agendas that include education, mining, agriculture and tourism projects (Banda 2011). Though the projects named here were not necessarily ICT projects, the researcher appreciated the fact that project management is a formal discipline which requires principled and tested methods of handling projects by professionally certified project practitioners.

2.4.1.3 Periods of different project management focus

2.4.1.3.1 The period before 1960

This period was characterised by the development of technology e.g. automobiles and telecommunications that reduced the project delivery times (Tichapondwa & Tichapondwa 2009:17). It was achieved by the automobiles enabling active resource apportionment and the telecommunications upping communication efficiency. The 1960s were viewed as the scheduling era (Sherhar & Dvir 2004). The PERT and the Critical Path Methods (CPM) were introduced. At that time the emphasis was on coordinating sequential and parallel activities and the control of performance (Sherhar & Dvir 2004). Tichapondwa and Tichapondwa (2009) note massive application of management science with significant technological advancements, e.g. paper copiers, the founding of Microsoft, Oracle and other software companies. The developments provided fertile ground for executing projects.

Developments in telecommunications resulted in networking projects beginning to dominate though with no strict formalisation. The reason was that all the telecommunication devices in various locations needed to be linked for them to communicate. Networking projects had a long history and were increasingly influencing the economies of countries hence needed careful management.

2.4.1.3.2 The 1970s

During the 1970s, the need for managing increasingly complex projects that needed expertise from different disciplines grew. During this era, teamwork and integration became critical (Sherhar & Dvir 2004:4). The researcher found no literature showing that Zimbabwe by that time was actively involved in this type of development. Though Zinyama and Nhema (2016) assert that the country adopted the use of ICTs in the 1970s, no further information was found in literature supporting the forms of ICTs that were adopted. Formalisation of project management in the country could only be traced back to the year 2009 when the Zimbabwe National Association for Project Management Practitioners was born and listed as a trust in 2010, now the Project Management Institute of Zimbabwe (PMIZ).

2.4.1.3.3 The 1980s

The 1980s marked the main focus of project management as uncertainty reduction. Project managers needed to make judgements that could remain in force and to guard against improbabilities (Sherhar & Dvir 2004:4). The same era was characterised by PC introduction and related computer communications networking amenities (Tichapondwa & Tichapondwa 2009). Project management during this era concentrated on risk management, group subtleties and value management. These three were all uncertainties in one way or the other. It was further noted that even though Zimbabwe had not formalised project management as a discipline, dealing with uncertainty was a necessity. Project teams had always been in existence though referred to by different names.

2.4.1.3.4 The 1990s

The 1990s were marked with a rapid increase in the pace of doing business. The time to market became the driving force in industry. Tasks and people needed to be integrated and differentiated at the same time (Sherhar & Dvir 2004). Systems needed to be responsive to the dynamics in business. This was tantamount to developing a new setting characterised by advances associated with the Internet. The Internet gave a quick, collaborative and adapted new gateway that allowed us to browse, buy and follow products and services online in real time (Tichapondwa & Tichapondwa 2009). The systems were characteristic of Enterprise Resource Planning (ERP) systems.

2.4.1.3.5 The 2000s

In the 2000s there was increased focus on adaptation, strategic thinking and globalisation. Since projects differ in the properties and circumstances surrounding them, it was paramount that organisations use adaptive approaches to project management. As far as strategic thinking was concerned, project management hinged on management being about business, hence it had to link practices with business approach whilst numerous projects were undertaken in conjunction with groups in different areas in the world i.e. globalisation (Sherhar & Dvir 2004:5). These trends were important drivers of project management research.

The country espoused the Integrated Results Based Management System (IRBMS) in 2005. In the same year, the government conducted an e-readiness survey across the country. The survey was the basis for the first national ICT policy and e-strategy. The policy provided a road map for a knowledge community. The level of project management training and certification was increased though it grew slowly. In 2009 the country developed the digital access and e-government agenda (Zinyama & Nhema 2016:2). Through ZimConnect, the government started efforts to connect the government and its people with a focus on infrastructure, capacity building and systems applications. The government through its membership actively participated in the developments of this era through such instruments as the SADC Declaration on ICT 1 (Malawi 2001) and the African Union (AU) consideration on telecommunications and ICT infrastructure and services as a primary public service infrastructure.

2.4.1.4 Why ICT projects fail

This research was much concerned with predicting the success of computer networking projects. The researcher found it rational to investigate from literature why ICT projects fail since failure and success could be viewed as two sides of the same coin. A comprehension of causes of project failure provided insights on project success. A computer networking project is a sub-element of ICT projects, driving the motive to understand the failure so as to deduce what needs to be done to increase the success rate. Causes of software failure were reported to be distributed across different areas e.g. project management and requirements engineering (Lehtinen et al. 2014:627). They define software failure as a recognisable flop in the cost, schedule, scale or value goals of the project.

The 2018 CHAOS report identified the following as the main causes of failure in ICT projects;

1. Absence of senior level management support and commitment.

2. Lack of client/user involvement.
3. Making deadlines which are not realistic as related to technology implementation requirements.
4. Poor risk management.
5. Either the non-use of a plan or poor communication of the plan.
6. Non-formalisation of the change control process.
7. Lack of verification and validation.
8. Testing and inadequate definition of the project scope (CHAOS Report 2018).

Verner, Sampson and Cerpa (2008:1) also identified a very long list of factors causing software project failure. The long lists of reasons for ICT projects failure justified the need to provide a solution to ICT projects failure. Different lists of perceived causes of software project failure (Verner, Sampson & Cerpa 2008:1; CHAOS report 2018, Lehtinen et al., 2014:6), though with considerable similarity, have noticeable differences. Statistics obtained from the Standish Group CHAOS reports (2011and 2014) show that from 2011 to 2014 the software project success rate fell whilst the percentage of challenged and failed projects increased. This was a challenge to software project management which had a ripple effect to all ICT projects that have a software component or work in conjunction with a software system.

It is important to note that the CHAOS reports are criticised for their definitions. Firstly, they define a successful project solely on conformance to an initial prediction of time, cost and functionality where functionality is defined only by the amount of features and functions. They do not focus on functionality itself. Secondly the definitions do not factor in the software development project's context i.e. usefulness, profit and user satisfaction. Thus the definitions have a weakness of them based on estimates of cost, time and functionality.

Project managers can be overwhelmed by the countless reasons for ICT project failure, resulting in difficulty in identifying the ones to control or ignore. Software was built from the 1960s though success rate of development projects remains undesirably low and little has been done to predict the outcome of these projects (Cerpa, Bardeen, Astudillo& Verner 2016). Sebestyen (2017) asserts that prediction and interpretation of success remains a complex problem, with many people suggesting different solutions and naming different factors and criteria to define success.

It was noted from Cerpa, Bardeen, Astudillo and Verner (2016) and Sebestyen (2017) that research needs to address the issue of project outcome prediction. The researcher, in light of this assertion, devoted section 2.4.1.8 to exploring the concept of project success. The most important discovery here was that ICT projects' success rates (and of course including computer networking projects) were still low, warranting more efforts for improvement and this research is one such effort.

2.4.1.5 Project Management challenges in Zimbabwe

Caliste (2012:2) asserts that the execution of project management tasks is not continually smooth and does not continually give the advantages initially envisioned. Damoah, Akwei and Mouzughi (2015) note that projects in developing countries were poorly planned. They cited failure of government projects in Ghana, Nigeria and Iran. At the top of the list was the fact that government projects were politically motivated with most senior positions being on political appointment rather than on merit. It means that the people who normally manage the government projects lack the necessary project management professional skills. Caliste (2012:10) argues that politics plays a critical role in the manner in which projects are executed in government and many of the challenges in public projects management can in some way be by-products of politics. Politicians are not normally eager to relinquish projects that bring a rapid triumph in the voting cycle for projects that can bring benefits in the future.

Other critical factors included delays in payment and bureaucratic procedures. These two factors are related in that the process of payment passes through several offices for signatures. It therefore means that the turnaround time for the payments is too long. In Zimbabwe for instance, the researcher noted that the same holds, with some service providers ending up suspending projects after waiting in vain for the payment procedures to be concluded. Mapepeta (2016) identified a strong correlation between socio-economic development and project management. Successful implementation of projects heavily relies on the socio-economic temperature of organisations in a country. Mapepeta (2016) agrees with Amponsah (2012:9) who propounds that Africa's ethnic ideals, economic and political conditions and organisational setting affect the implementation of projects. He argues that cultural and work values counter project management techniques and tools in the enhancement of project success. Thus, the country should have set a socio-economic temperature that is conducive to the successful implementation of socio-economic development projects in all sectors (Mapepeta 2016:2). He argues that a responsible government should be responsible for its citizens who would in turn establish responsible organisations which are successful and thus implement successful projects.

Citing the Zimbabwean scenario, the culture and values of most citizens have been corrupted to an extent that formal organisations are meaningless and hence the complete informalisation of the economy. Mbindi (2016) notes that local projects do not succeed because of incompetence in managing projects and lack of suitable project governance resulting in unscrupulous corruption. In many cases, it is the socio-economic climate that is a deterrent to project implementation and hence culminates in project success or failure (Mapepeta 2016:5)

2.4.1.5.1 Developing countries' ICT project challenges

Karunaratne, Peiris and Hansson (2018:17) identified the following challenges:

1. Insufficient ICT knowledge.
2. Unwillingness to change.
3. Inadequate support from executive management.
4. Lack of ICT skills.
5. Lack of time.
6. Use of traditional methodologies.
7. Lack of funding.
8. Rigid institutional procedures.
9. Lack of ICT tools and infrastructure.
10. Lack of resources e.g. space and material.

The challenges identified here by Karunaratne, Peiris and Hansson (2018:17) were expected to apply to Zimbabwe since it is also a developing country. This study confirmed only two of these challenges, namely, lack of support from senior management and lack of funding as paramount to computer networking projects' success. Additionally, other factors e.g. inadequate resources, insufficient ICT tools and infrastructure as well as lack of ICT skills were identified as factors affecting computer networking projects but not in the critical category.

2.4.1.5.2 Why Information Communication Technologies for Development (ICT4D) projects in Zimbabwe failed

Musiyandaka, Ranga & Kiwa (2013) identified the following to explain why ICT4D projects failed:

1. Inadequate network facilities.
2. Gaps in design principles.
3. Insufficient information assets.
4. Retrogressive attitude.

Musiyandaka, Ranga and Kiwa (2013) identified the four factors as providing major influence to ICT4D projects in the country. However, their work only identified with limited network infrastructure as a major drawback to the success of computer networking projects. The reason for the big difference between factors identified by Musiyandaka, Ranga and Kiwa (2013) and the findings of this research were mainly attributed to the type of the project and the setting of the research. The study by Musiyandaka, Ranga and Kiwa (2013) was on ICT4D projects whilst this research focused on computer networking projects. Secondly, the former study was in the field of education whereas this study was on the computer networking industry. The observation points to the fact that it is not wise for project managers to treat all ICT projects as alike. The intersection between these two types of projects was that both were carried out in the same country.

2.4.1.5.3 ICT sector challenges in Zimbabwe

Zinyama and Nhema (2016:7) identified four broad challenges that befell the country in terms of executing projects in the ICT sector. These were:

1. Inadequate communications infrastructure. They established that fast broadband networks were scarce with the greater part of the communal and inaccessible areas still uncovered due to a discrete methodology to collective service. This was in line with Musiyandaka, Ranga and Kiwa (2013) who discovered that the Mashonaland West Province had rural society with small population densities, poor road infrastructure, scantly positioned amenities, geographical features that mitigated against the formation of a telecommunications infrastructure at a reasonable cost, reduced access to information and inadequate infrastructural development. For the rural and remote areas of the country to be included in the developments, a lot had to be done in terms of connectivity which entailed more computer communications (networking) projects.

2. Inadequate electricity supply. It was noted that the country's power grid did not reach all parts of the country but left out a substantial population relying on substitute sources of energy. This tended to be more expensive and detrimental to the environment. As a result ICT developments were very difficult if not impossible in these areas.
3. Fragmented institutional arrangements. The convergence of technology platforms led to multiple services being availed on a common platform. Therefore, it was no longer necessary to have several institutions overseeing the development of electronic communications in the country (Zinyama & Nhema 2016:7). Computer networking projects became a necessity to enable technology convergence resulting in communication convenience.
4. Inadequate investment capital. On this one, Zinyama and Nhema (2016) were in agreement with Musiyandaka, Ranga and Kiwa (2013); Caliste (2012); Karunaratne, Peiris and Hansson (2018) and Amponsah (2012). The liquidity crunch currently haunting the country made it challenging for it to obtain funding for ICT projects that have future benefits. The infrastructure advancement and expansion in the ICT area was therefore adversely affected. Computer networking projects were not spared either.

It is essential to highlight that the factors established by Zinyama and Nhema (2016:7) relate to ICT projects in general whereas the thrust of this study was to treat ICT projects under their respective types but focusing on computer networking projects. Again the authors seemed to be biased towards the Zimbabwean situation more than the project itself. This explains why only two of the factors (inadequate investment capital and inadequate communication infrastructure) applied to the current research.

The Controller and Auditor Report (2011) on Zimbabwe National Water Authority (ZINWA):

Factors attributed to poor project performance were identified as:

1. Delays or schedule overruns leading to increased costs
2. Selection of incompetent contractors
3. Awarding too many contracts to one company
4. Delays in payment of certificates to contractors
5. Failure to adequately monitor and supervise projects
6. Delays in approving design changes
7. Unavailability of equipment for projects.

In many cases, these factors influence government projects which constitute most of the country's projects (Mbindi 2016). In as much as these factors were identified in the water authority (ZINWA) projects, the researcher noted that they all applied to ICT projects when compared with findings by Zinyama & Nhema (2016), Musiyandaka, Ranga & Kiwa (2013), Karunaratne, Peiris & Hansson (2018), Mapepeta (2016), Mbindi (2016) and Amponsah (2012)). As an example, the bureaucratic nature of governments always results in delays in buying equipment and paying contractors. The situation led to unavailability of equipment and schedule overruns leading to increased project costs.

Sherhar and Dvir (2004:6) did not come up with a list of challenges in ICT projects but discussed the side effects of adopting an inappropriate project management approach. They argue that "one size does not fit all", and that a collective illusion and miscomprehension in the domain of project management was that every project was viewed as similar to all others and that managers could apply comparable tools for every project. ICT projects were also affected in that way. They indicated that many studies did not discriminate project types and that project management literature has not completely answered to the challenge of categorising projects. This is why the researcher had to centre on computer networking projects' CSFs. "The project-is-a-project" syndrome can cause projects to fail and delays when organisations apply comparable procedures for all their projects (Sherhar & Dvir 2004:6). This means that projects are not the same and should be treated differently.

2.4.1.6 Examples of challenged projects in Zimbabwe

Mbindi (2016) notes that several projects were awarded to Chinese companies outside tender procedures and further asserts that projects not acquired through a visible, public and open tender system were normally over-charged and low quality. Examples of large projects that were awarded to Chinese companies included the Tokwe Mukosi Dam in Masvingo and the construction of the USD98 million National Defence College and the Long Cheng Plaza in Harare.

The Tokwe Mukosi Dam had a baseline schedule of 1998 – 2004 but it was completed in 2016 with a schedule overrun of 18 years (Mbindi 2016). This was a serious failure of such a large project which obviously meant a huge increase in costs.

The government of national unity (2009), contracted approximately USD500 million to China in a period of about four years mainly for construction projects that included roads, airports and hydro-electric power stations (Mbindi 2016). Chinese projects were not selected according to government procedures as they were favoured via government agreements.

2.4.1.7 Efforts to address Project Management challenges in Zimbabwe

The National ICT Policy aims at providing connectivity in all schools to further bridge the urban-rural digital divide as well as enhancing learning by using technology tools and promoting computer literacy in the country (Karunaratne, Peiris & Hansson 2018:7). Non-governmental organisations and the government started providing ICT equipment in different programmes to reduce the digital divide between the rural and urban areas (Musiyandaka, Ranga & Kiwa 2013). As part of this effort, the government launched the Schools Computerisation programme in 2009. In 2002 the Presidential Schools Computerisation Programme was launched with computers being provided to primary and secondary schools (Musiyandaka, Ranga & Kiwa 2013). The aim of the programme was to provide support for the realisation of the ICT policy through enhancement of learning. The second phase of the programme was launched in 2011 in conjunction with the Ministry of ICT focusing on the development of e-learning initiatives for secondary schools (Musiyandaka, Ranga & Kiwa 2013).

The government through the Postal and Telecommunications Regulatory Authority of Zimbabwe (POTRAZ) availed a revolving fund to support ICT innovation projects. This development meant the efforts at national level to promote the utilisation of ICTs in the country would be realised. However, without good project management all these efforts may not result in the success of the ICT projects.

Other than the financial support through POTRAZ, the Infrastructure Development Bank of Zimbabwe (IDBZ) in conjunction with the Zimbabwe Public Sector Investment Programme (PSIP) financed ICT projects in the country. Most of the funded projects were those focused on building ICT Infrastructure including the Fibre Optic Backbone and the procurement of the related equipment.

Examples of funded projects in Zimbabwe

Key projects funded by the IDBZ included the Africom International whose co-funders were IDBZ with 30%, NSSA 20% and Africom (Pvt) Ltd with 50%; The Pilot Border Automation funded by a government debt from Afrosoft Holdings and the Optic fibre network implemented by the state owned telecommunications provider, TelOne, funded by the government under the Public Sector Investment Programme (PSIP). The government as the major stakeholder provided support for ICT projects. The funding enabled the availability of equipment to project managers. However, as noted earlier, there was also need for the training and certification of project practitioners who would in turn provide expert management of these ICT projects.

2.4.1.8 ICT Project success

Another contentious issue in ICT project management is the meaning of success itself (Masamha & Mnkandla 2017). The problem dates back to the 1980s as Pinto and Slevin (1988) note that researchers and project practitioners rarely agree on the factors that distinguish a successful project from a failed one. In the same light, Bannerman (2008:1) indicates that there had been interesting dialogue on the nature and meaning of project success but no agreement had been reached. Presently, to establish the success or failure of a project is a more challenging task than before; success is not only viewed variably by different people, but also the type and sector of the project may inspire one's perception of success (Masamha & Mnkandla 2017).

Bannerman (2008) notes that projects are distinct but multifaceted activities that influence change and Salamah and Alnaji (2014:1) view a project as organising people and resources to accomplish set objectives in a defined time frame with a limited budget. The triple constraint or the magic triangle can be used to distinguish good projects from bad projects though it is not the correct indication of determining the performance of a project (Cavarec 2012). One should also consider business criteria taking into account the fact that success or failure is directly influenced by the stakeholder gratitude (Cavarec 2012). Mohagheghi and Jorgensen (2017:1) define a successful project as one that is found to provide the desired customer benefits and where no stakeholder complain of huge challenges on the success aspects of time utilisation, financial control, value and achieved functionality. This dovetails with Bannerman (2008) who notes that project success differently refers to 'timely, financially efficient and according to user requirements' and the success of the artefact in attaining the business goals of that project. However, they admit that the definition of success is subjective.

A common meaning of success is difficult to reach since different practitioners and scholars have a different understanding of success given their diversified backgrounds and experiences. Which part of the project should be considered successful? Does a successful project continually provide a successful artefact for which it was developed or is success a function of good project management practice (Masamha & Mnkandla 2017)? Project success is continuous and views differ with the stakeholder's experience and the movement of time (Bannerman 2008). The success of a project should be viewed in terms of both the project management success and the product success. Essentially, a project may produce a poor product with successful project management. Conversely, the product of the project must not be a determinant of project management success (Masamha & Mnkandla 2017). The researcher realised that the success of a project is viewed and understood from different angles or perspectives. Any project is undertaken to achieve a specific set of requirements, under given constraints. Project constraints include time for development, budget available and other necessary resources.

The researcher came to the realisation that the success of a project is, therefore, a function of how those constraints were handled or how the final product met the requirements or meeting the project delivery deadline. In other words, the researcher noted that project success either focuses on the project process or the quality of the project product. A project may be successful because its product meets the user expectations though the process was poorly managed; or the project can be viewed as a failure only by looking at the final product ignoring the fact that the process management was done correctly. The researcher recommends that stakeholders look into these aspects to qualify their conclusions about a project's success.

The researcher found no evidence of stakeholder agreement on the common perspective in defining what project success meant. Therefore, in this research, project success was taken to mean a recognisable success in financial utilisation, time scale, scope or value objectives of the project and meeting the delivery date. This was arrived at following an analysis of literature on the definition of projects success (Salamah & Alnaji 2014; Cavarec 2012; Mohagheghi & Jorgensen 2017; Karunaratne, Peiris & Hansson 2018). The researcher looked into important definition elements from the definitions given in literature in order to strike a balanced view.

2.4.1.9 ICT project success in Zimbabwe

Project management is in itself a complete entity that has its own body of knowledge, exists in and for itself, with its own corpus of knowledge, ideas, approaches and schools of thought (Garel 2012:46). Project management is as old as the time of Egyptian pyramids construction, however, modern project management has taken a new form due to the nature of today's projects (Hall 2012:130; Tichapondwa & Tichapondwa 2009; Sherhar & Dvir 2004). Today's projects are more complicated since they are heavily interconnected especially in the case of enterprise-wide systems. Nowadays, business environments are dynamic, unpredictable and unreliable, calling for project managers to be furnished with reliable knowledge and superior practice as well as proficiencies on how to attain project success (Hall 2012). It means that in as much as project management started long back, it is the art of management which has changed (Tichaponndwa & Tichapondwa 2009). Sherhar and Dvir (2004) note that projects were now not simply executed for new artefact building, but for several other reasons that include process building and process reengineering.

The researcher noted that organisations in Zimbabwe had offices in different locations calling for intensive use of computer networks for their communication and sharing of files. These organisations were heavily interconnected using computer enterprise wide networks. The environment in which business was carried out was dynamic due to technological advances. More so, the country's political and economic uncertainties resulted in the environment being unpredictable and unreliable. The researcher established that computer network infrastructure on which the enterprise-wide systems running needed project managers who were equipped with dependable, advanced knowledge and skills in managing the computer networking projects.

One of the successful ICT projects in Zimbabwe was the Telemedicine Pilot Project in the Manicaland province launched by the Posts and Telecommunications Regulatory Authority of Zimbabwe (POTRAZ) in 2018. The aim of this project was to expand on the Pan African e-network telemedicine from the hub at Parirenyatwa Hospital in Harare to the rest of the country. The project was an ICT-based healthcare model that could be used as a tool that gives specialised medical care to people in all health institutions. The system provided these services to all hospitals and clinics targeting inaccessible areas with meagre or no telecommunications by using off-site specialists. The model used for the telemedicine project aimed at isolating and controlling the utilisation of technology for enhanced access to and providing efficient delivery of affordable health care systems.

2.4.1.10 ICT projects success factors in Zimbabwe

There are many factors that govern ICT projects' success. However, researchers identified different though related factors that impact on ICT projects' success in the country. Notably there are Musiyandaka, Ranga and Kiwa (2013); Taruwona (2011) and Karunaratne, Peiris, and Hansson (2018).

Karunaratne, Peiris and Hansson (2018:17) isolated the following CSFs for ICT projects in the country:

1. Expert knowledge use
2. Use of ICT tools
3. Integration with the current process
4. Acceptance from top management
5. Stakeholder willingness
6. Supportive environment
7. Having a strategic plan or ICT policy
8. Support for updating knowledge i.e. long life learning
9. Availability of funds

Taruwona (2011:1) identified the following as the top five project critical success factors in the country:

1. Project planning
2. Stakeholder buy-in
3. Executive support
4. Use of formal standards
5. Controlled scope, time and cost.

Musiyandaka, Ranga and Kiwa (2013) identified the following factors impacting ICT4D projects in the country:

1. Sound ICT policy
2. Information exchange

3. Partnerships i.e. the government has limited resources, so partnering helps it to cover that gap.
4. Progressive attitude

The work on success factors for ICT projects in the country (Musiyandaka, Ranga & Kiwa 2013, Taruwona 2011 and Karunaratne, Peiris, & Hansson 2018) agree in many aspects. The first common element is having a sound ICT policy. An ICT policy is a critical tool in sustainable development since it provides direction for the developments and gives a basis for control, monitoring and evaluation. Secondly support from top executives. No project can actually commence without the approval and backing by top executives. It is the executive that provides resources and the environment for the project. On this second factor, the researcher also discovered that it impacts computer networking projects' success. The third common aspect was the use of expertise i.e. allowing the recruitment of trained and certified project practitioners. The fourth common factor was a supportive environment. Even if the project team were to comprise of experts, the project can still be challenged if the environment is not supportive. Lastly the researchers agreed on stakeholder involvement and participation. Normally, a project has different stakeholders; including the project sponsor, system users, organisational management and the project managers. Therefore, there is need for buy-in from all the stakeholders for the project to succeed.

2.4.2 Project management techniques and tools

Hall (2012:139) argues that traditional projects were deterministic whilst modern ones are non-deterministic. Modern projects are rendered difficult in terms of scheduling and budgeting. The modern projects lack transparency about their progress (visibility), have very short durations especially those that are technology-based (Hall 2012). Project management as a profession is relatively young, and is currently growing and becoming vitally integrated into every aspect of every industry (Matthew, Shahadat & Crawford 2016:6, Milosevic & Lewwongcharoen 2004). They argue that no modern organisation can survive without implementing projects as everything is achieved through one form of project or another. Project leaders need to be provided with appropriate tools and techniques to schedule and execute projects in very short cycles to produce relevant systems.

Milosevic & Lewwongcharoen (2004) assert that to do well, one must first have good tools i.e. Project managers need good project management tools for them to deliver good artefacts. The fact that hundreds of project management tools are available to managers means that they should select appropriate ones for a given project which are both effective and efficient. Managers need to have reliable knowledge and experience on how to achieve project success (Masamha & Mnkandla 2017). The researcher understood that ICT projects were best suited to this type of challenge since they rely on ever changing technology. All ICT projects have a software component. Software itself is intangible hence its development process lacks visibility. Once the development process is not visible, the project is non-deterministic. The researcher noted that management of such projects, therefore, needs prediction techniques to cater for uncertainty.

Santos, Santos, Tavares and Varajao (2014) note that government health projects had a diverse emphasis focused on offering conditions that provide people with health. Health projects' typical features substantiate the need for research regarding building specific model of success factors to support executive management and project managers in executing projects. The researcher inferred that the scenario is true for different types of ICT projects. Santos, Santos, Tavares and Varajao (2014) observe that a specific and appropriate model is important as a means of forecasting and analysis in evaluating accurately and steadily minimising the chance of project failure and therefore assists in enhancing the project performance.

2.5 ICT projects CSFs

ICT projects are those having the objective to build or introduce an ICT system (Leydesdorff & Wijsman 2007:15). ICTs cover a vast array of software, hardware, telecommunications and information management approaches, applications and devices used to manipulate information (Taylor, 2015:9). Past research has mainly focused on ICTs in general (e.g. Nethathe, Waveren & Chan 2011; Nour & Mouakket 2013; Ram & Corkindale 2014 and Ziemba & Oblak 2013). Other researchers looked at CSFs for specific ICT project types, e.g, Chiyangwa and Mnkandla (2017) who studied agile software development CSFs.

Despite focusing on ICT in general, researchers gave critical success factors (CSFs) as lists. Nethathe, Waveren and Chan (2011) propounded that project success factors are not common to every project and that different factors influence different types of projects. Though they studied agile software development projects' CSFs, Chiyangwa and Mnkandla (2017:1) note that there is universal research context to establish perceptions of all pertinent CSFs for agile development and their associated concepts which have an important meaning to the software development industry. Chiyangwa and Mnkandla (2017:3) further argue that there was scant information available relating to the critical success factors that impact agile software development. Within the agile software development itself, there was no complete research framework for the CSFs (Chiyangwa & Mnkandla 2017).

A few researchers did mathematical modelling of critical success factors for ICT projects. Examples include Nethathe, Waveren and Chan (2011) who applied the Cronbach's alpha method and principal component factor analysis with varimax rotation; Hung, Chang, Hung, Yen & Chou (2016) used the Modified Delphi method; Rebeiro, Antony, Lepikson and Peixoto (2016); used multivariate factor analysis to reduce their number of critical success factors. However, they were not specific on the type of ICT projects. Neverauskas, Bakinaite and Meiliene (2013:4) argue that the abundance of CSFs does not benefit programme managers to get a solution since they do not have a pure answer as to which factors are more suitable for a specified project and a particular environment (Nethathe, Waveren & Chan 2011).

Zucker (2017) note that on software development projects, we were no better at delivering a project today (2017) than we were 20 years back. This means more research had to be undertaken to improve software development projects' success rates. The same argument holds for computer networking projects since no computer network can run without software. In ICT, the CSFs were generalised whereas the ICT projects themselves are varied and could not be equally influenced by the same set of factors. As a result, it was necessary to examine the current literature to establish ICT projects' CSFs and then use an appropriate method to identify factors specifically critical to computer networking projects.

In light of the fact that the critical success factor concept guaranteed an orderly means of establishing the key aspects that need the relentless and cautious attention of management in a bid to attain performance objectives (Ram & Corkindale 2014:4), this research isolated CSFs specifically influencing computer networking projects. It is this set of CSFs which required careful management for computer networking projects to succeed. However, the critical success factor approaches have been criticised for over-selling the critical success factors as an objective solution for any situation rather than guidelines for management (Standing & Cripps 2015:6). They further postulate in agreement with Nethathe, Waveren and Chan (2011) that the notion of success is context dependent. Ram and Corkindale (2014:2) question the legitimacy of most claimed critical success factors and warn researchers who may need to use them to carefully consider the reliability of the assertion before using them. Hence, computer networking project managers should analyse and understand their project context or environment before deciding on applying the CSF approach.

2.6 Project success

This research focused mainly on establishing computer networking projects' CSFs and their use in predicting the project's success. Section 2.5 discussed the concept of CSFs and their role in managing projects. This section examines the project success concept. The examination is important for the prediction model results to be meaningful. For instance, when the model suggests that the computer networking project is likely to succeed, the stakeholders should thus all have the same understanding of that success.

Literature is full of reviews which comprehensively discuss project success (Serrador & Turner 2014; Davis 2016; Ata ul Musawir, Serra, Zwikael & Ali 2017; Joslin &Muller 2016), but the meaning of success is inconsistent (Davis 2016). Many ways exist that attempt to measure project success (Serrador & Turner 2014). Traditionally, methods to measure project success centred on the "iron triangle"; i.e. attaining the set scope of work according to the client expectations on time and budget (Serrador & Turner 2014; Davis 2016; Ata ul Musawir et al. 2017; Joslin & Muller 2016). Project success is viewed as the attainment of a certain blend of biased and unbiased measures, shown in the success criteria and determined at the end of the project (Joslin & Muller 2016). Project success is the loyalty of the project to the financial limit, set time and meeting the user expectations (Pankratz & Basten 2018:2), it expresses the supposed quality of a project when the artefact is put to use (Hussein, Ahmad & Zidane 2015). Despite the unavailability of an agreed meaning of project success, researchers consent that project success in only attained through the application of good practices by managers (Radujkovic & Sjekavica 2017).

Project management involves all management activities that include organising and controlling of all facets of a project, with all stakeholders being eager to attain project activities safely according to financial, time and performance criteria (Radujkovic & Sjekavica 2017). Project adherence to planning is considered an inadequate measure of success due to many reasons e.g.

political influence, lack of adequate methods to estimate budget and schedule (Pankratz & Basten 2018:3).

Over the years, the comprehension of project success criteria has changed from a generic 'iron triangle' to include more success criteria e.g. value and stakeholder satisfaction. Ata ul Musawir et al. (2017) note an increasing appreciation by the project management fraternity that the traditional iron triangle criteria is incomplete. Measurement of project success concentrated on tangibles, the current school of thought is that eventually, project success is best determined by the stakeholders (Serrador & Turner 2014). Davis (2016) notes that there are varied views among the three primary stakeholders: executives, project team and the client. The meaning of project success finally rests with the group of stakeholders that would have been consulted to evaluate the project. As the emphasis of projects moves away from artefact to value creation, it is important to extend these criteria to the value provided by the project (Ata ul Musawir et al. 2017).

The concept of project success is more complex than a twofold outcome of success and failure. A project may fail on the aspect of output efficiency, but may remain successful in outlay efficiency. In addition, a project that provides the expected output according to financial, time and quality limits may not obviously be an achievement if it does not provide the targeted advantages (Ata ul Musawir et al. 2017). In many situations projects are implemented as planned but end up failing because they would have failed to provide real benefits to the client or sufficient profits for the organisation (Serrador & Turner 2014). Pankratz and Basten (2018) argue that due to the inaccuracies of measuring project success according to its adherence to planning, some projects may be considered a failure whilst others a success. In agreement, Radujkovic and Sjekavica (2017) note that it is promising for a project to be successful from an unsuccessful project management process and vice-versa.

Evaluating success is a function of time i.e. with time, it may not matter whether the project was executed according to the resource constraints. After the project artefact has been delivered, the effect on the user and client satisfaction becomes more important (Serrador & Turner 2014:6).The notion of "success and failure" of projects is arguable in line with the context e.g. stopping a project because the business landscape has changed does not mean the project has failed (Ata ul Musawir et al. 2017).

To deal with the intricacy of project success, there is need to view it as a multi-faceted entity. Therefore, there is the requisite first to differentiate project management success and project product success (Ata ul Musawir et al. 2017:4; Pankratz & Basten 2018:3). Serrador and Turner (2014) assert that it is important to differentiate project management success, where the project is properly managed to attain the expected scope on time from cost and project success in which case the project meets the intended business goals. Project management success refers to the classical triple constraint criteria whereas project success involves the achievement of strategic goals of the client and the expectations of other stakeholders (Ata ul Musawir et al. 2017). Volden (2018:2) sees these two as levels of project success where project management success is concerned with the completion of the project artefact and product success is concerned with the outcome of the process i.e. the effect of the project product to the stakeholders.

The definition of success criteria is further complicated by the availability of contending and differing criteria due to differences in stakeholders' interest, power and influence (Hussein, Ahmad & Zidane 2015). Differences in stakeholders may entail geography, customs, working principles, realisation of goal and the myriad of skill domains involved in the project. Also, the definition of success criteria may be incomplete due to inadequate knowledge about the variety of stakeholders at the beginning or insufficient knowledge about the real use of the artefact. The result is improper utilisation of resources, clashes or disagreements between the parent organisation and the project organisation (Hussein, Ahmad & Zidane 2015). Unrealistic targets may also lead to a successful project regarded as partial failure i.e. if the target is set too high, a very close effort is regarded as a fail. Hussein, Ahmad and Zidane (2015) consequently argue that there is need to define the success criteria from the start. Following this argument, the development team must establish the goal of defining the project criteria over and above the necessity of assessing project deliverables or project process by various concerned parties. Agreeing on the meaning of success criteria from the beginning should be done by all stakeholders in order to develop a shared comprehension among them. Stakeholders should define the success criteria in the same way, have same knowledge about the objectives of the project and how their achievement shall be measured.

The researcher understood project success as more than what the traditional triple triangle purports. Project success, after taking into account time, budget and scope of the project, must include value creation. It was noted through this research, that value was a very critical success metric for a project. This fact is buttressed by the fact that the project quality relies on the time frame in which the project product will be in use. The value or usefulness of the project product either increases or decreases with time, hence it is not static. Another fact that the researcher discovered was that the success or failure of a project depends on who is evaluating it (the stakeholder). In light of this, the researcher considered a common perspective of all the stakeholders to define what success entails and mandatory in each unique project. In other words, all stakeholders must have a shared meaning of the success criteria beforehand to avoid disagreements on the measurement of success or failure of the project.

2.7 Evaluating project success

Davis (2016) outlines “The Square Route” framework of determining the project success hinged on the work of Atkinson (1999). The basis for the framework was cost, quality and time, ‘The Iron Triangle’. He further notes that there was also the need to consider the product maintainability, reliability, validity, information quality and use. In this research, the researcher inferred that even if the project produces a product within budget and schedule as well as meeting its requirements, it has to be maintainable, reliable and valid. If the product cannot meet this criteria, then it may not provide value to the owner organisation hence unsustainable. In other words, any computer networking project traditionally had to meet the cost, budget and time constraints. Over and above that, the computer network as a product of the project has to be maintainable, reliable and valid. The product has to benefit both the organisation in terms of enhanced efficiency, effectiveness, more profits, strategic objectives as well as organisational learning and benefits the stakeholders through content users, social and environmental impact etc. (Davis 2016). From the aforementioned, the researcher noted that it was clear that project success extends beyond the traditional iron triangle. In this study, the wholesome meaning of project success criteria was adopted.

Khan et al. (2013) as cited in Joslin and Muller (2016:3) amalgamated models for measuring project success from literature on success factors for forty years forming a superset of the success criteria from renown scholars on project success. The model equilibrates hard and soft factors and measures twenty-five success criteria variables organised in five categories. The model contains the three criteria popularly known as the ‘Iron triangle’ and more project success criteria attributes of:

1. Project efficacy
2. organisational benefits
3. influence of the project

4. stakeholder fulfilment
5. Future prospects of the project artefact.

The additional success criteria by Joslin and Muller (2016) agree with the one by Davis (2016). They both extended the original success criteria based on cost, quality and time. The extension includes the benefits brought to the organisation, project stakeholders and the community. All these benefits need to be sustainable for true success.

The ‘Triple-test performance framework’ breaks down project success into 3-dimensions as follows (Ata ul Musawir et al. 2017:5):

1. Project management success associated with the iron triangle and is an indication of the manager’s performance in attaining the project agenda as determined by the client;
2. Project ownership success, a measure of the project owner’s performance in realising the business objectives;
3. Project investment success measuring the real quality created by the project outlay as determined by the project sponsor.

The researcher noted that PSOS and PSIS analyse project success from the sponsor’s perspective, where benefit realisation is more important. Arguably the inclusion of these criteria offers a more comprehensive view of project success (Ata ul Musawir et al. 2017:6).

In this study, it was deduced from the triple-test performance framework that the three stakeholders necessary in determining the project success are the project manager, owner and sponsor. It is therefore the perceptions and satisfaction of these three stakeholders that matter most in determining project success. The stakeholders view project success or failure through each other’s work, e.g. the project manager cannot say the project management was successful but the project owner. The sponsor determines project ownership success as a measure of the owner’s performance in realising the business objectives and the project outlay success in terms of the real quality produced by the investment. The project management success in this framework refers to the scope, budget and time as in the traditional iron triangle.

Volden (2018:3) outlines a standardised evaluation criteria used by the United Nations. The framework involves evaluation of a project according to:

1. The relevance or need of the project,

2. Are the resources and time used reasonably? (Efficiency)
3. Were the specified objectives attained? (Effectiveness
4. What other pros and cons may be as a result of the artefact?
5. Will the advantages continue after project completion (sustainability)?

In this research, the researcher noted that in as much as these criteria were more comprehensive, they were developed from the "iron triangle" (Budget, scope and time). It was also noted that items 1 to 3 reflect the iron triangle. Items 4 and 5 provide an extended view in which case the project should be measured against its impact to the business and society and the sustainability of benefits derived from the project outcome. Consequently, it is difficult to say with finality that a project is successful just after its completion for the reason that the sustainability of the product's positive impact can only be measured over time. Though it is hard to establish how sustainable a project artefact is, it is imperative to have a tentative measure of success that does not necessarily include sustainability. Success involves the implications of the project even after project completion. In essence, a computer network is meant to enable the linkage among spatially located entities for purposes of sharing data and information. Therefore, the next important aspect to be considered is how sustainable the network will be and for how long will it continue to benefit the organisation in question.

The researcher noted that literature on the success criteria of projects basically relate to the same items of success. Here project success is measured according to its meeting intended requirements or user expectations within the time and budgetary constraints. This is in line with the traditional iron triangle meaning that at this stage if the project passes, then it meets the ordinary success standard.

1) Were the resources optimally and reasonably utilised? This criterion is two-fold, on one hand we assess if the owner organisation honoured the level and schedule of resource provision. On the other hand we evaluate the efficient use of the provided resources by the owner organisation to the project manager.
2) Value generated by the project investment. Here the real benefits emanating from the project are considered. If a project meets the time and budget constraints, it does not follow that it offers sufficient advantages to the client.
3) Sustainability of benefits. Can the organisation continue to enjoy the benefits after the delivery of the project product?

In this study, challenged projects, those which were delayed by different factors or met a limited number of functionalities, were considered as a failure for the reason of synchronising success with the binary nature of the logistic regression analysis model developed. The developed logistic regression analysis model has only two possible outcomes: success and failure, so the addition of challenged projects could not be handled by the model.

2.8 Mathematical modelling

Mathematical modelling is important in many areas whilst its prospective contributions in yet other domains is gaining momentum (Quarteroni 2009). Different people define a mathematical model differently. A mathematical model is the art of converting challenges from given domain into manageable mathematical constructions whose abstract and mathematical analyses provide intuitions, answers and directions valuable for the initiating application (Neumaier 2004); a simplified representation of some real life unit that can be an equation(s) or source code purposed to imitate important attributes whilst excluding non-essentials (Bokil 2009); a translation of our views on how the world works into mathematical formulations (Lawson & Marion 2008); a set of equations which define the evolution of the state variables (dependent variable) over the independent variables (Bellomo, Angelis & Delitala 2008). This research used the term mathematical model as defined by Bellomo, Angelis and Delitala (2008:6). The definition captures the solution to the main purpose of the study which was to build a logistic regression analysis model to predict computer networking projects' success. The dependent variable in the model was the success of a computer networking project. The independent variables were the computer networking projects' CSFs identified in the study from the meta-synthesis analysis done and the administration of an online survey to computer networking project practitioners.

Mathematical models have broad uses in physics, life sciences, engineering and many other disciplines (Hao Wang 2012). This research was one of the attempts to apply mathematical modelling to computer science. Why do we use mathematical models? Models help us better understand real world systems and are made for specific goals (Quarteroni 2009) with clear assumptions since they are only valid under certain conditions. Bokil (2009) suggests five reasons for using mathematical models. Firstly, mathematical models are used for scientific understanding i.e. a model expresses a hypothesis about a situation and enables one to relate that hypothesis to real life data. Mathematical modelling permits a comprehensive understanding of the system modelled and paves the way for improved design or control of the system (Neumaier 2004). Such models are also important experimental tools for constructing and evaluating concepts, assessing quantifiable speculations, solving precise problems shaping sensitivities to changes in parameter values and approximating important parameters from data (Neumaier 2004).

In this research the model developed helped to screen factors important to computer networking projects' success from the general lists given in literature. Thirdly, mathematical models enable us to use our scientific understanding to manage the world. A model may help predict diseases, weather patterns, the success of a project etc. The researcher deduced that when one has a scientific understanding, he/she can use it to develop models used to manage existing systems or predict events. The logistic regression analysis model built in this study forecasts the success of computer networking projects.

Fourth, Mathematical models can be used for simulated experimentation. A mathematical model is critical when realistic experimentation may be impossible. In cases where say humans are used, researchers cannot carry out tests on people. Instead we can experiment with a model and then infer the results. As an example, trying unapproved drugs on people is not ethical hence unacceptable. Experimentation was not adopted in this research since no danger of any kind was anticipated. All the data that was collected was through questionnaires (hard copies & online) and interviews, of which the participants were not forced to participate. Fifth, the curse of dimensionality. Bokil (2009) notes cases where a purely experimental method is not viable since the data needed for the experiment grows swiftly with increase in the amount of variables rendering modelling with a computer affordable.

2.9 Motivation for using a mathematical model

This section justifies the use of mathematical modelling in the research on developing a logistic regression analysis model to predict computer networking projects' success in Zimbabwe. Firstly, the researcher was motivated to develop a mathematical model to aid computer networking projects' management due to its wide use and success in other fields of study. Mathematical models were found to be of broad use in physics, life sciences, engineering and many other disciplines (Hao Wang 2012). In an effort to minimise the effect of business failure, different models to predict business failure have been created (Wu 2010).

Many researchers developed and successfully implemented mathematical modelling for ICT projects and the following were some of the mathematical modelling techniques used: Nethathe, Waveren and Chan (2011) applied Cronbach's alpha method and principal component factor analysis with varimax rotation; Rebeiro, Antony, Lepikson and Peixoto (2016) used multivariate factor analysis to reduce their number of critical success factors. In business applications, Dimitras, Zanakis and Zopounidis (1996) undertook a survey on business failure focusing on forecasting techniques while Jardin (2015) studied how to enhance the accuracy of failure models in bankruptcy prediction models and Hu et al. (2015) developed a cost-sensitive and ensemble – based prediction model for outsourced software project risk prediction.

Chen (2015) used logistic regression analysis for explaining the variation in the failure of capital projects and high classification accuracy. Saxena (2017) used logistic regression analysis to identify differences in competencies between private and public limited enterprises and Zhou, Wang Zhang and Wei (2014) also used logistic regression analysis in face recognition for classification of facial features.

Various mathematical models previously utilised in predicting various aspects of ICT and related projects are discussed in later sections of this chapter. The models involves Cronbach's alpha method, the Factor Analysis, the Principal Component Analysis, the Multivariate Factor Analysis, the Delphi Method and Logistic Regression Analysis. The idea was to examine how these methods were used in previous studies thereby paving way for deciding which ones could be used in the current study for building a model that predicts computer networking projects' success.

Mathematical models were successfully applied in ICT project management research including research by Dimitras, Zanakis and Zopounidis (1996); Nethathe, Waveren and Chan (2011); Jardin (2015); Hu et al. (2015) and Rebeiro, Antony, Lepikson and Peixoto (2016). Specifically logistic regression analysis modelling was successfully applied in project management research by researchers that include Zhou, Wang Zhang and Wei (2014); Chen (2015) and Saxena (2017). Literature on the successful application of mathematical modelling that include logistic regression analysis gave the researcher confidence to develop a logistic regression analysis model that predicts computer networking projects' success.

2.9.1 The Cronbach's Alpha Method

Cronbach's Alpha test is among the commonly used measures of reliability in research. It describes the trustworthiness of an average of **p** measurements where the **p** measurements can be **p** raters, occasions, or questionnaire items (Bonett & Wright 2014); It is a figure that measures the internal consistency in a group of survey items that a researcher trusts all measure the same thing and are therefore related and could be transformed into a scale (Lavrakas 2008; Bonett & Wright 2014).

In this research, a questionnaire was developed and administered both online and offline. The questionnaire items were tested for their reliability using the Cronbach's alpha test. The threshold value of Cronbach's alpha was 0.7 in agreement with literature. The reliability of Cronbach's alpha may vary with subpopulations, different ages and so on (Bonett & Wright 2014). In this study, respondents to the questionnaire were computer networking project practitioners only, hence there was no issue of subpopulations. Bonett and Wright (2014) argue that reliability should be scrutinised under varied demographic and testing situations and that a confidence interval for the difference in population Cronbach's alpha values could be documented for all desired pairs of demographic or testing situations. This study did not have subpopulations and was carried out in one country, hence the research was not affected by the issue of reliability across demographic conditions. There was also no need to calculate and report on Cronbach's alpha values on any pairs of demographic and testing conditions. Cronbach's test was done for the internal consistency checks on the instrument items.

2.9.2 Factor Analysis

Analysis of large volumes of data is necessary for analysing various phenomena and opportunities in business. Factor analysis is a frequently used tool to handle large amounts of data (Lummas 2012). The main function of factor analysis is to condense data so that associations and trends can easily be interpreted and comprehended. It is used to rearrange variables into a finite and small set of categories according to collective variance (Yong & Pearce 2013:1). The technique is suitable for handling huge amounts of data, as they have a great ability for data reduction and expedite the design of combined variables (Roche 2011).

Factor analysis (FA) is an investigative technique applied to a set of observed variables that strives to find latent factors from which the observed variables were produced (Williams &

Abdi 2010). It analyses the interrelationships in a huge group of indicators in order to comprehend their latent structure, thereby enabling the reduction to a smaller set of aggregated variables (Roche 2011:5) On a lighter scale, factor analysis intends to analyse the relationship between two observable variables and how they are influenced by a different lesser group of unobservable variables (Lummas 2012).

Factor analysis can manage at the same time hundreds of variables, offset random error and invalidity and unravel intricate interrelationships into their main and discrete uniformities. It takes thousands and possibly millions of measurements and qualitative observations and resolves them into discrete patterns of occurrence making it clear and more accurate, the construction of fact-linkages going on perpetually in a person's mind (Rummel 2011).Yong and Pearce (2013) give the broad purpose of factor analysis as to condense data so that relationships and trends can easily be interpreted and comprehended. It reduces a number of variables into smaller groups based on collective variance. Summarising a multitude of measurements into a smaller group of factors without dropping valuable information enables us to achieve some economy of description which is one goal of scientific investigation (Quarteroni 2009). Factor analysis is usually used to reorganise variables into a smaller groups based on common variance.

Factor analysis can be categorised into exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) (Taherdoost, Sahibuddin & Jalaliyoon 2016; Williams, Onsman & Brown 2012; Yong & Pearce 2013).

The researcher employed the exploratory factor analysis (EFA). The idea was that the approach reduced a huge amount of factors critical to ICT projects in general into a smaller and manageable set. The researcher initially did not have an idea on the specific critical success factors that influence computer networking projects rendering exploratory factor analysis the better choice.

2.9.2.1 Exploratory factor analysis

Exploratory factor analysis establish the hidden structure of a given data set by determining shared factors (latent variables), Therefore EFA explains the common variance (Lorenzo 2013; Yong & Pearce 2013:2). Common variance here referring to the shared variance among the variables. EFA is suitable where researchers have no expectations of the number of the factors (Taherdoost, Sahibuddin & Jalaliyoon 2016:2; Williams, Onsman & Brown 2012:4). It enables the researcher to discover the primary variables to formulate a theory or model from a comparable big set of hidden dimensions often represented by a set of items (Taherdoost, Sahibuddin & Jalaliyoon 2016; Williams, Onsman & Brown 2012:4). The major criticism of exploratory factor analysis is its subjectivity and that subjectivity of the researcher is limited by the researcher being systematic, thoughtful and the application of sound judgement to hidden variables and factor reduction and building (Williams, Onsman & Brown 2012; Yong & Pearce 2013).

EFA was used in this research since the researcher did not have any idea on the number and nature of the factors critical to computer networking projects' success. The approach was appropriate since the researcher intended to explore the main variables to create a model to predict computer networking project success from ICT projects' CSFs. To avoid subjectivity the researcher tried to be systematic and thoughtful by using established techniques such as the KMO and the Scree test in the process (Williams, Onsman & Brown 2012).

2.9.2.2 Confirmatory factor analysis (CFA)

This is a form of structural equation modelling (SEM) applied to test the proposed theory by the researcher or model (Taherdoost, Sahibuddin & Jalaliyoon 2016: Williams, Onsman & Brown 2012). It has suppositions and prospects based on priori model and theory about the number of concepts and which concept, theories or models best fit (Williams, Onsman & Brown 2012:4).

The fact that the approach uses structural equations to test a proposed theory, it was found inappropriate for this study. The purpose of the study was mainly the formulation and application of a model to predict the success of computer networking projects. The researcher did not start with a model or theory; therefore there were no assumptions or expectations. The research started by acknowledging the existence of a wide variety of ICT projects' CSFs. Nothing was found on computer networking CSFs from the literature consulted.

2.9.2.1 Components of factor analysis

Factor analysis begins with factor extraction. The principal component analysis is used to extract maximum variance from the dataset with each component thus diminishing a huge number of variables into a lesser number of factors (Yong & Pearce 2013:3). PCA can be used as the first step to reduce the data, then apply a true factor analysis technique (Yong & Pearce 2013). The factor loadings of principal component analysis and factor analysis are fairly related, so rotation has to be done despite the extraction method chosen. (Roche 2011). Factors are rotated to remove ambiguity on those factors. Rotation aims at attaining an optimal simple structure which tries to make every variable load on lesser factors as possible simultaneously maximising on the number of high loadings (Yong & Pearce 2013).

Quantimax and varimax are the two types of rotation under orthogonal techniques. Quantimax rotation entails the minimisation of the quantity of factors necessary to explain each variable whereas varimax rotation minimises the quantity of variables that have high loadings on individual factors making small loadings even lesser.

2.9.2.1.1 Correlation matrix

This is a rectangular array of numbers giving the correlation coefficients between a single variable and every other variable in the investigation (Chetty & Goel 2015; Taherdoost, Sahibuddin & Jalaliyoon 2016). The correlation between a variable and itself is always 1. The correlation coefficients above and below the principal diagonal (with 1s) are identical (Chetty & Goel 2015). Drop any pair of variables having a value less than 0.5 (Chetty & Goel 2015). The off diagonal elements should all be very small i.e. close to 0 in a good model.

In this research a correlation matrix was developed. The matrix was used to select variables to use in the model development.

2.9.2.1.2 Rotated component matrix

Rotation diminishes the number of factors on which the variables under scrutiny have high loadings (Chetty & Goel 2015). Rotated component matrix was employed in maximising high item loadings and minimising low item loadings thereby giving a more interpretable and streamlined solution (Williams, Onsman & Brown 2012:10: Yong & Pearce 2013:6). Rotation thus made interpretation of the analysis easier. Heavily loaded factors on components were identified and used for further analysis. One of the rotational techniques commonly used in factor analysis is Varimax rotation (Williams, Onsman & Brown 2012). The technique produces factor structures that are uncorrelated by reducing the quantity of variables that have high loadings on each factor and tries to make less loadings even lesser (Yong & Pearce 2013).

In this research Varimax rotation was utilised to maximise the high item loadings and minimising low loadings. The technique was suitable since it enabled the researcher to interpret the results with ease and thereby manage to develop a simplified solution in the form of the model.

2.9.2.1.3 Kaiser-Meyer-Olkin index

Kaiser-Meyer-Olkin (KMO) is also known as a measure of sampling adequacy (Arifin 2017; Chetty & Goel 2015). KMO is an overall measure of sampling adequacy for a group of items (Taherdoost, Sahibuddin & Jalaliyoon 2016). It is a comparable measure of the degree of correlation which shows whether it is promising to analyse a correlation matrix or not i.e. the strength of the relationship among variables (Arifin 2017; Chetty & Goel 2015). The researcher checked and dropped factors with either cross loadings on two or more components or factors or items with no loadings on any of the factors (Krishnan 2011). A component that has more than one factors loading on it is considered weak (Krishnan 2011).

2.9.2.1.4 Bartlett's test of sphericity

The purpose of the Bartlett's test is to test the hypothesis that the correlation matrix is an identity matrix (Krishnan 2011; Arifin 2017; Chetty & Goel 2015; Taherdoost, Sahibuddin & Jalaliyoon 2016). This means that the diagonals are ones and the off diagonals are zeros.
A significant result (sig < 0.05) shows that the matrix is not an identity matrix (Krishnan 2011; Williams, Onsman & Brown 2012). In other words, the Bartlett's test is a way of showing the strength of the relationship among the variables. EFA should be applied when the correlation matrix is not an identity matrix (Taherdoost, Sahibuddin & Jalaliyoon 2016). If the KMO indicates sample adequacy and Bartlett's test of sphericity indicates the item correlation matrix is not an identity matrix, then the researcher can move forward with the factor analysis (Taherdoost, Sahibuddin & Jalaliyoon 2016).

In this research the significant result (sig < 0.05) was also considered to indicate that the matrix was not an identity matrix meaning that the variables adequately relate to one another, hence the reason to continue with running EFA.

2.9.2.1.5 Communalities

A communality indicates the degree to which an item correlates with all other items (Krishnan 2011). In other words, it is a table that indicates how much of the variance in the variables is explained by the extracted factors (Chetty & Goel 2015). It is the percentage of item variance explained by the extracted factors (Arifin 2017). The cut off value is guided by the researcher's preferences (Arifin 2017). However, a variable with a low communality (0.0-0.4) may battle to load significantly on any factor (Krishnan 2011) therefore a cut off of 0.5 i.e. 50% of item variance explained is practical (Arifin 2017; Chetty & Goel 2015).

In this research the researcher identified low values in the extraction column and ignored them in making conclusions on the importance of individual factors. The cut off point for the communality was set at a minimum of 0.5.

2.9.2.1.6 Determining the number of factors

The researcher had no idea in advance on how many factors to use, thus he began by performing principal component analysis. Extraction was done without indicating the number of factors. Many ways are available to determine the number of factors to use. These include the Kaiser Eigenvalue >1, the Scree test, parallel analysis and the percentage variance explained (Arifin 2017; (Taherdoost, Sahibuddin & Jalaliyoon 2016; Yong & Pearce 2013:6).

It is highly recommended in factor analysis to use multiple criteria for factor extraction (Taherdoost, Sahibuddin & Jalaliyoon 2016). In any research the researcher should ensure an optimal number of factors since extracting many factors may cause unwanted error variance and extracting very few factors may exclude important shared variance (Yong & Pearce 2013).

In this study, the researcher began by running the principal component analysis without specifying the number of factors. The methods of extraction employed were Kaiser Eigenvalue >1, Cattell's Scree test and the percentage variance explained. The researcher used the three techniques together for cross validation of the techniques. Using more than one technique improves on the weaknesses of an individual method by the other. The results are therefore expected to be robust.

2.9.2.1.7 Percentage Variance explained

Eigenvalues reflect the number of extracted factors whose total should be equal to number of items which are subjected to factor analysis (Chetty & Goel 2015). It is important to note the total amount of variability of the initial variables explained by each factor solution (Rahn 2019). If on the one hand there are say three factors which combined explain most of the variability in the initial nine variables, then those factors can be a good, simpler alternative for all the nine variables. The rest can be dropped without losing much of the initial variability (Rahn 2019). On the other hand, if it takes seven factors to explain most of the variability then all the nine variables may all be used.

The percentage variance is used to establish the amount of variance that the factors explain. The eigenvalues are shown in a table that is divided into three categories i.e. initial eigenvalue, extracted sums of squared loadings and rotation of sums of squared loadings (Chetty & Goel 2015). For interpretation we are concerned with extracted sums of squared loadings (Chetty & Goel 2015). Factors that explain acceptable level of variance are then defined. The greater the percentage of variance a proposed model manages to explain, the more valid the model (Lorenzo 2013). There is the need to report on the percentage explained variance for individual factors and also on the total percentage of explained variances of the retained components (Lorenzo 2013). The reason is to choose an optimum number of components that account for the maximum possible variance. There is no consensus on cumulative percent of variance in factor analysis (Williams, Onsman & Brown 2012), with natural scientists favouring 95% and humanities 50-60% (Taherdoost, Sahibuddin & Jalaliyoon 2016:5).

In this research, computer science was taken as a softer science than the natural sciences but harder than humanities, hence the researcher decided to take the cumulative percent of variance to range between 60% and 80%.

2.9.2.1.8 Variance (eigenvalues)

If principal component analysis is used, the variance equals the eigenvalue (Taherdoost, Sahibuddin & Jalaliyoon 2016). Consequently, the size of the eigenvalues can be used to establish the number of factors. Retain the factors with the greatest eigenvalues (See Table 2.1). For example, using the Kaiser criterion, one can only use the factors with eigenvalues greater than 1. Factors with eigenvalues greater or equal to 1 (≥1) are taken because a factor with an eigenvalue of 1 explains similarly to variance explained by a single variable and the idea is that only factors that explain at least the same amount of variance as a single variable are worth keeping (Rahn 2019; Arifin 2017; Taherdoost, Sahibuddin & Jalaliyoon 2016; Williams, Onsman & Brown 2012). The cut-off value of 1 must be used with care because some important factor just below 1 may be left out or you may end up with more factors (Rahn 2019). In some cases the technique may result in over estimation of the number of factors extracted and so requires a second method such as the Scree test to balance the scale (Yong & Pearce 2013:6).

Table 2. 1: Variance (eigenvalues)

PC number	Eigenvalue	Explained variance (%)	Cumulative explained variance (%)
1	2.96	60.07	60.07
2	0.74	15.09	75.16
3	0.72	14.66	89.82
4	0.25	5.12	94.94
5	0.23	4.70	99.64
6	0.02	0.36	100.00

In this research only factors with Eigenvalues greater or equal to 1 were considered. Apart from the use of eigenvalues to determine the factors to consider or conversely to drop, the Scree test was also used.

2.9.2.1.9 Cattel's Scree Plot/test

The Scree test/plot (Figure 2.2) is a popular method used to establish the number of factors to retain (Taherdoost, Sahibuddin & Jalaliyoon 2016). It is considered the most reliable technique for a sample size of 200 (Yong & Pearce 2013:7). The graph always show the eigenvalues on the vertical-axis and the number of factors on the horizontal-axis. The graph always show a downward curve (Rahn 2019; Chetty & Goel 2015).

The point where the slope of the curve is plainly levelling off shows the number of factors that should be obtained by the analysis (Rahn 2019; Arifin 2017; Chetty & Goel 2015; Taherdoost, Sahibuddin & Jalaliyoon 2016; Williams, Onsman & Brown 2012; Yong & Pearce 2013). Both the Scree plot and eigenvalues were used to determine the number of factors to retain. It was remembered that the idea behind factor analysis is to minimise the huge number of factors that depicts an intricate idea to a small number of interpretable hidden variables (factors) (Rahn 2019).

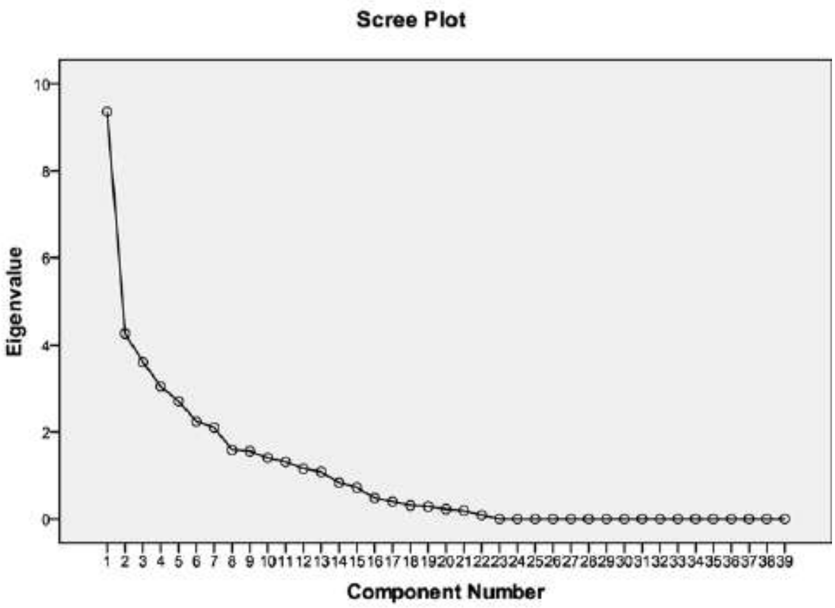


Figure 2. 2: The Scree Plot

However, the interpretation of the Scree plot is subjective as it requires the researcher's judgement and thus, the number of factors to retain and results can vary (Taherdoost, Sahibuddin & Jalaliyoon 2016:5; Williams, Onsman & Brown 2012). The problem can be reduced by increasing the sample size with high communalities.

In this research the researcher employed both the eigenvalues and the Scree test to ascertain the number of factors to keep for analysis. The main reason for using both techniques was to cater for weaknesses of each technique thereby improving on the trustworthiness of the results.

2.9.2.1.10. Interpreting the factors

Interpretation entails the researcher scrutinising which variables are associated with a factor and providing that factor with a name (Williams, Onsman & Brown 2012). The classification of factors is a prejudiced, theoretical and inductive process. Traditionally, for a meaningful interpretation two or three variables should load on to a single factor (Williams, Onsman &

Brown 2012:10). Loadings close to -1 or 1 show that the factor strongly influence that variable. The indications of the loadings show the direction of the correlations and do not influence the interpretation of the size of the factor loading or the number of factors to keep (Yong & Pearce 2013:6). Loadings close to 0 show that the factor has a frail impact on the variable. Some variables may have high loadings on more than one factors. Such variables cause confusion in the analysis and cannot be used.

In cases where rotation is done, rotating factors streamlines the loading structure, enabling one to easily interpret the factor loadings. The rotated loadings can be sorted to help assess the loadings in a factor.

In this research the significance of a variable was considered regardless of the sign on the loading. However, the extent of the loadings was taken into consideration in the interpretation. All the variables with a weak influence were not considered and those variables that had high loadings on multiple factors were dropped. A varimax rotation was later executed on the data. The rotated factors were sorted for ease of interpretation. The interpretation mainly focused on the variables with high loadings of the factors and a composite influence of the high loadings. The researcher took factors that when taken together account for most of responses (Williams, Onsman & Brown 2012).

2.9.2.1.11 Results presentation

The results were reported as follows:

1. Extraction and rotation methods used were specified.
2. The KMO and Bartlett's test of sphericity results were given.
3. The number of extracted factors, in accordance with the employed techniques (the Kaiser Eigenvalue >1 and the Scree plot.
4. Details of the thresholds of the factor loadings, communalities and factor correlations were reported.
5. Details about the repeat exploratory factor i.e. item removed, reductions/increase in the number of factors etc.
6. The percentage variance explained in the final solution.
7. The threshold of the Cronbach's alpha.

8. Summary table including factor loadings, communalities, Cronbach's alpha and factor correlations.

2.9.2.2 Why use factor analysis

Huge data sets comprising many variables can be minimised by observing categories of variables, meaning that factor analysis amasses collective variables into expressive groups (Yong & Pearce 2013). Factor analysis is necessary in research that include any number of variables, questionnaire items, or a group of tests which can be compacted into a lesser number, to get at a hidden idea, and to expedite interpretations (Yong & Pearce 2013: 2).

In this study, the researcher started off with almost one hundred variables (the factors affecting the success of ICT projects obtained from literature). These factors were made into items on the questionnaire used in the online survey conducted. The factor analysis approach was therefore suitable for this study. The method enabled the researcher to reduce the great number of critical success factors for ICT projects into only five that were considered critical for computer networking projects as a particular instance of ICT projects. Factor analysis made it simpler to concentrate limited key factors rather than considering a huge number of variables that may include less important ones. The main argument of this research study was that not all ICT projects were the same and project managers cannot apply the available CSFs across all types of ICT projects. The researcher therefore used the factor analysis technique as part of the methods to screen the critical success factors. The expected end result was the development of a shorter list of critical success factors for the success of computer networking projects (Table 6.1). The research went further to use the resultant shorter set of critical success factors in a logistic regression analysis model to predict computer networking projects' success.

2.9.2.3 Strengths of factor analysis

Exploratory factor analysis has the following strengths (Adapted from Roche 2011):

1. It provides a comprehensive solution with great power of data reduction.
2. Easily handles error.
3. Minimises the possibility of double counting highly similar attributes and handles issues pertaining to measurement error.
4. The factor loadings can be saved and used in future analysis for deductions and model evaluation.

The exploratory factor analysis technique was chosen for the research to benefit from all the stated strengths. The resultant list of computer networking projects' CSFs was an aggregated solution to the establishment of a prediction model for the project success. The large number of available lists of ICT projects' CSFs from various researchers definitely have similar factors written in different ways. SPSS used to do the analysis took care of the factor reduction and the measurement error. The results were also saved for future use.

2.9.2.4 Limitations of factor analysis

In applying exploratory factor analysis, the researcher was aware of the following limitations:

1. Problem of naming factors. Yong and Pearce (2013) indicate that naming the factors in factor analysis may be difficult since names may not correctly reflect the variables in a factor. This was in agreement with Roche (2011) who argues that the final factor scores tend to be difficult to interpret. In this research, the researcher therefore inferred that if this were to happen to factors that influence project management then managers are likely to misfire when trying to monitor the progress of a project.
2. Some variables cannot easily be interpreted due to their loading onto multiple factors, a situation called cross loadings. In this research, however, no split loading occurred.
3. Results of factor analysis cannot be reliable unless the research has a huge sample size at a unique point in time (Yong & Pearce 2013). Roche (2011) points out that combinations and weights may differ every time fresh data is considered, resulting in similarities being more complicated e.g. differences in time scale or nationality. In this research data was collected locally and it was not collected at different times. This limitation therefore did not affect the research results per se but probably the effect can be felt in the future if a similar research is to be executed either in the same country.
4. The researcher cannot get a single aggregation solution since the solution depends on the selection of extraction and rotation methods. In this study, the Principal component analysis with varimax rotation was used to extract the factors. The results of the study thus can only be understood in that regard.

The researcher mitigated the stated limitations by first making sure he named variables using technical terms from the ICT project management fraternity so that they reflect the same issues for every ICT project practitioner. Names like 'Top management support' were used. The second limitation was catered for by using a sizeable number of variables (closer to one hundred) and carrying out the research in the same environment simultaneously.

2.9.3 Principal Component Analysis

Principal component analysis is sometimes computed as an approximation of exploratory factor analysis (Lorenzo 2013). Its aim is to account for as much variance of the observed variables as possible using less compound variables commonly referred to as components (Lorenzo 2013). In other words, its purpose is to extract maximum variance from the dataset in every component thereby lowering a huge number of variables into a lesser number of components (Yong & Pearce 2013:6). In principle, component analysis observes variables that are relatively not error-prone and each unobserved hidden component is a perfect linear aggregation of its variables (Krishnan 2011). It is ideal where data reduction and composite-construction are the goals (Krishnan 2011).

The researcher employed the principal component analysis since the research aimed at determining critical success factors starting with a very big set of factors obtained from literature. The approach was used in conjunction with exploratory factor analysis. The initial variables needed to be trimmed into a fewer set that could further be analysed to obtain those factors critical to computer networking projects. The resultant set of the computer networking projects critical success factors laid the foundation for the development of the logistic regression analysis model that predicts the project success.

In this study, the researcher used the Principal component analysis technique to extract factors that were critical to computer networking projects. The researcher used SPSS to carry out the component extraction. The extraction of factors was effected through forward and backward chaining followed by Kaiser-Normalisation. The researcher also employed the Nagelkerke R-Squared value to measure how the developed logistic regression analysis model accounted for the variation in the dependent variable. It should be noted that the inherent mathematical manipulations involved in factor analysis and principal component analysis were not discussed in this study since they were catered for by SPSS used to do the analysis. It should also be noted that the thresholds used in the principal component analysis were discussed under section 2.9.2.

2.9.4 The Delphi Method/ Technique

Cornel and Mirela (2008) propound that forecasting or prediction can influence decision making to a large extent and that forecasting can either be quantitative or qualitative. Qualitative methods use the judgement of experts to make a forecast and can be applied in cases where historical data is insufficient or unavailable or when forecasted events cannot be described by quantifiable information. The Delphi forecasting method is one example of the qualitative forecasting approaches (Cornel & Mirela 2008; Avella 2016).

In the same light, this researcher inferred that the success of a computer networking project could not be deduced from past successes or failures since they were unique in many ways (team composition, environment, organisation characteristics, availability of resources etc.). Using only this argument, the Delphi method would suit the current study.

The Delphi technique developed in the 1950s was viewed as a process to get reliable consensus of opinion of a group of experts by a series of questionnaires separated by controlled feedback on opinions (Dalkey & Helmer 1963). The same sentiments were echoed by Cornel and Mirela 2008; Donohoe, stellefson and Tennant 2012 and Avella 2016. The Delphi method is a compromise approach employed to establish the level of consent on an issue. It is an iterative process done by the researcher and the professionals in a domain, for the purpose of building themes, requirements, directions or forecasts about a specific topic (Tsaroucha, Boath, Porteous & Write 2015). It is an interactive process with cautiously designed progressive questionnaires with summarised feedback of sentiments deduced from previous responses (Cornel & Mirela 2008; Donohoe, Stellefson &Tennant 2012; Avella 2016; Kenton 2018; Dufresne 2017). The Delphi technique is meant to collect input from participants without requiring them to be interviewed face-to-face. In a pure Delphi study, there is no direct interaction or communication among the experts, to avoid the social processes and possible biases from the group setting (Tsaroucha et al. 2015; Dufresne 2017; Avella 2016).

Panellists are invited to confirm, or to modify, their previous response for the questions that have not yet reached consensus. The goal of most Delphi studies is the dependable and resourceful searching for ideas or the development of appropriate information for decision making (Tsaroucha et al. 2015).

In most cases, the process is used to establish consensus among experts with varied views or perspectives. The method uses an iterative process of problem solving that involves problem definition and discussion; feedback and revisions. The process is repeated for a predetermined number of rounds or until some predetermined condition has been fulfilled (Tsaroucha et al. 2015; Dufresne 2017). The Delphi method was recently developed into e-Delphi in which case recent attempts were made to computerise the traditional Delphi process so as to optimise the method's ability to organise widespread and diverse group thinking, while capitalising on the benefits of the traditional Delphi method (Donohoe, Stellefson & Tennant 2012:4)

The Delphi process is shown in Figure 2.3.

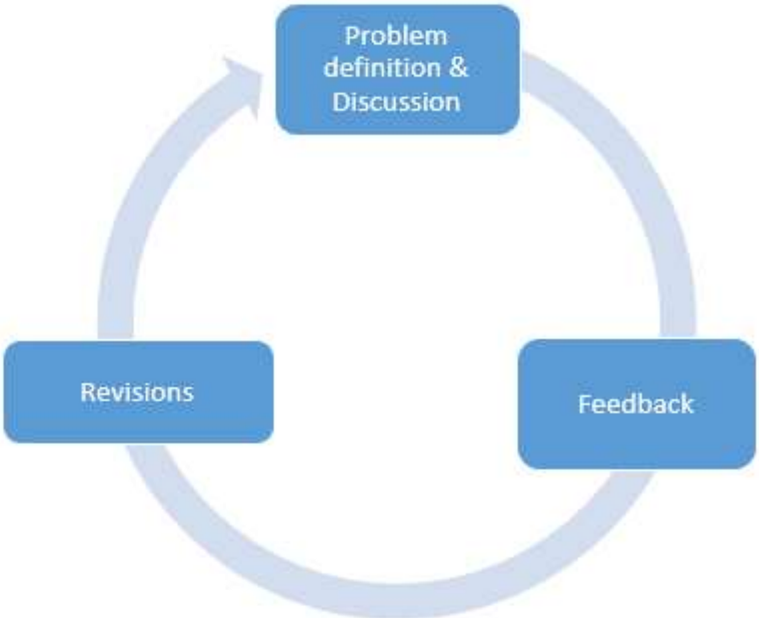


Figure 2. 3: The Delphi Process

(Adapted from Tsaroucha et al. 2015)

The method has a probable huge attrition rate due to the approach often needing long answers in the early phases of the process and the active involvement of the panel members over a lengthy period of time (Tsaroucha et al. 2015).

2.9.4.1 Benefits of the Delphi Method

1. The method is versatile and can be used in any discipline (Cornel & Mirela 2008).It is flexible and simple to use (Avella 2016)

2. The method is cost effective since there is limited financial resources needed to carry out the process (Avella 2016).
3. Participants may be in different geographical areas and does not require bringing everyone together for a physical meeting (Cornel & Mirela 2008; Kenton 2018; Avella 2016).
4. Covers a wide range of expertise by aggregating expert opinions from a diverse set of experts (Cornel & Mirela 2008; Kenton 2018; Avella 2016)
5. Anonymity of participants helps prevent dominance of some experts over others.

This research could have benefited from using the Delphi method since the method can be applicable in any field of study including computer science. The method does not require the use of large amounts of money since the work mainly requires internet connectivity which the researcher had at his work place. The research also needed responses from a wide range of experts situated in different geographical areas and required anonymity of the respondents to avoid dominance by some influential personalities. However, the method was not used because its benefits were outweighed by the drawbacks as discussed in the next subsection.

2.9.4.2 Drawbacks of using the Delphi method

1. Continued commitment is required from participants who are being asked similar questions multiple times but is not guaranteed (Dufresne 2017). Some respondents may drop out when asked to explain their arguments (Avella 2016).
2. Researcher bias - the process is heavily controlled by the researcher such that he/she may influence the result (Avella 2016; Cornel & Mirela 2008). This does not produce a comprehensive and helpful research result.
3. Lacks interactions as compared to live meetings (Kenton 2018)
4. Results depend on the quality of the participants. In many cases top experts in the field can be difficult to rope in (Cornel & Mirela 2008).
5. The scientific nature of the method is questionable, due to the small number of professionals in one domain.

   The Delphi method does not produce statistically significant results, i.e. the results simply represent a synthesis of opinions of the experts in the group (Cornel & Mirela 2008).

To mitigate the challenge of attrition in the Delphi method, Donohoe, Stellefson & Tennant (2012) recommended the following:

1. The researcher needs to select participants with high interest in the research problem.
2. The participants need to be informed of the process and goals at the outset of the Delphi process.
3. The researcher needs to invest in transparency i.e. sharing feedback on the research portal where all communication should be effected.
4. Maintaining communication with the participants and provide regular timelines.
5. Monitor attrition via internet-based survey platform/ portal.

Though the Delphi method was feasible for this study it was not used. The reason was that its drawbacks outweighed the benefits. To begin with, the method requires continual commitment by the chosen participants. These participants in the form of highly skilled ICT projects managers were not easy to come by and rope into the study. Those who were to be roped in could not be persuaded to remain active throughout the research making the results weak. If these top experts failed to be part of the study, the researcher could end up working with fewer and less experienced project practitioners further weakening the research results. Finally the researcher did not choose to use this method due to its limitations as a scientific method which relegates the findings to an aggregation of expert opinions.

2.9.5 Logistic Regression Analysis

2.9.5.1 The essence of logistic regression analysis

In many scientific domains, a shared problem is how to forecast a categorical outcome when there are multiple predictors, which may or may not be responsible for that outcome (Menard 2010). Logistic regression is a proficient and strong way to analyse the impact of a set of independent variables on a binary outcome by measuring each independent variable's exclusive influence (Stoltzfus 2011). It is a special case of a generalised linear regression model. Generally, it is a method to measure the relationship between a binary outcome variable and one or more dichotomous or incessant predictors (Rausch & Zehetleitner 2017). Logistic regression is a well-known non-linear statistical model with a stretchy logistic function presented to establish the fundamental mathematical form of logistic model (Zhu et al. 2018). The logistic function ensures that whatever approximation is given, the result will always be a number between zero and one, explaining why the logistic model is normally the first to be selected when a probability is to be ascertained. The model depicts the relationship between the probability of a binary response variable and a set of related explanatory variables.

This method formed the core of the study. The researcher utilised the method's capability to measure the relationship between a binary outcome variable (the success/ failure of the project) and multiple dichotomous or continuous predictors (the critical success factors for computer networking projects). A link function and a logistic regression analysis model were developed that constituted the primary mathematical form of the logistic regression analysis model. The logistic function ensured that for any estimate given, the result was always a number between zero and one. The method was the most appropriate one since the prediction of project success is a probability and always has a value between 0 and 1 inclusive. Logistic regression analysis enables the analysis of the effect of a group of independent variables (critical success factors for computer networking projects) on a binary outcome (the success/failure of the project) by quantifying each independent variable's unique contribution into the developed link function.

2.9.5.2 The historical perspective of logistic regression analysis

Logistic regression combines two separate mathematical traditions, of which one is the analysis of contingency tables (Menard 2010). Here, all the variables are measured as either dichotomous, nominal or ordinal and in which case the variables usually have comparatively fewer discrete groupings. Expanding from two variables to three variables to multivariate contingency tables result in the construction of log-linear analysis to handle intricacies of multidimensional contingency tables (Menard 2010). The second mathematical tradition is ordinary least squares (OLS) multiple regression analysis. Here, the variables are usually measured at the interval, or are incorporated as dummy variables (Menard 2010).

On the one hand, the original techniques used in log-linear analysis did not handle predictors measured at a continuous interval or ratio scale level very well. The ordinary least squares regression, on the other hand, did not handle dichotomous, nominal or ordinal dependent variables very well (Menard 2010).

Logistic regression comes in different forms. The type or form to use is a function of the nature of the research to be done and the variables (Stoltzfus 2011). With linear regression, linear regression analyses continuous outcomes. It supposes that the connection between the outcome and independent variables pronounce a straight line (Stoltzfus 2011). The regression comes in two forms: simple linear and multivariate linear regression.

2.9.6 Logistic regression assumptions

In using the logistic regression analysis technique, there are assumptions to be considered as noted by Stoltzfus (2011) and Menard (2010), it is a must that one meets the basic assumptions for conducting logistic regression. The assumptions for logistic regression analysis include the following:

1. Independency of error or expected value of error – all sample group outcomes are different from one another, i.e. no duplicate responses. The expected value of error thus, e = 0. Once data include repeated measures, errors are similarly correlated, and the assumption is not obeyed (Stoltzfus 2011)
2. No auto-correlations - it is assumed that no correlation exist in the error terms created by different values of the independent variables. Mathematically this is expressed as:

   $$E\ (e_i, e_j) = 0$$

   Where E **(e_i, e_j)** represents the expected value of the association (correlation or covariance) between $\mathbf{e_i}$ and $\mathbf{e_j}$.
3. Error normality – the errors are normally distributed for every set of values of the independent variables.
4. Homoscedasticity – the variance of the error term, **e**, is the same or constant for all values of the independent variables.
5. Absence of perfect multicollinearity – This means absence of redundancy among independent variables. In case of multiple regression, none of the independent variables is a perfect linear combination of the other independent variables;

   I.e. For any I, $R_i^2 < 1$,

   Where R_i^2 is the variance in the independent variable x_i

   That is explained by all the other independent variables x_1, x_2, $x_3 \ldots x_{j-1}$, $x_{i+1} \ldots x_k$, If any two variables are correlated then they should not both be encompassed in one model. A logistic regression model with highly correlated independent variables normally result in large standard errors for the estimated beta coefficients of these variables (Stoltzfus 2011). The solution is to exclude at least one redundant variables (Menard 2010).

6. Specification – i. all relevant predictors of the dependent variable are included in the analysis; ii. No irrelevant predictors of the dependent variable are included; and iii. The type of the relationship is linear though enabling the transformations of dependent or independent variables (Menard 2010).

In this research it was assumed that all sample group outcomes (i.e. the success or failure of the project in question) were independent of each other, i.e. no duplicate responses were allowed. It was further assumed that there was no correlation among the error terms from different values of the independent variables (the critical success factors for computer networking projects). Another assumption made in this research was that the variance of the error term was the same for every value of the independent variables and that every significant predictor of the dependent variable (critical success factors for computer networking projects) were part of the analysis. Finally, only relevant factors of the dependent variable were part of the analysis. The researcher made sure that these were achieved by the use of the Principal component analysis from SPSS. The Principal component analysis ensured that correlated factors were not treated as different but rather eliminated the redundancy. Correspondingly, there was no correlation among the error terms and no correlation between those error terms.

2.9.5.4 Selection of variables in logistic regression

The method of selecting variables in a model differ depending on the problem and discipline (Bursac, Gauss, Williams & Hosmer 2008). The cautious selection of independent variables is the first important step. Despite the fact that logistic regression is flexible since it allows many varied types, one has to justify the approach to the selection using known and approved theory, previous studies etc.(Stoltzfus 2011).

A usual tendency in mathematical modelling is minimisation of variables to the level that the most parsimonious model that depicts the data is reached which results in mathematical stability and generalisability of the results (Bursac, Gauss, Williams & Hosmer 2008). One way may be to start by including all the variables irrespective of their univariate results since they may be influential in a way notwithstanding their mathematical performance. One must be cognisant that a huge number of variables in the model may produce mathematically unstable outcome, with low generalisability even below the current study sample (Stoltzfus 2011). A different school of thought suggests inclusion of all significant variables in the model despite their importance in order to control confounding (Bursac, Gauss, Williams & Hosmer 2008). The method, however, can cause numerically unstable estimates and larger standard errors (Bursac, Gauss, Williams & Hosmer 2008). Thus, it is critical to acknowledge and account for the role of potential confounders (Stoltzfus 2011). A confounding variable is one whose relationship with both the outcome and another independent variable obscures the true association between that independent variable and the outcome. There are several methods to select variables e.g. forward, backward and stepwise selection.

The researcher used forward selection and backward selection (in SPSS) to select variables. The ensuing subsections discuss forward selection and backward selection as ways of component extraction.

2.9.5.4.1 Forward selection

In forward selection the score chi-square statistic is calculated for every effect outside the model and determines the greatest of them; if it is significant at some entry level, the matching effect is added to the model. Once that effect is put in the model, it is not removed from the model. The process is done until none of the remaining effects meet the specified level of entry (Bursac, Gauss, Williams & Hosmer 2008). The researcher used SPSS to perform the forward selection and the resultant factors or variables are included in chapter six.

2.9.5.4.2 Backward elimination

In this case the results of the wald test for each parameter were scrutinised. The least important effect not meeting the level of remaining in the model was eliminated. Once an effect is eliminated from the model, it remains so. This procedure was iterated until no other effect in the model met the given level for elimination (Bursac, Gauss, Williams & Hosmer 2008). SPSS was also used to perform the backward selection. The resultant factors or variables are discussed in chapters five and six.

2.9.5.4.3 Stepwise selection

The same applies to forward selection with the exception that effects currently in the model do not mandatorily remain. The effects are included and excluded from the model in such a way that each forward selection phase may be succeeded by at least one backward elimination phases (Bursac, Gauss, Williams & Hosmer 2008). The stepwise selection process stops if no more effect can be included in the model or if the effect just entered into the model is the sole effect eliminated in the succeeding backward elimination. The researcher did not use this selection methods since it had no value addition to what was obtained from the forward and backward selection.

2.9.5.5 Number of variables to include

It is not enough to determine which variables to include but also there is need to establish how many variables are appropriate (Stoltzfus 2011). The challenge in doing this is the selection of the least number of those variables that largely explain the outcome while being cognisant of sample size constraints. An example is having thirty people and thirty independent variables in the logistic regression model resulting in an overfitting model. This means that the model will have projected beta coefficients for independent variables that are a lot bigger than they should be and greater than the expected standard errors. All in all, the model become unstable because the logistic model expects that there be more outcomes than independent variables to repetitively cycle through varied solutions in search of the best model fit for the data via the process of maximum likelihood estimation (Stoltzfus 2011).

In as much as researchers need to lower the number of variables to a minimum, there is no collectively agreed standard of choosing the right number of outcomes for preventing an overfit model but there exist some rules of thumb that can be used. For each independent variable, there exists no fewer than ten outcomes for every binary group. There is no common agreement on this since some researchers argue for more than ten whilst others for even fewer than ten depending on the research (Stoltzfus 2011).

2.10 Model building strategies

The basic purpose of mathematical modelling is to translate real life problem situations into mathematics. In addition, mathematical modelling reveals new relations among phenomena embedded in the situations by organising them (Erbas et al. 2014). In this study, the revelation

was the insights developed into the factors critical to the success of computer networking projects rather than grouping them together into ICT projects critical success factors.
The challenge with problems found in science and engineering comes from the intricacies of the systems in question and models give a sufficient tool to split this intricacy and make a problem manageable (Velten 2009:3). The foundational strategy that scientists and engineers use to break system complexity is simplification i.e. if something is complex, make it simpler. This means that the best model is the unsophisticated model that produces the desired output i.e. which remains intricate enough to assist us comprehend a system and to provide a solution to the problem (Velten 2009:4).

It is important to identify the correct type of model for a study (a logistic regression model in this case). Selecting the model construction approach is closely related to selecting independent variables. Therefore, these two components should be applied at the same time when executing a logistic regression analysis (Stoltzfus 2011). In general, three model construction approaches exist that are applicable to regression techniques, namely direct, hierarchical and statistical approaches (Stoltzfus 2011). Zhang (2016) expresses these approaches as purposeful selection of variables, stepwise selection and best subsets. It is important for one to identify the most suitable model for one's intentions since these approaches are not interchangeable i.e. they provide varied model fit statistics and independent variable point estimates for the same data. None of the model building strategies was proved to be superior to others (Stoltzfus 2011; Zhang 2016). The model building strategy is partly science, partly statistical and partly common sense (Zhang 2016). However, it is recommended that the researcher selects as less variables as possible but leaving the model still reflecting the true outcomes of the data. In any model building strategy, variable selection is the first step (section 2.9.5.4). Surprisingly, many studies do not explicitly state the model building strategy, a situation which compromises the reliability and reproducibility of the results (Zhang 2016).

The default technique is the direct model building because it puts all independent variables into the model simultaneously making no suppositions about the order or comparable value of these variables. All the variables have the same importance at the beginning of the regression analysis. It mostly suits situations where there are no a priori hypotheses about which variables have more importance than others (Stoltzfus 2011).

The hierarchical approach entails the addition of variables serially to determine if they continue enhancing the model depending on their pre-determined order of priority. This method is practically helpful in elucidating trends of causal relationships among independent variables. However, it can be difficult as the causal trends grow in complexity, resulting in it being more complicated to have precise and concrete deductions or inferences from the data in some cases.

The stepwise approach determines independent variables to include or exclude from the model. This is achieved relying on predefined mathematical criteria that are directed by the outstanding characteristics of the sample analysed (Stoltzfus 2011). The approach comes in different forms, including forward selection and backward selection. It is important to note that stepwise regression is in a way contentious due to its reliance on automated choosing of variables that tends to benefit from random chance factors in a specified sample (Stoltzfus 2011). Because of this fact, stepwise regression may be left to preliminary screening or hypothesis testing only. Also, all types of model need validation before they are accepted for the future because models are naturally anticipated to work better with the initial sample than with the succeeding ones.

2.10.1 Internal and external model validation

Logistic regression models are regularly applied in forecasting a dependent variable from a group of independent variables (Hyeou-Ae 2013). Once a model has been developed, it needs to be tested or validated (Salija, Bilandzic & Stanic 2017). Several approaches have been proposed to estimate the performance of models (Steyerberg, Harrel Jr, Borsboom, Eijkemans, Vergouwe & Habbema 2001). Study parameters, for example, sample size, can be vital in selecting a suitable method to validate a linear regression model. The dilemma is on determining whether results of the logistic regression analysis on the sample can be extrapolated to the entire population from which the sample was drawn (Hyeou-Ae 2013:7).

In model validation, normally, the whole data set is divided into two subgroups: the training sample and the test sample, in which case the train sample is used to build the model and the test sample for testing how well the model works (Salija, Bilandzic & Stanic 2017; Steyerberg et al. 2001). For the establishment of internal validity of model results in the same data set, Stoltzfus (2011) identifies the four methods which are commonly used.

The first such method is the k-fold cross validation or dividing the sample into k – number of distinct and equal sized subsets (folds) for model construction and validation purposes. The second method is the holdout method in which dividing the sample into two independent groups before the model construction is done with the training group used to produce the logistic regression model and the test group used to validate it (Stoltzfus 2011, Steyerberg et al. 2001) i.e. developing the model with a sub-sample of observations and validating it with the remaining sample (Hyeou-Ae 2013). Thus, the model performance is determined on similar but independent data (Steyerberg et al. 2001:2). The third method is called the leave-one-out used for cross validation. It is a type of the k-fold method in which the number of folds equals the number of subsets in the sample. The model can be validated by producing a model and approximating its coefficients in one data set and then using this model to forecast the outcome variable from the other data set and checking the residuals (Hyeou-Ae 2013).

The fourth approach is varied types of bootstrapping i.e. getting repeated sub-samples with replacements from the whole sample group. One must attempt external validation in a fresh study scenario as more proof of statistical validity and clinical importance (Stoltzfus 2011; Hyeou-Ae 2013; Salija, Bilandzic &Stanic 2017) (chapter seven). If any red flags are raised, either adjust the model accordingly or clearly formulate any constraints for the model's future use. The most common standard measures used for this purpose are the Kolmogorov–Smirnov (KS) statistic, the ROC curve and the confusion matrix (Salija, Bilandzic & Stanic 2017).

2.10.2 Interpreting model output

One benefit of logistic regression is that interpretive results are obtained since the regression coefficients represents odd ratios (Steyerberg et al. 2001). Peng, Lee and Ingersoll (2014) assert that researchers need to include sufficient information in reporting model results. In documenting and interpreting logistic regression results, Hyeou-Ae (2013) in agreement with Peng, Lee and Ingersoll (2014) identify four types of information that need to be presented:

1. Overall evaluation of the model. The mathematical importance of each regression coefficient tested using Wald Chi-square statistic should be indicated i.e. slope, test of the intercept (p<value), and if (p<value is significant then the intercept has to be part of the model (Hyeou-Ae 2013).
2. Statistical tests of individual predictors. Inferential statistics including likelihood ratio score and Wald tests should be included.

3. Goodness-of-fit statistics. The researcher should include the inferential goodness-of-fit e.g. Hosmer-Lemeshow test or the Chi-Square statistic. If the Hosmer-Lemeshow test is insignificant it indicates that the model correctly fits the data.
   With small sample sizes, the Hosmer-Lemeshow test was proved to be less powerful hence requires large sample sizes exceeding four hundred.
4. An assessment of the predicted probabilities. The extent to which predicted probabilities are in line with the real outcomes in a classification table. Compare the overall correct prediction with the chance level of 50% (Hyeou-Ae 2013).
   In interpreting the logistic model output one has to consider two things: assessing the overall model fit and the interpretation of the individual variable results.

After creating the logistic regression model, establish how well the model fits the sample data as a whole (Stoltzfus 2011). Commonly used methods of determining model fit are the Pearson Chi-Square and the residual deviance statistics. Both methods ascertain the difference between observed and the predicted outcomes. Inadequacy of model fit is shown by greater test values showing a greater difference. In as much as model fit indices are important parts of logistic regression, one should also make use of diagnostic statistics before getting to any deductions about the sufficiency of the final model (Stoltzfus 2011). These statistics assist in establishing whether the overall model fit does not change for all possible arrangements of the independent variables.

2.10.3 Application of logistic regression

Logistic regression analysis is an important research approach due to its flexible use in different study situations (Stoltzfus 2010). It may be used to establish relationships between an outcome and independent variables abundantly known as covariates, predictors and explanatory variables or to establish how well an outcome is predicted from a set of independent variables. The logistic regression model was in use in many fields such as medicine healthcare and finance (Zhu et al. 2018).

In some circumstances, it is more precise and efficient than other multivariate mathematical approaches such as frequency ratio and bivariate statistics etc. (Menard 2010). Logistic regression has very wide applications as indicated by Menard (2010) who cites its success in the prediction of lightning strikes at Kennedy Space Centre and Landslide hazards in Kansas.

Examples of the application of logistic regression analysis indicate that it can apply to both hard and soft sciences (Menard 2010).

Selected work explored the fields in which logistic regression analysis has been applied before. This work included papers by Zhu et al. (2018) and Nakamoto, Nishikubo and Kobayashi (2018). Zhu et al. (2018) present a simple process that uses logistic regression algorithm for geological risk and favourability evaluation. They analysed three important parts, namely, evaluation units, variables and models. The process seeks the quantifiable associations between the hydrocarbon occurrence and important geologic factors anchored on earlier exploratory drilling results.

2.10.4 Examples of the success of logistic regression analysis modelling

Geological risk and favourability evaluation

Geologic factors were found to be important to geological risk and favourability evaluation. Zhu et al. (2018) identify geological factors as commonly involving the geological elements e.g. source and reservoir and processes e.g. generation and expulsion that were important for the occurrence of hydrocarbons. Zhu et al. (2018) took the fundamental geological variables consequent of their regional study and petroleum system analysis and vetted them depending on the availability and usefulness in a specified subsurface condition. Logistic regression exposes the exceptional influence of individual variables after altering for others. Detecting independent variable influence in logistic regression starts with the equation (Stoltzfus 2011):

$$\text{Probability of outcome } (\bar{Y}_i) = \frac{e(\beta 0+ \beta 1x1+ \beta 2x2+\cdots+ \beta ixi}{1+e(\beta 0+ \beta 1x1+ \beta 2x2+\cdots+ \beta ixi}$$

A binary outcome given as a probability must be between 0 and 1. The independent variables in linear equation could potentially take any number (Stoltzfus 2011).

The logit scale handles this challenge by mathematically converting the initial linear regression equation to produce the logit of the odds of being in one outcome group ($\bar{Y}$) versus the other group (1- $\bar{Y}$).

Zhu et al (2018) represented the same basic regression model as:

$$\text{Logit (p)} = \ln(\frac{p}{1-p}) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_m x_m \qquad (1)$$

$$P = \frac{\exp(\beta 0 + \beta 1x1 + \beta 2x2 + \cdots + \beta mxm}{1 + \exp(\beta 0 + \beta 1x1 + \beta 2x2 + \cdots + \beta mxm} \quad (2)$$

(Zhu et al. 2018; Stoltzfus 2011).

Where **p** stands for the probability of hydrocarbon occurrence showing the likelihood that an object might contain hydrocarbons at a certain place;

where x_1, x_2, x_3, …,x_m are the instrumental geological variables regulating hydrocarbon accumulation β_0, β_1, β_2, β_3 and so on are the model parameters (coefficients) (Zhu et al. 2018).

The **m** represents the number of selected variables, and

Logit (p) is the logit transformation of p(x) by the natural log of the odds.

Beta values (model parameters) for model fitting were computed from the maximum likelihood estimation method. This method calculates the values of the unspecified parameters by maximizing the chances of getting the observed set of data (Zhu et al. 2018). Logistic regression provides, through repetitive cycles, the most powerful linear combination of independent variables that raises the likelihood of revealing the observed outcome called maximum likelihood estimation (Stoltzfus 2011).

The likelihood function: $l(\beta) = \prod_{i=1}^{n}$ piyi(1-p_i) 1-y_i (3)

Taking natural logs of both sides

$L(\beta) = \ln[l\ (\beta)] = \sum_{i=1}^{n}[yi \ln(pi) + (1 - yi)\ln(1 - pi)$ (4)

Where a sample size **n** independent observations is assumed.

It is depicted as (x_i, y_i), I = 1, 2, 3… n);

Y_i is the value of the dichotomous outcome variable (hydrocarbons occurrence).

X_i is the value of the independent variable (Zhu et al. 2018).

Food texture evaluation

Nakamoto, Nishikubo and Kobayashi (2018) proposed a food texture evaluation method founded on a magnetic food texture sensor. The sensor had two distinct sensing components that acquired time series force and vibration data during food fracture (Nakamoto, Nishikubo & Kobayashi, 2018). The feature quantities derived from the measured waves were used to determine food textures using logistic models. The models evaluated food textures in laboratories via experiments. The findings showed that the planned evaluation method was applicable in visualising food textures using radar charts.

The quantification of the food textures was done using a logistic regression model that allowed any real data **k** and takes values between 0 and 1 as an output. Nakamoto, Nishikubo and Kobayashi (2018) puts the logistic regression equation as:

$$P(K) = \frac{1}{1+e(-k)} \quad (1)$$

It was assumed that **k** is a linear function of multiple explanatory variables

$X = (x_1, x_2, x_3 \ldots x_r)$.

Therefore, $k = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_r x_r$ (2)

In this case the multiple explanatory variables were the feature quantities obtained from the time-series data. The food texture is interpretable as a conditional probability p (k) under the condition x (Nakamoto, Nishikubo & Kobayashi 2018). The parameters $\beta = (\beta_0, \beta_1, \beta_2 \ldots \beta_r)$.

In the research by Nakamoto, Nishikubo and Kobayashi (2018), the logistic regression model was also successfully used to predict an important element namely the food texture which is an important aspect in the food industry.

In this study, the researcher noted that there were many situations in which logistic regression analysis modelling was applied with notable success. This section gave only two success stories of the model. The researcher identified the critical success factors for computer networking projects (Table 6.1). Like in the case of Zhu et al. (2018), the researcher screened ICT projects' CSFs from literature using the principal component analysis with Varimax rotation followed by Kaizer- Normalisation (chapter five). This resulted in a fewer number of critical success factors that were critical specifically to computer networking projects. In this research the experimental approach was inappropriate since the computer networking projects' CSFs cannot be determined experimentally.

The researcher as a result had confidence in trying out the logistic regression analysis modelling in predicting the success of computer networking projects. No study was done before on CSFs of this category of projects nor their success prediction.

2.11 Designing and developing mathematical models

2.11.1 Properties of good models

Researchers use different approaches in the design and development of mathematical models. Oyediran (2016) identified properties that he suggests for any mathematical model as:

1. **Validate the model**. In this case every model needs to be tested. Empirical data is used to verify whether the results obtained from the model actually reflect reality.
2. **Sensitivity analysis**. Check if the results from the model on one scenario is applicable to other scenarios. The model output should be comparable to the data available and sensitive to various changes.
3. **Error analysis**. Make sure that the difference between the results from the model and the real life data must be very small. In other words a good model must produce least error.
4. **Model weakness**. Identify and document the conditions that would limit the performance of the model.
5. **Model strengths**. Identify and document investigation conditions for which the model performs well.

In this study, the suggestions by Oyediran (2016) were incorporated as indicated and effected in chapter seven. Model validation, sensitivity analysis and error analysis were included in chapter seven. In chapter eight the weaknesses and strengths of the models developed were discussed.

2.11.2 Design and development

There is no strict procedure in mathematical modelling for reaching a solution by using the given information (Erbas et al. 2014:2). According to Salija, Bilandzic and Stanic (2017), model development considers variable inclusion and selection, logistic regression model assumptions, multicollinearity and interpretability of the model. Variable selection was covered in section 2.9.5.4. In addition, assumptions of the model, multicollinearity and interpretability of the model were catered for.

Research is a cyclical process that includes multiple cycles (Erbas et al. 2014; Frejd 2014; Squires & Tappenden 2011). Figure 2.4 shows the cyclic nature of research. The essence of mathematical modelling stems from the existence of two worlds in life, namely, the reality and mathematics as shown in Figure 2.4. Phenomena occurs in real life and results are observed. On the contrary, in the mathematics world, mathematical models are built and used, and their results observed/recorded. Man uses the modelling to understand real world phenomena. This is achieved through comparing results from mathematical models and real life model results. The comparison produces similarities and/or disparities between the reality and the perceived reality which prompts either the refinement of the mathematical model or the formulation of new models to explain the emergent phenomena. The same process occurs again, hence the cyclic aspect. Figure 2.4 summarises the activities involved in the cycle of research.

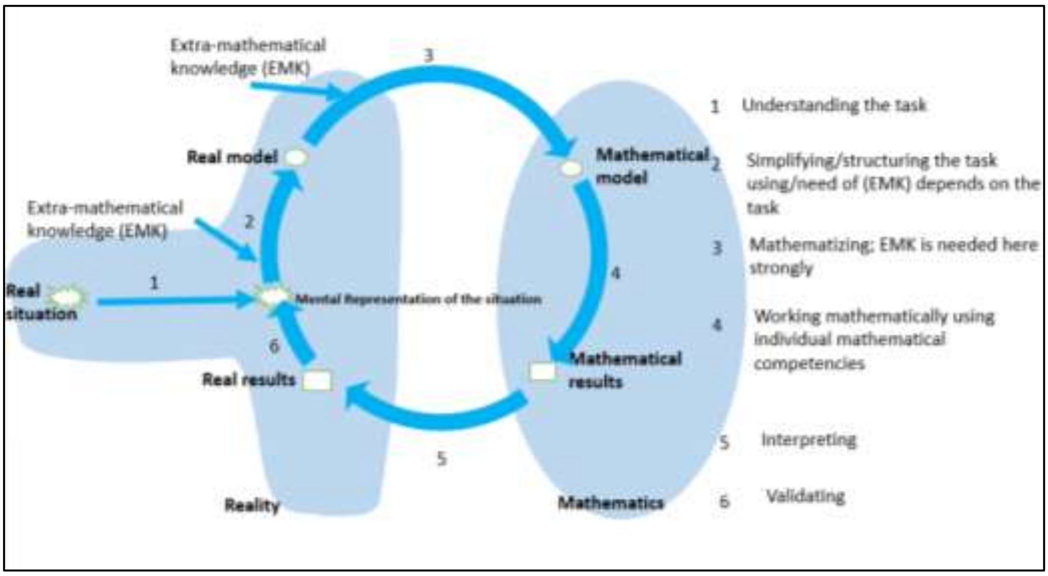


Figure 2. 4: Bloom and LeiB Modelling Cycle

(Adapted from Frejd P 2014)

Modelling is a non-linear process that includes five interrelated steps:

1. Identifying and simplifying the real world.
2. Building a mathematical model.
3. Transform and solve the model.
4. Interpret the model.
5. Validate and use the model.

These steps identified by Erbas et al. (2014) agree with Wang (2012). Wang (2012) proposes a process that can be used for modelling. He puts it in the form of a flow chart. This research followed Wang's (2012) guidelines on developing the Logistic Regression Analysis Model for predicting the success of computer networking projects (Figure 2.5).

The first step was to define the real world phenomena or data under study. In this case it pertained to data about critical factors ICT projects' success. This data was the foundation for building the logistic regression model to predict computer networking projects' success.

The next phase was to formulate simplified assumptions upon which the research was conducted. The third stage dealt with the actual model development (chapter six). The developed logistic regression analysis model was analysed followed by computer simulation (chapter seven).

The third stage was the derivation of mathematical inferences originating from the analysis and model simulation (chapter eight). The mathematical inferences were interpreted for the researcher to make real world conclusions, in this case, the computation of values indicating the possible success or failure of a computer networking project. The real world data from the first step was used to calibrate the developed model so that it measured exactly what it was supposed to measure. The last activity was to validate the model constructed (chapter eight). The validation was aimed at determining the correctness and value of the model developed.

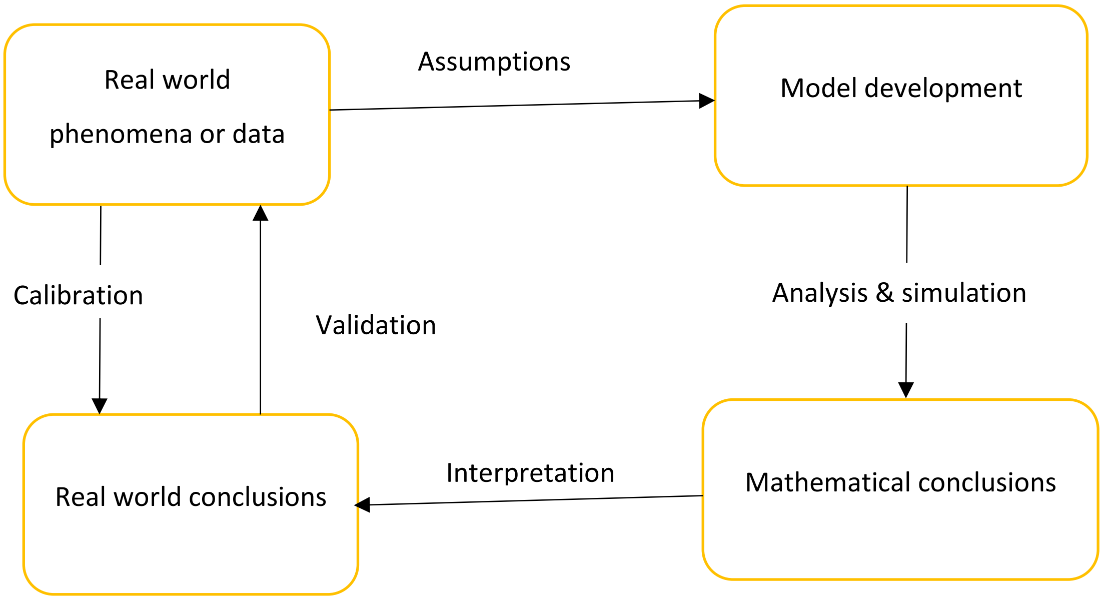


Figure 2. 5: The modelling process

(Adapted from Wang 2012)

A mathematical model is an attempt to describe a natural phenomenon quantitatively (Cain 2014:1) or an abstraction of reality or simplified representation of some real world entity (Bokil 2009). Models of natural systems (such as computer networking projects) always incorporate assumptions regarding the system modelled (Cain 2014). When the assumptions are not met, the model performs badly. There are many ways of constructing models and when studying models, it is important for the researcher to identify categories of models (Marion 2008:4) and to select the most appropriate model for the situation. One way of categorising the models is by using the type of outcome they predict. Basically, every model is either deterministic or stochastic (Cain 2014).

In this research, the researcher identified the following categories of models before making selections.

2.11.4 Algebraic equations

These represent the exact algebraic relationships between important variables. Algebraic models determine what would happen if a quantity changes (Cain 2014). They, however, do not show how those quantities change. Equations are convertible into computer code to provide mathematical answers to state variable trajectories (Bokil 2009).

This study was mainly concerned with building a logistic regression analysis model to forecast computer networking projects' success. Important variables here were the success of the project and the different variables representing the CSFs for computer networking projects. The essence was to see how the success is determined from the CSFs as variables. The fact that there was no need to the relationship could not be well represented by algebraic expressions because they varied.

2.11.5 Evolution equations

Evolution equations contain derivatives i.e. rates of change of dependent variables with respect to time (Cain 2014). The researcher was not concerned with the rate of change but the probability of success of the project rendering this type of modelling inappropriate.

Statistical/ empirical models

They quantify relationships between random variables (Cain 2014). The models ignore the mechanisms by which variations in the system take place (Marion 2008). In other words, the study was concerned with the relationship between the success of a project as the dependent variable in the logistic regression model and the CSFs as the independent variables. The prediction was hinged on the effects of these independent variables to project success. CSFs may be the same but they influence the success of a project differently depending on other factors such as the environment or economic climate. This modelling technique was employed to design the logistic regression analysis model since the researcher was concerned with the relationships only and not the mechanisms by which the circumstances around these variables vary. In this study, it was adequate to give a comprehensive account of the setting of the research not the mechanisms or circumstances causing changes in that setting.

Deterministic models

In deterministic models the initial state of a system completely determines all future states (Cain 2014: Bokil 2009). These models do not take random variation into consideration and always produce the same outcome from a certain starting point (Marion 2008).

At the initial stage of the study, the researcher highlighted that there were no CSFs for ICT projects and computer networking projects in Zimbabwe. The realisation motivated the researcher to use a unique three stage process of enquiry (meta-synthesis analysis, questionnaire and interview) to establish these. A deterministic model design could not work since the research did not start from a predefined state of affairs and the researcher expected to get different prediction results based on the conditions (values corresponding to the CSFs). In addition, this type of model ignores random variation that characterise different project settings.

Stochastic models

Stochastic models being statistical in nature predict the spread of likely outcomes (Marion 2008). These models take randomness into account (Cain 2014).Stochastic models provide plenty results according to the actual values that the random variables obtain in individual cases (Bokil 2009). With stochastic models, one can repeatedly simulate outcomes by generating random numbers and joining a big number of simulations to estimate the spread of the outcomes (Marion 2008).

This study used the stochastic model design. The design was mostly suitable due to the fact that the research's main objective was to build a logistic regression analysis model that predicts computer networking projects' success. In itself it is a statistical model. Secondly the study used CSFs that varied according to different project teams and environments, therefore, the chosen model design needed to cater for randomness in the values assigned to the CSFs. Third, in different project settings, the predicted value for project success varies hence the model should provide a huge number of varied findings based on the given inputs. Lastly, the researcher needed to test the model using simulations and this was possible with stochastic models.

Continuous models

Time is considered as a continuous variable (Cain 2014). Continuous models use differential equations as the building blocks of the model (Bokil 2009). In these cases, the differential equations model the relationship between variables with specified limits. The current study considered project management in a natural setting that had no limits. The model did not have to determine patterns of variables in a continuum of time. The purpose of predicting the project success was to determine the probability of that project to succeed. The logistic regression analysis model did not fall under this category.

Discrete models

Time is considered to be discrete (Cain 2014). The models use difference equations as their main constructs (Bokil 2009). In the project time was not an issue. The model can be applied any time and at any stage in the life cycle of a computer networking project. As a result, a discrete model was not suitable for this research.

Mechanistic models

These models use a lot of theoretical information describing the occurrences at each level of a hierarchy by taking into account processes at lower levels (Marion 2008). Mechanistic models begin with an account of the way nature might work. They give a group of estimates associating the independent and dependent variables (Bokil 2009).

In a mechanistic model, the factors on the ground are recognised within the confines of the concerned project. The modelling approach was appropriate for this study since the prediction of project success starts by the circumstances in the project environment. The researcher described the research setting and administered a questionnaire to obtain the perceptions of the project team and its stakeholders. The responses were coded and fed to the developed model to predict the success of the project. It follows that different values (probability of success) were attained from different values of independent variables (CSFs).

Analytic models

Analytic models are methods of exploring dynamics over time in which they separate the outcome on one side of an equation and all the determining factors on the other. An analytic model, therefore, shows how the outcome is determined from the input. Exploring indicates that the dynamics in the project process are not known in advance. The starting point of prediction in this research was the administration of a questionnaire to the project team members. The responses were the determinants of the project success. The developed logistic regression analysis model had the project success on one side and the determinants on the other. Hence, the researcher considered the analytic design technique as part of the model design.

Computational models

In the same way as the analytic models, the computational models explore dynamics over time but are employed where there are non-trivial feedback loops in the process for the result to be on either side of the equation. In these cases, computational solutions are suitable for models that intends to construct in realistic heterogeneity (Cain 2014). The process of project prediction is not cyclic as such there were no feedback loops to consider. Computational modelling was for that reason inappropriate for this study.

The logistic regression analysis model developed in this research was stochastic, statistical and analytical. In addition, it employed the mechanistic principles. The comprehensive aggregation of these modelling approaches resulted in a powerful prediction model that is reliable.

2.11.6 The don’ts of mathematical modelling

As a guiding principle, this research followed the don’ts of mathematical modelling identified by Velten (2009) as follows:

1. Do not think that the model is real. This means that the researcher was cognisant of the assumptions made when evaluating it. Due to this guiding principle, the researcher included a section on the weaknesses of the model or areas of its improvement in chapter eight.
2. Do not extend the findings outside the area of fit. The model needs to be used only to predict in the region where it is adequately sustained by the data. Though no experimental data was collected in this study, the equivalence was the data gathered during interviews. The researcher therefore, in concluding the research and giving recommendations, drew lines between where this model is able produce valid results and where it may not, unless or otherwise some modifications or recalibrations were made.
3. Do not distort reality to fit the model. In this study, the researcher always adjusted the model whenever it failed to match reality. The purpose of this was to avoid distortion of reality so that the model is viewed as a success.
4. Do not keep a failed model. If ones testing proves that the model does not perform to the level expected, then it must be discarded. The researcher validated the model (chapter eight) and the tests showed that the model performed well, hence retained the model for future use. The fact that the reality was not distorted to suit reality and the tests producing positive results indicated that the developed model was viable and not discredited.
5. Do not blindly support your model. The researcher used all possible ways to critique the model such that the true picture was obtained and documented.

Points 3-5 required the researcher to drop models which failed validation. All these factors meant that the researcher always needed to use the models with care.

2.12 Simulation

Simulation is the exploitation of a model in a manner that it works in time or space (Underger 2008); it is the artificial operation of real life processes over time and encompasses the creation of synthetic history and observation of that history (Singh 2012); or the use of a mathematical model to establish the reaction of the system in various scenarios (Oyediran 2016). Computer simulation is now an important component of science and engineering (Oyediran 2016).

There are several reasons why researchers use simulation. Underger (2008) gave the reasons for simulation that include: that it enables one to view the relations that would otherwise be deceptive due to their isolation in time or space, testing all facets of a envisaged change or addition without utilising resources to their attainment, allows one to quicken or slow down occurrences so as to study them better and exploring possibilities without the need of experimenting with the real world systems.

2.12.1 Simulation steps

The first step was to develop the model. In this case the researcher developed a logistic function coupled with its link function (chapter six). The model ensured that there was objectivity in any circumstance in which the model was applied.

The second step was to simulate the model (chapter seven). This is when historical, current or anticipated data was fed into the simulated model. Results were produced based on the supplied data.

The third step involved analysing those results from step two. This made it possible to deduce or observe future implications from the model. In this project, that involved the prediction of the success of the computer networking project. The value produced by the model indicated how well the project is expected to fare.

Step four was learning from the model. Since the results of a simulation are mainly a function of its input, what we obtained from the logistic regression analysis model showed the direction in which the project was likely to take given certain input variables. In this research if the predicted results indicated possible failure, then there was the need to identify the factors that were influential. Once those factors were identified and analysed, the project management team could devise a way of improving on those factors. The aim here was to get and use the simulation results to improve the performance of the project in question.

The fifth step was to revise the model and simulation. There are cases where the results may indicate a misnomer between the model and the simulation. In such cases, the developers of the model need to look into the compatibility issues between the model and the simulation. In this research no such cases arose. In the event of any disparities, revision of either the model or the simulation or both should be done. Finally, the five steps were repeated until an adequate level of understanding was developed.

Figures 2.6 and 2.7 show the process of simulation (Oyediran 2016). The two figures start from the realisation that simulation begins when there is a problem in the real world. The next stage is the formulation or design of mathematical models which use data collected from real life situations to produce results which are interpreted to provide solutions to the identified problems. The figures also indicate that the models have to be validated and evaluated to enhance the trustworthiness of the model. The model results need to be analysed to produce effective conclusions.

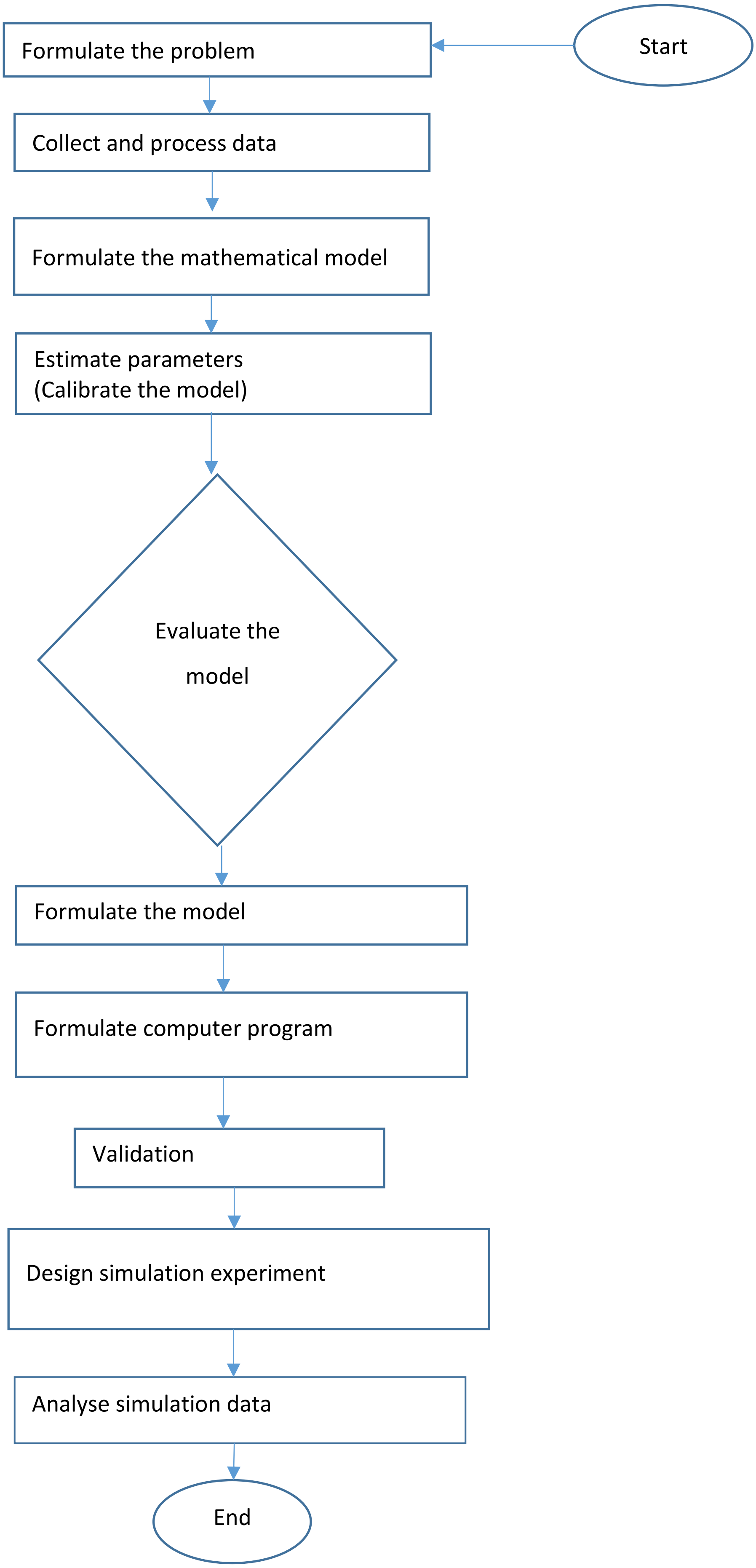


Figure2. 6: Simulation process

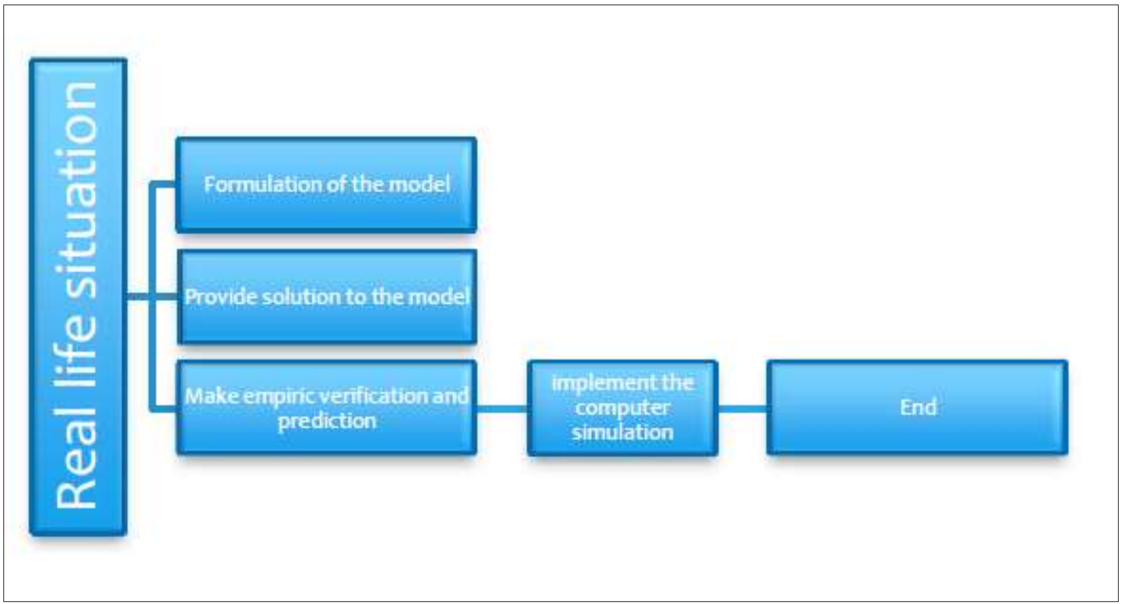


Figure 2. 7: Modelling process

(Adapted from Oyediran 2016)

Simulation was important in building and using the logistic regression analysis model developed in this study.

2.12.2 Running the simulation

In simulation, system behaviour at any instance of input variables is judged by executing the simulation model for a finite number of times (Carson & Maria 1997). Simulation experiments driven by random and artificial data have become a significant tool in the sciences (Leigh & Bryant 2015:1). Simulations usually involves models with parameters that are unspecified or vaguely known. Carson and Maria (1997) observe that the execution of a simulation model can only give the solution to the 'what-if' problem. Figure 2.8 shows a pictorial representation of simulation. The input x_1, x_2 … x_n represents the input values in respect of the coefficients of the independent variables. The output Y_1 to Y_n represents the predicted values indicative of the effect the input variables have on the binary outcome in logistic regression analysis. In between the input and output is the simulation process itself as a black box. In practice, scholars have to be either extremely choosy about the parameters to change, or to use only a limited group of probable values, or to use a huge number of speedy computers (Leigh & Bryant 2015).

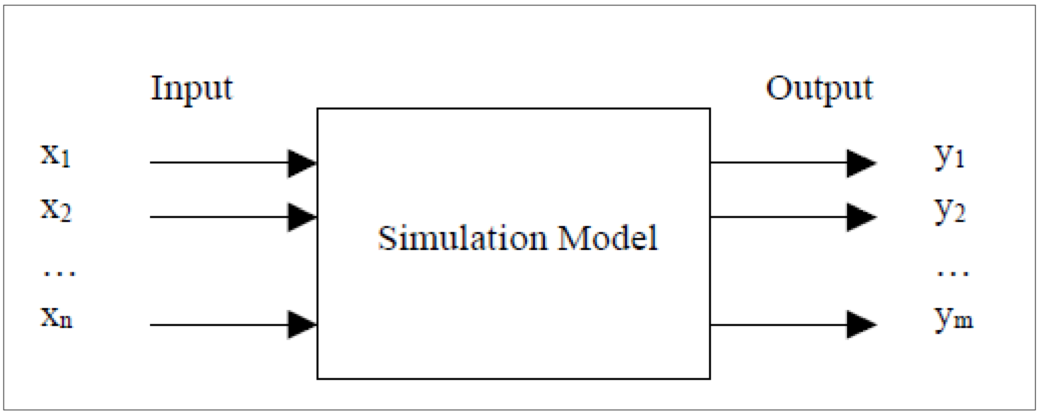


Figure 2. 8: Simulation model

Validation, improvement and limitations of models

Processes are usually complex and experiments are always subject to error (Cain 2014:4). Thus, models must incorporate assumptions that should be realistic. Include in the model only the most important variables. A model should exhibit predictive power as much as possible (Cain 2014). A model is a testable illustration of a system (Komolafe, Chikhunmen & Abiodun 2018) hence in refining a model, validation against experimental data is key (Cain 2014). Importantly in computer science, constructs, models and methods that succeed on paper might not actually perform in real life situations, therefore, instantiations give the actual proof (March & Smith 1995).

In this study, the researcher used both real life and simulation data in the logistic regression model to ensure that the logistic regression model does not run only on paper but also in real contexts (chapter seven). This research centred on predicting computer networking projects' success. In essence, prediction uses previous and current data to determine performance or effect in the future, hence there was serious need to include simulation in the study. Simulation gave the researcher and/or the project manager a platform to study the future of a computer networking project without committing a lot of resources as well as being better informed in deciding whether to continue with a project. Since this research centred on predicting computer networking projects' success, all the values used in the simulation were arbitrary i.e. they were estimated.

In this study, changes were made to the input variables in the model (the critical success factors for computer networking projects) so that the researcher observed and identified the justifications to changes in the output variable (the success of computer networking project).The changes made addressed the 'what-if' question so that the individual variable contribution to the success of computer networking project. This study had only five critical success factors for computer networking projects (Table 6.1). There was also a specific, binary outcome (the success of a computer networking project) that was predicted through its probability variation across the parameter space (the set of critical success factors). As a result, there was no need to be careful in variable selection that requires the use of fast computers.

2.13 Thesis choices and activities

Reviewed literature indicated that CSFs produced by different researches were in most cases generalised. No literature was found on CSFs for ICT projects in Zimbabwe. In addition, no work was found in literature that focusses on the management of any type of computer networking projects, let alone the prediction of computer networking projects' success.

This research studied ICT projects' CSFs in general and used qualitative meta-synthesis analysis (chapter four) to reduce them to a manageable number. This number was further studied to determine those factors critical to computer networking projects. The resultant set comprised only five CSFs relative to the long lists obtained from literature. The shorter set (Table 4.7) is easier to manage. Qualitative meta-synthesis analysis was chosen to prevent the researcher from reinventing the wheel since a lot of research was done in the area of CSFs for ICT projects.

To cater for the uniqueness of various ICT projects, the researcher used a questionnaire to ask the project practitioners on the CSFs for computer networking projects in the country. The researcher appreciated the fact that project management is a formal discipline which requires principled and tested methods of handling projects by professionally certified project practitioners. As such, this research was concerned with project practitioners in identifying computer networking projects' CSFs.

The use of plastic money (i.e. plastic cards, such as credit cards, debit cards etc.) is increasingly adopted in the country. People could hardly transact in cash. Computer networking made online buying and selling as well as money transfers easier. This research therefore, focused on computer networking projects as a specific instance of ICT projects. All types of ICT projects in one way or the other depend on computer networks. The few projects discussed in this chapter show the importance of computer networks and their related applications. The success of computer networking projects forms the foundation for the success of ICT projects thereby giving value to this research.

No model was found in literature that predicts the success of a computer network project. A logistic regression analysis model based on the identified CSFs for specifically computer networking projects was developed and used. The model predicts computer networking projects' success. It does this by calculating a value that gives them an indication of possible success or failure such that no or limited resources can be wasted in projects that are likely to fail. The predicted results indicate to the stakeholders whether or not to proceed with the project. It is incumbent upon the major stakeholders to make a decision either to proceed with the project as it is or to make the necessary adjustments or in the worst case scenario to abandon the project altogether. The rationale behind the decisions is to safeguard the financial resources meant for the project. The prediction model became handy in the dynamic, unpredictable and unreliable business landscape like the one that prevailed in Zimbabwe.

2.14 Chapter summary

From this chapter, it was clear that much research was carried out on ICT projects failure and success and their critical success factors. Long lists of ICT CSFs and causes of their failure were available in literature. In all these studies, ICT projects were studied in their broadest sense seemingly disregarding the fact that ICT projects are varied broadly. Fair researches on mathematical modelling of some aspects of ICT project management including logistic regression modelling were identified. However, no work was done specifically on determining and modelling computer networking projects' CSFs. Though many prediction models were developed for other fields notably business, health and social sciences, no model was developed for the prediction of the success of computer networking projects in particular. This research, therefore, filled the gaps by establishing computer networking projects' CSFs as a type of ICT projects, developing a logistic regression analysis model that forecasts computer networking projects' success.

Chapter three: Methodology

3.1 Introduction

The strength of any research findings largely rests on how they were found i.e. the methodology used (Kumar 2011). This third chapter provides the methodology utilised. The researcher was very thorough on the methodology described in this chapter to provide a better foundation for the authenticity and trustworthiness of the findings of the research. The chapter provides a blueprint of the research process i.e. the paradigm employed, design, approach, research methods, tools and techniques, study population, the sampling design and the framework for data analysis among others.

3.2 **Research Paradigm**

A research paradigm is a school of thought that considers the research process from a particular perspective. It describes how the researcher perceives the world i.e. the researcher's school of thought that guides the interpretation of findings (Kivunja & Kuyini 2017:1; Shah & Al-Bargi 2013:2; Chilisa & Kawulich 2015:2; Mohajan 2017). It is the abstract window through which the researcher establishes the methodological facets of the research to come up with the research methods used data analysis. Different philosophical assumptions (paradigms) reside in the world. Paradigms lead to different strategies of enquiry (methodologies) and to different ways of approaching how we gather empirical material and analyse it (methods) (Jha 2017: Chilisa & Kawulich 2015:8). Importantly, there is a strong association between paradigm and methodology. Methodological insinuations of paradigm selection permeates the formulation of research question(s), the choice of respondents, data gathering instruments and data analysis (Kivunja & Kuyini 2017:11). Most research is done using one of the four major research paradigms: realism; positivism, critical theory and the constructive theory (O' Sheedy 2012:86). Paradigms differ on their suppositions about reality, what knowledge is and its origin, ideals and their place in research (Chilisa & Kawulich 2015). Each of these paradigms has a set of corresponding research methods suitable for it. However, Ignou (2005; 36) argues that even though each research paradigm has a set of corresponding methods, a researcher is free to choose methods that borrow from more than one paradigm. In this study, the researcher used different paradigms variously according to the varied nature of the research questions. The following sections discuss the five main paradigms and indicate their suitability or unsuitability to this research.

3.2.1 Positivism

Positivism believes in the existence of absolute truths i.e. reality is objectively given (Jha 2017; Chilisa & Kawulich 2015). Proponents of this paradigm argue that truths exist to explain different phenomena in real life and can be described by measurable properties (Jha 2017; O'Sheedy 2012; Shah & Al-Bargi 2013). The truths can be known and tested experimentally. Its character is routed in the scientific method of investigation that entails experimentation to investigate observations and respond to questions (Kivunja & Kuyini 2017; Shah & Al-Bargi 2013; Chilisa & Kawulich 2015:8; Walliman 2011). Positivism tries to establish the cause and effect relationship (O'Sheedy 2012:86; Kivunja & Kuyini 2017:5). The paradigm draws is power from deductive logic, formulation and testing of hypotheses to make deductions. Explanations to phenomena is therefore provided and predictions made in accordance with the measurable outcomes (Kivunja & Kuyini 2017:5).

The positivist paradigm suggests the use of both quantitative and qualitative methods (Kumar 2011:41).

In ICT project management resources used are mostly very expensive and cannot be rational to experiment with ICT projects especially computer networking projects that use very expensive equipment such as servers, computers, routers, bridges, gateways and expensive transmission infrastructure.

In this study, focus was on computer networking projects. Literature reviewed did not show factors that influence computer networking projects. From a positivist perspective these factors exist as absolute truths though no one had identified them as yet. Research on ICT projects' CSFs in different country settings produced different results indicating non-existence of absolute ICT projects' CSFs. A positivist approach was not suitable for this research mainly because of its basis of absolute truths and need for experimentation to reach at objective truths. In this case, following this perspective would mean having a concrete set of ICT projects' CSFs and experimenting with expensive networking equipment which was beyond the budget for the research.

3.2.2 Realism

Realism has commonalities with positivism i.e. absolute truths exist that explain phenomena. Realists, however, view positivism as too simplistic in its viewpoints. Realities are believed to deal with the environment in which they are. The realists observe that in most cases the nature of relationships is very complex so that it is difficult for people to measure (Chilisa & Kawulich 2015:5). Albeit, instruments and the understanding of the researcher are often inadequate to find the absolute truth.

The understanding from the perspective of realists is that many examinations of a reality from different viewpoints may be necessary for getting overall understanding of the relationships (O'Sheedy 2012:88). Realism was not used in this research due to its similarity to positivism in terms of its underlying principle of the existence of absolute truths as explaining phenomena in real life situations. This paradigm, however, has an added advantage in that it considers the environment in which the problem situation is found. Participants were computer networking practitioners in Zimbabwe who used their expertise, experience and the knowledge of their environment and work to respond to the research instruments. There was no way their truths in terms of critical success factors for computer networking projects could objectively be the same as those from outside Zimbabwe.

3.2.3 Constructivism

This paradigm encompasses the understanding that truths are a result of the researcher's belief system in a given context. The paradigm ascribes weight to the perceptions of the participant (O'Sheedy 2012:87). In this paradigm, social reality is traditionally established and is formed by humans. Research focuses on the hostilities, encounters and inconsistencies in modern society and tries to liberate humankind i.e. helps remove the causes of hostilities and dominion (Jha 2017).

The constructivist paradigm was inappropriate for the study since the participant's beliefs could not be of any importance to the improvement of project management. Project management is a discipline with values and principles that go beyond a simple belief system. Beliefs alone cannot drive a computer networking project.

3.2.4 The critical theory paradigm

The critical theory aims at empowering the participants so as to find answers to own challenges. The theory does not question the existing situation. How (2003:16) propounds that "facts do not speak for themselves", but it is an interconnection of relationships with embedded facts that provides illustrative importance as opposed to mathematical significance. Critical theorists view speculation as a vital element of reason. If we can understand one thing then we can mirror and understand its image. Geus (1981:55) explains a critical theorist as one who aims at emancipating and enlightenment, and people conscious of concealed facts or ideas empowering them in the process to determine the real truth. “Critical theories … are ‘reflective’ or ‘self-referential’: a critical theory in itself is always an inherent part of the object sphere which it depicts” (Geus 1981:56).

The critical theory normally displays the associations between concepts and theoretical viewpoints and their collective setting and therefore strives to contextualise or historicise concepts in line with their origins within social processes. The critical theory was considered the best in this research since literature was full of factors critical to the success of ICT projects in general but very little was found that was particular to specific types of ICT projects (computer networking projects included). No research so far was found that focuses on ICT projects and computer networking projects’ success in Zimbabwe.

The researcher thus used meta-synthesis analysis to determine ICT projects’ CSFs. The identified CSFs were used as the foundation for determining ICT projects CSFs and computer networking projects’ CSFs in Zimbabwe through a questionnaire followed by interviews. The computer networking projects’ CSFs were the variables in the developed logistic regression analysis model to predict their success.

The process entailed getting the preliminary data from literature and the computer networking projects practitioners thereby empowering them in coming up with methods of data collection suitable for this paradigm that include purposive sampling, open ended interviews, observation and questionnaires as well as Journals (Cain 2014). This paradigm supported the use of questionnaires and meta-synthesis analysis of published articles ICT projects’ CSFs in this study.

3.2.5 Interpretive paradigm

The interpretive paradigm is similar to the critical theory. The truth is based on the participant’s perception of reality. It places much value on the association between the researcher and the researched. The thoughts and beliefs of the researcher have a bearing on the outcome of the research. The interpretive paradigm aims at gaining insights into the complex social relationships forming that particular environment resulting in a better understanding than using other means, for example, the experimental method (How 2003:10). Weight is put on comprehending the individuals and their explanation of the situations surrounding them (Kivunja & Kuyini 2017:8; Shah & Al-Bargi 2013: 6). The proponents of this paradigm assert that it aims at comprehending experiences through meanings humans assign to them. Therefore, there is no predefinition of dependent and independent variables as it emphasises the complete intricacies of human sense making as the condition develops (Jha 2017). In the interpretive paradigm, concepts do not develop before research but succeed it, so that it is built on the data produced by the research. Its proponents assume that there is no unprejudiced knowledge which does not depend on thinking and reasoning by humans, therefore, knowledge and meaning are acts of interpretation (Shah & Al-Bargi 2013:6). They aim at exploring individuals' views, share their meanings and construct perceptions about the observed scenario.

In this study the interpretive paradigm was used in conjunction with the critical theory paradigm. It was suitable since at the start of the research there was no literature on CSFs for ICT projects in Zimbabwe and no CSFs for computer networking projects in Zimbabwe. As such, the researcher had to use meta-synthesis analysis to identify CSFs for ICT projects from literature. A questionnaire was developed based on the identified CSFs to get insights into ICT projects' CSFs in Zimbabwe. The questionnaire was followed by interviews to get more insights and clarity on the CSFs for ICT projects in Zimbabwe. The fact that data about critical success factors was gathered and analysed before a logistic regression analysis model was constructed indicates that theory here did not precede research. In the final analysis the logistic regression analysis model was built to predict the success or failure of computer networking projects that was initially not in the literature.

3.3 Research Approach

A research approach is a plan of action that provides focus to the conduct of research methodically and economically (Mohajan 2017:3). In order to bring intended results, the researcher employed the qualitative and the quantitative approaches. It started with meta-synthesis analysis of CSFs for ICT projects from literature. A questionnaire was later administered to ICT project practitioners in Zimbabwe based identified ICT projects' CSFs obtained from literature. Interviews were conducted as follow ups to gain more insights into the CSFs for ICT projects and computer network projects in Zimbabwe.

In this process several factors were established by the researcher from a wide range of practitioners in the ICT field especially those involved in computer networking projects. The qualitative part of the research involved reviewing of secondary sources of data (books, journal articles, abstracts etc.) through meta-synthesis analysis to identify ICT projects' CSFs. Meta-synthesis analysis was employed in establishing fewer ICT projects' CSFSs. A questionnaire was administered to determine CSFs for computer networking projects. The analysis was quantitative in which SPSS version 23.0 was used. Interviews were then conducted with Computer networking project practitioners in Zimbabwe. The analysis was also quantitative and NVivo was used for the purpose. The factors identified were used in the second stage of the study where the logistic regression analysis model was constructed.

The success/failure of computer networking projects was the dependent variable and computer networking projects' CSFs were the independent variables. The objective here was to develop a mathematical model that when given values for each independent variable as input, should produce a value which practitioners use to predict the possible success or failure of the project. Once the value is known, the manager can advise the stakeholders on the most appropriate decision to make.

The decisions range from continuing with the project as it is, to make some recommended changes or to abandon the project altogether so as to reduce the wastage of resources.

3.4 Research Design

A research design is the overall strategy used in the research for putting together all the pieces of the research in a smooth flowing and logical manner in order to effectively deal with the research problem questions (Ignou 2005:26; Mohajan 2017: Kumar 2011:95). It is the umbrella line of attack chosen to put together the different parts of the study in a smooth flowing and logical way, thus warranting that the research effectively addresses the research problem. It is the scheme for the collection, measurement and analysis of data (Malhotra 2007: 17; De Vaus 2001:1; Kumar 2011:40). Research design includes how data shall be gathered, the instruments to be used, how those instruments shall be used and how the researcher intends to analyse the collected data (Walliman 2011; Chilisa & Kawulich; mohajan 2017). Research design can either be qualitative, quantitative or mixed (Chilisa & Kawulich 2015; De Vaus 2001; Kothari 2004). Quantitative design includes correlational design, causal comparative and the experimental design. Qualitative design uses case study, narrative, grounded theory and phenomenology, exploratory and meta-analysis design. Researchers use qualitative, quantitative or mixed data collection depending on the research and data to be collected (Jha 2017).

This study used a mixed research design, the objective was to get the best of each research design type which eventually improved the strength of the results.

3.4.1 Qualitative research

Qualitative research involves qualitative phenomena i.e. those that relate to or encompass quality (Kothari 2004:16). The emphasis in qualitative research is to comprehend, explain, examine, find and elucidate scenarios, experiences etc. (Kumar 2011:103). Qualitative designs include: case study and historical in which the researchers, narrative, grounded theory and Phenomenology design which involves the study of (Chilisa & Kawulich 2015).
Qualitative data can be collected through, interviews, observation, focus groups, texts/documents, audio/video etc.

This research used the grounded theory and the phenomenology research designs. The document analysis used in qualitative meta-synthesis, the questionnaire and the interviews were all part of the Grounded and the Phenomenology qualitative research designs. The Grounded theory was chosen because the researcher wanted to understand the factors that were critical to computer networking projects' success and isolate them from the abundant lists of ICT projects' CSFs. The fact that literature was abound with ICT projects' CSFs, the researcher intended to establish factors that were critical specifically to computer networking projects. The study resulted in building a model from critical success factors that were identified.

The phenomenology design was chosen because the researcher wanted to use the experience of project practitioners in their natural setting. The researcher realised that it was only from the people directly involved with computer networking projects that the CSFs for such projects could be obtained. Finally the research heavily relied on computer networking project practitioners' experience in the projects.

3.4.2 Quantitative research

These are centred on the measurement of quantity and relates to occurrences that can be quantified (Kothari 2004:18). In this type of research, measurement and classification needs of the details generated requires that study designs are organised, inflexible, fixed and pre-determined in their use to guarantee correctness in measurement and classification (Kumar 2011:104). Quantitative research designs include correlational design where the relationship between at least two variables is explored through a correlational analysis (Chilisa & Kawulich 2015). Kothari (2004:18) adds simulation as the other research design or approach under quantitative research.

This research used the simulation design in chapter seven to "experiment" with the logistic regression analysis model developed to exercise a large number or possible permutations of CSFs to validate the model. A Deep neural network model developed using Python programming language and Jupyter Notebook was used for the simulation. Simulation made it possible to make several options with limited resources.

3.4.3 Simulation

It encompasses the building of a man made environment in which important information and data can be created (Kothari 2004). This entails the running of a mathematical model that symbolises the form of a live process. For the initial conditions' values and parameters, a simulation is executed to mimic the behaviour of the process over time.

Simulation was used in this study (chapter seven) to evaluate the effectiveness and usefulness of the logistic regression analysis model that was developed to predict computer networking projects' success.

3.4.4 Exploratory design

This type of design usually applies to a research problem with fewer or no prior studies to compare with when forecasting the outcome of an event or phenomenon. It focuses on the researcher discovering new knowledge and experience for future investigations (De Vaus 2001). The design is often used in cases where the researcher wants to determine and comprehend of how best to continue in studying a situation or how a methodology would be useful to collect data about the research question. Exploratory design aims at the following among others:

1. Familiarising with the primary issues surrounding the phenomenon.
2. Establishing a well-substantiated image of the phenomenon being investigated.
3. Creation of fresh knowledge and postulations.
4. Production of speculative theories and hypotheses.

The overall design of this research was largely exploratory. The reasons were that there was no literature on computer networking projects' CSFs.

The researcher therefore began by familiarising with the general ICT projects' CSFs and proceeded to establish a grounded picture of how researchers came up with those critical success factors (using meta-synthesis analysis). The researcher also studied the differences between computer networking projects and other ICT projects via interviews to expose the gaps in managing them. The research generated new ideas and insights into computer networking projects' success. The study culminated in the construction of a logistic regression analysis model that predicts the success of computer networking projects.

3.4.5 Meta-synthesis analysis design

This is an investigative methodology designed to methodically appraise and condense the results from different studies (De Vaus 2001). It results in an increase in the capacity of the researcher to investigate effects of interest. The goal of meta-analysis is to construct a novel comprehension of a research problem through examining variances in the findings from other (De Vaus 2001). The strength of this design is a function of stern loyalty to the criteria used for including researches and the accessibility of information in each piece of work to correctly analyse their findings.

In this research, meta-synthesis analysis was done to study the available ICT projects' CSFs and reduce them to a sizeable list (chapter four). This smaller list was the basis for the questionnaire that was administered. The analysis of the responses produced a smaller list of computer networking projects' CSFs. The researcher ensured that the meta-synthesis analysis had:

1. Clearly defined objectives, variables and outcomes that were investigated
2. A well-thought and recorded justification for article inclusion.
3. An account and examination of the level of heterogeneity among the sample size of articles reviewed.

4. Rationalisation of the methods used to examine the studies.

Meta-synthesis analysis was carried out to help the researcher to:

1. Determine gaps in literature on computer networking projects’ CSFs as a specific type of ICT projects.
2. Offer a means of examining research published about ICT projects’ CSFs.
3. Highlight research problems in using the critical success factor model for the future of computer networking projects.

3.4.6 Mixed research designs

These entail having quantitative and qualitative design elements. It is the most favoured approach in cases where the study needs both qualitative and quantitative designs to articulate the problem (Chilisa & Kawulich 2015). Quantitative data collection techniques include social surveys, questionnaires, cards, logs and statistics (Jha 2017). In essence this research used mixed research designs that encompass exploratory, meta-synthesis analysis (chapter four), grounded theory and phenomenology.

The research started by studying the concepts of mathematical modelling and simulation. This helped the researchers to get a deep understanding of the processes involved in mathematical modelling so as to design and develop the model to predict computer networking projects’ CSFs. Literature on ICT projects’ CSFs was analysed using a meta-synthesis approach. A questionnaire was developed based on these ICT projects’ CSFs and administered to computer networking project practitioners to determine a set of computer networking projects’ CSFs in particular. The questionnaire was followed by a set of interviews for the researcher to gain more insights into the critical success factors for computer networking projects. These interviews also helped to address issues raised from the analysis of the questionnaire responses.

A logistic regression analysis model was developed that made use of the identified computer networking projects’ CSFs as independent variables to forecast the possible success of a given computer networking project. Simulations were done to validate the logistic regression analysis model followed by testing the logistic model in live computer networking projects to establish its applicability in real life scenarios. The stages followed in this study are shown in Figure 3.1.

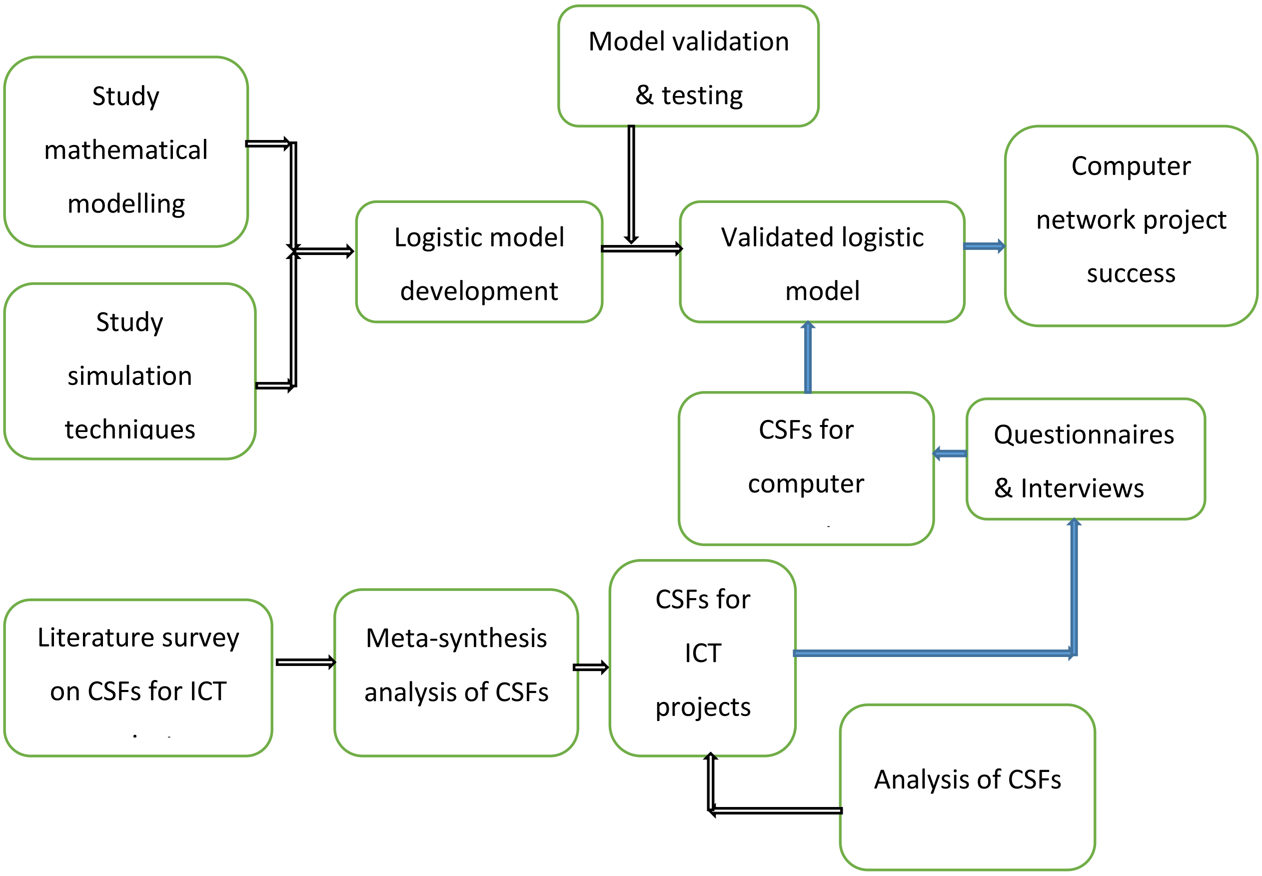


Figure 3. 1: Organisation of the research

3.5 Methodology

Research methodology is a universal plan that describes the way in which the study is to be carried out and determines the methods to be employed (Setzer 2015; Chilisa & Kawulich 2015:5). In other words, it refers to the research design, methods, approaches and procedures used in a study that is adequately planned to answer a specific question (kivunja & Kuyini 2017:3; Kothari 2004:21). Research methodology is built upon aspects of paradigm, theoretical framework, research approach etc. The researcher needs also to identify the applicable techniques and justify the choices made (Kothari 2004:21). Therefore research methodology is not limited to research methods but also encompasses the reasons behind the methods used in the context of the research study and why we are not using others so that research results can be evaluated either by the researcher or by others (Kothari 2004:21). This methodology section of the thesis was dedicated to doing this, serve for ethics and validity which were covered and reported in chapter one.

3.5.1 Methodology in Computer science

Demeyer (2011) opines that computer science as a research area has since been battling with its identity. On the one hand, it is a domain entrenched in mathematics which produced in robust theories. On the other hand, it is entrenched in engineering resulting in the creation of artefacts that have entirely distorted the society. As a result of all this, computer science has derived its research methods from those areas, that is, a mathematical approach with truisms, hypotheses and proofs, with quantification, measurements and comparisons. Hassani (2017) notes that as opposed to reputable science domains, research in computer science is not sustained by well-known, internationally accepted approaches. This is due to it being in its formative years and uncertainty in its meaning. It has wide coverage and intersects with other disciplines. He concludes that computing research employs the same principles and procedures as any other scientific research noting that all domains of science including computer science need to adapt the inclusive methodologies to carry out the research tasks.

From this perspective, this research used a number of different paradigms, designs and methods including the interpretive and critical theory paradigms; qualitative and quantitative designs which included exploratory, simulation, meta-synthesis analysis and phenomenology among others. Further, it should be noted that the research addressed different aspects/questions at different stages which called for the variation in paradigms, designs and methods.

Software engineering research (of which project management is part) in particular has experienced the same identity crisis as computer science. Research in software engineering having prominence on processes and team work have to consider group undercurrents and intellectual aspects, hence adopts some research methods from sociology and psychology as well (Demeyer 2011). This research dealt with mathematical modelling for the prediction of computer networking projects' success through their critical success factors, hence the human factor was a definite consideration. Questionnaires and interviews were used to gather information on computer networking projects' CSFs.

Since the main objective was to build a mathematical model to predict computer networking project success, a scientific approach was found to be necessary. Freitas (2009) proposes that computer science can be studied using theoretical, experimental and simulation methods depending on specific areas within the domain of computer science. The development of the mathematical model required a theoretical method. This was appropriate since it required logic and mathematics to develop the model. The model that was developed was tested using data collected from real life cases. Freitas (2009) postulates that the experimental method is adopted for the extraction of findings from real life implementations. Experiments can investigate the authenticity of theories, or can merely do explorations to attempt getting fresh knowledge. In this study, the researcher collected critical success factor data and fed it into the mathematical model that had been developed which predicts the possible success of the project. It was not possible to have all necessary conditions needed in a project during the research experiments. This is when simulation was used. In the simulations, the researcher formulated possible project conditions and simulated the performance and predicted the possible success of the project using the mathematical model developed embedded in a machine learning model.

Research in a scholarly setting refers to the process of a thorough and logical inquiry or investigation in a domain, with the goal of ascertaining or rethinking facts, theories, applications etc. (Ayash 2015). The final objective is to ascertain and transmit new knowledge. This research discovered the CSFs for managing computer networking projects which were then modelled mathematically to predict the success of the projects.

3.5.2 Population

The best research design work acknowledges the importance of the target population (Jha 2017:2). Target population means all the people who meet a specific criteria given for a research study (Jha 2017; Kothari 2004: Walliman 2011). A population has elements, where an element is an entity in a given population that cannot be further broken down which can be an individual, school, department office etc. (Alvi 2016; Taherdoost 2016; Jha 2017). A given population may be homogenous or heterogeneous where a homogeneous population is the one that has all its members being similar in all respects and a heterogeneous population's members are not similar. This research was concerned with the management of computer networking projects. Four organisations that focus on the design, implementation, installation and upgrading of computer networks were chosen as study areas for the research. The organisations had different departments focusing on different aspects e.g. human resources, marketing, sales, IT and so on.

In this study the researcher was only concerned with the people in the Information Technology Department that had direct influence on the computer networking projects (computer networking project practitioners). Personnel that include IT directors, IT managers, operations managers, network engineers and network technicians constituted the population in this study. The four identified organisations had a total of two hundred people who were considered for this study. Every Networking practitioner in each of the organisations qualified to be counted in the population. This was so because the researcher noted that computer networking companies or organisations do not employ a lot of experts in the field. Thus, the population for the study was two hundred.

3.5.3 Sampling

In most research, researchers deal with huge populations. In such cases it can be both cumbersome and unreasonable to consider everyone in the population. It is therefore unrealistic to deal with all members in a population, therefore a smaller number, the sample, is selected for assessment (Alvi 2016; Taherdoost 2016; Kothari 2004: Walliman 2011). This should be done in a manner that each sector or group in the population is fairly represented. A sample, therefore, is a relatively smaller number of people chosen from a population for the purposes of investigation and these members are referred to as participants (Alvi 2016; Taherdoost 2016). The correctness of research findings heavily rely on how the sample was selected. The goal of sampling design is to efficiently reduce the gap between the figures produced from the sample and those prevailing in the population (Kumah 2011:42). Technically, researchers are not concerned with the sample itself, but in the comprehending of how they can possibly infer from the sample and then extrapolate to the whole population. Sampling makes it possible to investigate the population in a huge geographical area or discover more about that population by investigating an area in detail via a smaller sample (Jha 2017:3).

An optimal size is important if meaningful deductions are to be drawn from a research study. Too large a sample brings administrative burden and costs while too small a sample gives inaccurate results (Malhotra 2007).

3.5.4 Sampling techniques

The researcher should determine the appropriate method of choosing a sample (sample design). This is a convincing plan chosen before any data are gathered for determining a sample from a given population (Kothari 2004). Sampling techniques come in two main forms or categories namely, probability and non-probability sampling (Alvi 2016; Jha 2017). Probability sampling methods, commonly called random sampling, have every element in the population having a probability of being selected in the sample. Elements that constitute the sample are selected randomly and have probabilities assigned to them objectively. Non-probability sampling, also referred to as judgement or non – random sampling, has its members/elements of the population not having an equal chance of being selected to be in the sample. There is no random selection of elements for investigation but the selection is guided by the researcher's subjective judgement. This research employed non-probability sampling as described in the next section.

Non- probability sampling techniques

This type of sampling include techniques that include volunteer, convenient, purposive, quota and snowball sampling (Alvi 2016, Jha 2017). The elements included in the sample gathered without any specified probability structure in mind. This study used purposive sampling when selecting participants for interviews to establish the factors critical to the success of computer networking projects. In purposive sampling, the researcher constitutes the having a planned purpose in mind. The method for including participants is defined in advance (Alvi 2016; Jha 2017). Therefore, only members of the target population who meets the criteria are included in the investigation.

After obtaining the permission to collect data in each organisation, the researcher requested for the staff complement from the human resources department. The researcher then proceeded to get each member's email address from the section heads. Participants were selected on the basis of their expertise and experience. The researcher ensured that purposefully all the managers were interviewed. The reason was that managers were expected to have more experience in project management. The questionnaire was administered through email as an online survey to all the project practitioners.

The population in this study comprised of people from four organisations totalling two hundred.

All the two hundred practitioners were purposefully made participants for the study to increase the validity of the results and findings (Alvi 2016; Jha 2017; Kothari 2004; Shah & Al- Bargi 2013). All the available computer networking project practitioners in the four organisations were sampled since the total number in itself was reasonable for the type of research.

How respondents were reached

For the administration of the questionnaire, the researcher used emails to reach the participants. Telephone calls were used for follow-ups and reminding the participants of due dates of returning the completed questionnaires. The researcher used both emails and telephone to apprise participants of the interview dates. On the appointed dates the researcher visited the participants' work places where the interviews were undertaken. Each interview was allotted fifteen minutes on average.

Participants' consent

No participant was forced to take part in the research. Before a participant took part in the research by either completing the questionnaire or taking part in the interview, he/she was requested to complete the participant consent form. The form used was approved by the UNISA's Ethical Clearance Office.

How participants contacted the researcher

In cases where respondents asked for contacts, the researcher provided his contact details as well as those of the supervisor. The contacts included emails and mobile numbers. These details were in the introductory sections of the data collection instruments, namely, the questionnaire and the interview guide (Appendices J and K).

Ethical issues

Ethical issues were addressed in chapter one. The researcher first prepared all the necessary ethical documents as required by UNISA. These documents included the research proposal, questionnaire, interview guide, and consent form and permission letters to carry out the research. The researcher, after following the university ethical procedures, was granted an ethical clearance certificate. Copies of these documents were included as appendices (Appendices A to D).

3.5.5 Sources of data

A unique three staged process (meta-synthesis analysis-questionnaire-interview) of data collection was used to collect the research data. Meta-synthesis analysis was used to identify critical success factors from literature on ICT projects in general. The identified CSFs were then used to construct a questionnaire to collect data on ICT projects' CSFs in Zimbabwe.

Issues raised from the questionnaire responses were further dealt with through interviews. In addition, interviews were used to provide more insights into the management of ICT projects in the country. During the interviews more effort was put on computer networking projects management.

Meta-synthesis analysis

Meta-synthesis analysis (chapter four) was used to collect data on ICT projects' CSFs in their broadest sense from published research. Meta-synthesis analysis entails an analysis of findings from previous results i.e. an analysis of a collection of analyses (Walliman 2011: 105). This secondary data was already available in published form, and it was data that was collected and analysed by someone else (Kothari 2004:124). Secondary data was analysed and patterns evident from the findings were documented, chronological progressions were examined to isolate repetition of particular findings to build up a convincing case for computer networking projects' CSFs (Walliman 2011:100). The sources of this data included journals, books, magazines and newspapers. In this study, no reference was made to unpublished sources (diaries, letters, autobiographies etc.) due to their irrelevance to the problem under study. ICT projects' CSFs from the meta-synthesis analysis carried out laid the foundation for the question items in the questionnaire.

Questionnaire

The second stage of the unique three stage process employed in data collection was the questionnaire. A questionnaire is a list of question items, whose answers are put by the respondents (Kumar 2011:138). The respondents are assisted to understand how to respond to the questions before they fill it in.

One set of structured questionnaire containing both closed and open questions was used (appendix J). The questions were derived from the ICT projects' CSFs that came from meta-synthesis analysis done in the first stage of the unique three staged process of data collection. The CSFs from the meta-synthesis analysis were used to formulate question items included in the questionnaire. The rationale of doing this was that though the computer networking projects under study were from Zimbabwe, they had to adhere to internationally approved principles. Effort was made to make the questions clear and easy to understand for the respondents to answer them with minimum difficulty. It was assumed that not all the critical success factors listed in literature were also critical to all types of ICT projects, notably computer networking projects. However, these critical success factors formed the basis for the questionnaire.

The advantages of using a questionnaire were that the questionnaires were administered to many people simultaneously. In addition, a questionnaire was cost effective and convenient in collecting data (Ferber 2006). In addition, the questionnaire accorded respondents an opportunity to relook at their responses conveniently without pressure from the researcher. Questionnaires allowed uniformity since respondents received an identical set of questions. The questionnaire also permitted anonymity. Malhotra (2009) argues that secrecy raises the rate of response and may increase the probability that responses indicate genuinely held opinion. In this research the questions were mostly closed to allow for standardised responses which made the documentation and data analysis easier to manage (Milne 2008). Open-ended questions were used to enquire more information on views regarding factors influencing the success of computer networking projects.

The researcher was guided by Neuman's (2008) principles for developing proper question items that do not use jargon, slang, ambiguity etc.

A Likert scale was used in designing some of the questions in the questionnaire. In this research, respondents’ attitude towards given critical success factors were sought, hence the relevance of the Likert scale.

Interviews

The third stage of the unique three staged process of data collection was the interview. An interview is any man-to-man interaction, either physically or otherwise, between at least two people with a specific purpose in mind (Kumar 2011:137). The researcher used face-to-face in-depth interviews to directly source first-hand information from computer networking project practitioners. The purpose of the interviews was mainly to clarify issues raised from the completed questionnaires and to identify any additional insights into the management of computer networking projects. By completing the three stage process of data collection, the researcher had developed much confidence in the ICT projects and computer networking projects’ CSFs in Zimbabwe. The final list of critical success factors for computer networking projects in Zimbabwe was used to develop the logistic regression analysis model to predict the success of the projects. The interview guide (Appendix K) was prepared in advance and it contained structured, semi-structured and open-ended questions (Jha 2017) in order to get detailed responses from the interviews. The researcher, as the interviewer, had the leeway to choose the format and content of questions to be asked from the respondents and to select the way of asking the questions and choosing the order in which they were asked (Kumar 2011). All these were taken care of in the preparation of the interview guide (Appendix K) and in carrying out the interviews. The interviews were conducted at the respondents' work places in Harare, Chinhoyi and Bindura. A total of eighteen senior project practitioners were interviewed. These included network managers and network engineers. The whole essence of interviewing was obtaining knowledge and meaning from an associative relationship between the researcher and the interviewees.

The interview data was analysed using NVivo version 10.0. This is a very comprehensive and reliable tool for analysing interview data. The analysis produced a much smaller set of computer networking projects' CSFs (Chapter five).

Simulation

Simulation was utilised in checking the effectiveness of the developed logistic regression analysis model. This was very important since the researcher had limited time and financial resources to try the model in many real life computer networking projects. Mathematical models or simulations show the impact of different inputs into a system and estimate the probable outcomes (Walliman 2011:124).

Simulation enabled the researcher to derive conclusions about the model from a large set of possible combinations of situations and identified critical success factors.

A machine learning was used to run the simulation. This was achieved through the development of a deep neural network binary classification modelling. The results showed the predicted performance of computer networking projects either as a failure or success. Python programming language (Version 3.6.8) on the Jupyter Notebook platform was used to develop the deep neural network binary classification model used to simulate the developed logistic regression analysis model.

Tensorflow 2.0 beta1 was the major machine learning library used. Reasons for the choices were that Python is a portable language that can safely run on a variety of platforms such as Windows and Macintosh. In addition, Python is free and open source and has a large standard library. Thus, Python provides a rich modules and functions for rapid application development.

It is also extensible i.e. other languages such as C/C++ can be used to compile the code. Jupyter Notebook enables the combination of code, comments, multimedia, and visualisations in an interactive document (a notebook) that can be shared, re-used, and re-worked. Full details of the simulation done are reported in chapter seven.

Python was used to develop the code used to simulate the developed logistic regression analysis model developed in this research to predict the success of computer networking projects in Zimbabwe. Every important information, data and code that was used for the model evaluation can be accessed at
https://www.dropbox.com/sh/4g4676nlmg0efg4/AABv1FC1nhQxT83zywUpWq0fa?dl=0.

3.5.6 Pre-testing of the research instruments

This was done for both the interview guide and the questionnaire. It was deemed important to test research instruments before using them to collect the real research data (Kumar 2011:150). The pre-testing of the research instruments entailed a critical analysis of the comprehension of each question and the corresponding meaning as understood by a respondent. The first step was for the researcher to read articles on how to develop questionnaires and preparing and executing an interview. The second stage was carefully developing the instruments and sending them to the supervisor for comments. The last stage was administering the instruments to selected people in the computer networking field. A total of ten people in industry in Harare answered the questionnaire and their feedback were used to enrich the questionnaire.

As for the interview guide, the researcher interviewed three members of a local organisation for fifteen minutes each on different days. The interviewees were the Information Technology division director, the technical manager and the network manager. The feedback was used to improve the interview guide.

Effort was put in ensuring that the pre-testing was carried out under real conditions on people similar to the target population. The purpose was to expose challenges that the prospective respondents might have in either comprehending or interpreting the questions. Every data collection instrument and related documentation were accompanied by a cover letter that provided important details to the respondent.

3.5.7 Data analysis

Data need to be summarised into fewer manageable groups and tables for analysis i.e. data should be classified into some rational and usable groups (Kothari 2004). Analysis is breaking something down into smaller parts in order to comprehend it (Jha 2017). Data from the questionnaires were fed into SPSS version 23.0 and used to derive a list of factors which the respondents had indicated to be critical for computer networking projects' success in Zimbabwe. Cronbach's alpha test was used to test the instrument for reliability.

Cronbach's Alpha

There is no single acceptable value for the Cronbach's alpha coefficient (Tavakol & Dennick 2011; Goforth 2015) indicating that what makes a good alpha (α) coefficient in research is arbitrary (Goforth 2015). Some researchers recommend a minimum value of 0.65. In general the minimum alpha value is 0.7 for reasonable results to be obtained (Namdeo & Rout 2016; Taber 2018; Inal et al. 2017; Tavakol & Dennick 2011; Chiyangwa & Mnkandla 2017). This research used 0.7 as the minimum threshold for the Cronbach's alpha value. This test was used to test the internal consistency of the instrument used to collect data for the study.

The researcher was careful when using the alpha value since it has drawbacks associated with it. Some researchers (Agbo 2010) argue that it is not sufficient for measuring reliability and may need to combine with other methods e.g. the Spearman's rank correlation. The alpha value is not reduced by correlating errors even if they exist instead a large number of items in the instrument produces a high alpha coefficient. In addition, highly homogeneous items normally produce high alpha coefficients (Abgo 2010). This study circumvented the problem by using a high cut off of 0.7 and increased the number of scale items.

Varimax rotation

Unrotated factor loadings brought challenges in their interpretation hence factor rotation was undertaken to simplify the loading structure, thereby enabling the researcher to easily interpret the factor loadings (Rahn 2019; Yong & Pearce 2013).

Rotation maximises high item loadings and minimises low item loadings thereby producing a more interpretable and simplified solution (Taherdoost, Sahibuddin & Jalaliyoon 2016; Yong & Pearce 2013). Varimax rotation method was used in this study for the rotation of factors which produced a factor structure that was uncorrelated (Taherdoost, Sahibuddin & Jalaliyoon

2016; Yong & Pearce 2013). The objective of rotation was to attain an optimal simple structure which attempted to make each variable load on as few factors as was possible, but maximising the number of high loadings on each variable (Yong & Pearce 2013:6).
Varimax rotation specifically minimises the number of variables that have high loadings on each factor and works to make small loadings even smaller (Yong & Pearce 2013).

Scree plot

To determine the number of factors to use in the analysis, two approaches were employed, namely, the Kaiser Eigenvalue>1 and the Cattell's Scree plot (Arifin 2017). The Scree plot is a graph that helps the researcher to decide on the number of factors to extract from the available data (Chetty 2015). It is a graph of eigenvalues on the vertical axis and the number of factors on the horizontal axis. The Scree plot always show a downward curve. The point where the slope of the curve plainly levels off indicates the number of factors that should be produced by the analysis (Rahn 2019; Krishnan 2011). In any study, a second method of identifying the number of factors should be employed to balance the scale (Yong & Pearce 2013). Thus, the Scree plot and the eigenvalue >1 methods were both used in this research for complementation. Variables with eigenvalues >1 were retained since they were viewed as contributing a relevant proportion of the information in a factor (Arifin 2017).

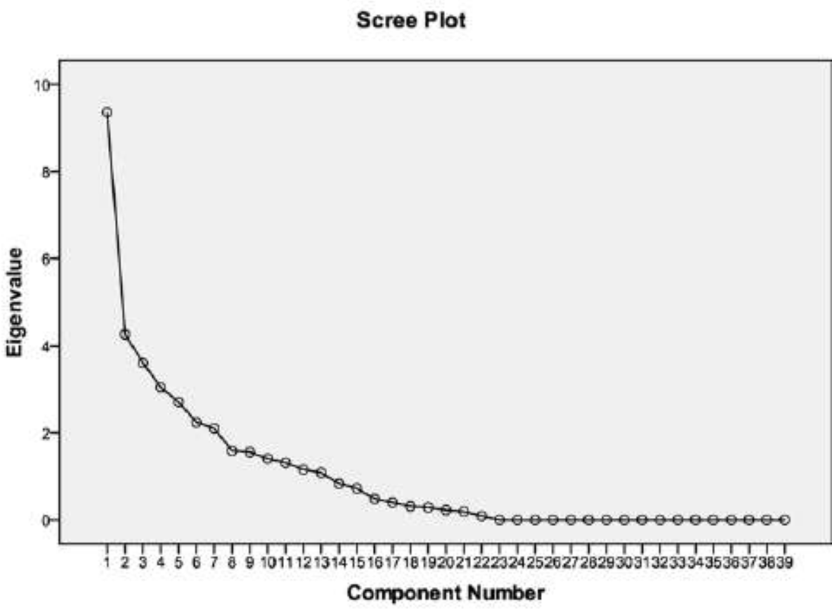


Figure 3. 2: The Scree Plot

Factor loading

The loading pattern of the variables was done to determine the variables that had the most influence on each factor. The researcher considered the variables with loadings close to -1 and those close to 1 as indicating strong influence on the variables (Rahn 2019; Krishnan 2011; Taherdoost, Sahibuddin & Jalaliyoon 2016). Loadings on the factors determined the strength of the relationships. The sign of the loadings showed the direction of the correlations and did not affect the interpretation of the amount of the factor loading or the number of factors to retain (Yong & Pearce 2013:6). Those with loadings close to zero were eliminated since that indicated weak influence.

Also, variables that loaded on multiple factors and those with no loadings were removed (Rahn 2019; Krishnan 2011). A variable that loaded on more than one factor was considered weak (Krishnan 2011), hence it was eliminated. Factors that had at least three variables loading on each were considered for the analysis (Taherdoost, Sahibuddin & Jalaliyoon 2016; Reiro Jr & Shuck 2015). The minimum threshold for a variable coefficient was taken to be 0.32 (Reiro Jr & Shuck 2015:9).

3.5.8 Logistic regression model development

A logistic regression model is a variation of a generalised linear regression model i.e. a method to enumerate the association between a binary outcome variable and more than one dichotomous predictors (Rausch & Leitner 2017).

A logistic regression models the likelihood of an outcome according to individual characteristics (Sperandei 2013). Because chance is a ratio, what is modelled is the logarithm of the chance given by;

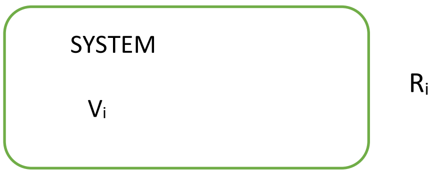
$$\text{Log}\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_m X_m$$

Where π is the probability of an event and β_i are the regression coefficients related to the reference group and the X_i explanatory variables.

In this study, the event in question is the success of a computer networking project and the explanatory variables are the computer networking projects' CSFs.

The main challenge in developing a logistic model is selection of variables to include (Sperandei 2013). The researcher started the regression by a full or saturated model in which all the identified variables are included. Variables were dropped one by one starting with the least significant.

Imboden and Pfenninger (2013) view a model as a box containing variables V_i and external relations as R_i in which the external relations are the input variables. External variables influence the system variables.



In this case a dimension is a measure of the number of system variables. In this research the dimension could not be established in advance since a survey had to be done to ascertain computer networking projects' CSFs which constituted the variables.

Mathematical models connect the variables in the model with mathematical relations (Imboden & Pfenninger 2013:6). A mathematical model is generally expressed in the form:

$V = \text{function of } \{R\} = f(R)$

In this research the success of a computer networking project S is a function of all the critical success factors (c_i)

I.e. $S = f(c_i)$

In this research, therefore, there was need to establish the factors (c_i) to be used in the relation $S=f(c_i)$ to produce the link function:

$g(x) = k + c_1x_1 + c_2x_2 + c_3x_3 + c_4x_4 + c_5x_5$

Where **k** is a constant

$\mathbf{C_1}$ is the coefficient of variable 1 given as $\mathbf{x_1}$

$\mathbf{C_2}$is the coefficient of variable 2 given as $\mathbf{x_2}$ and so on.

3.5.9 Rating of items

The study employed a one-sample t-test to check how the items were rated in the questionnaire. The t-test was performed against the **Not Sure** option. This was executed to check which questions were significant (Masamha & Mnkandla 2017).The result indicated whether or not respondents agreed that the listed items were important in evaluating computer networking projects’ success. Computer simulation was used to validate the resultant list of computer networking projects’ critical success factors (Chapter seven).

3.6 Summary of the research methodology

The research followed a Critical Theory and Positivist/realist paradigm. Participants were empowered to solve their own problem of identifying factors they consider critical to computer networking projects’ success. The researcher believed in the existence of a certain set of CSFs for computer networking projects’ success, whether they were known or unknown. So this research proved that those factors existed though they were not reported in literature. Participants in the research were ICT project management practitioners and they helped in getting solutions to the factors needed to predict computer networking projects success.

The objectives of the research were achieved in the manner described below:

1. To develop a framework for determining computer networking projects’ CSFs in Zimbabwe. The objective was implemented in a unique three stage process of meta-synthesis analysis of literature, questionnaire administration and follow up interviews to clarify issues raised from the questionnaire providing more insights into the critical success factors. The questionnaire responses were analysed using SPSS version 23.0 and the interviews by NVivo version 10.0.
2. Explore suitable designs and important mathematical modelling and simulation techniques useful in developing a logistic regression analysis model to predict computer networking projects success in Zimbabwe. This objective was implemented through studying literature on mathematical modelling techniques and principles which included text books and journals.
3. Develop a mathematical model to predict computer networking projects’ success in Zimbabwe. The objective was implemented using logistic regression analysis.
4. Test and evaluate the logistic regression analysis model developed to predict computer networking projects’ success. The objective was achieved through the application of a deep neural network model developed using Python programming language and Jupyter Notebook.

3.7 Model validation

The logistic regression model developed was tested and validated using different methods for robustness. The methods included the Kolmogorov-Smirnov test, ROC curve and the Confusion matrix (section 7.3). A brief description of each follows.

3.7.1 Confusion matrix

The Confusion matrix or contingency table contains information about actual and predicted classifications done by a classification system (Santra & Christy 2012). It shows the performance of a classification model on a test data set. In other words it shows ways in which a classification model is confused when it makes predictions. The number of correctly classified instances is the sum of diagonals in the matrix.

Table 3. 1: Example of confusion matrix

		Predicted	
		Negative	Positive
Actual	Negative	P	Q
	Positive	R	S

Key

P – Number of correct predictions that an instance is negative.

Q – Number of incorrect predictions of positive instance.

R – Number of incorrect predictions of negative instance.

S – Number of correct predictions that an instance is positive.

Accuracy here is the proportion of the total number of predictions that were correct (Santra & Christy 2012).

3.7.2 Kolmogorov- Smirnov test

Kolmogorov-Smirnov (KS) test based on differences in the cumulative distribution functions is used for one dimensional continuous data. It uses the maximum absolute difference between the distribution functions of samples (Lopes, Reid & Hobson 2007). KS is a non-parametric goodness-of-fit test used to determine whether an underlying probability distribution differs from a hypothesised distribution (Evans, Drew & Leemis 2008). The benefit is that it is free from distribution and applies each individual data point in the samples. The test is independent of direction of ordering of the data. The Kolmogorov-Smirnov test compares the empirical distribution function of data against the cumulative distribution function associated with the null hypothesis i.e. the observed compared to the expected (Lopes, Reid & Hobson 2007).

3.7.3 ROC Curve

The ROC curve and the confusion matrix were used to measure the model accuracy.
The ROC curve statistically models the false negatives and the false positives.
Properties of the ROC curve (Santra & Christy 2012).
1.0 – perfect prediction
0.9 – excellent
0.8 – good
0.7 – mediocre
0.6 – poor
0.5 – random
<0.5 – something wrong

3.8 Statistical treatment of data

This research utilised principal component analysis as the main extraction method for the factors with varimax rotation method and the Kaizer-Normalisation. The Principal component analysis technique (in SPSS) was employed to diminish the number of variables into a lesser and manageable set. Nagelkerke R-squared value was used to measure how the developed model accounted for the variation in the dependent variable (computer networking project success). Cronbach's Alpha test was employed to test the reliability of the instrument used to identify the critical success factors for computer networking projects.

Computer networking projects' CSFs were the independent variables that were modelled to predict project success. The logistic regression analysis model was developed that uses data about these variables in any project to produce a value that represents the success level expected. The CSFs were weighted and the weights used as their coefficients in the developed link function. The final value from the link function was used in the logistic regression analysis model. The result is a value between 0 and 1. For values up to 0.5 the project is predicted to succeed else it is predicted to fail. The benefit is that the stakeholders in that project are given room to protect resources (mainly money) in case a failure is found to be imminent. Secondly, clarification: a mathematical model helps to organise one's perceptions, exposes latent assumptions and ascertain data needs (Bokil 2009).

The researcher decided to use logistic regression analysis as the major approach to identifying critical success factors for computer networking projects. The model developed provided a means of quantifying the factors critical to the success of computer networking projects in real life and input them into a logistic function whose outcome was fed into the logistic regression analysis model. The result of the logistic regression analysis model was used to predict the possible success of the project. Meta-synthesis analysis (chapter four) was used to reduce a wider set of factors critical to ICT projects into a smaller set of factors that were critical to computer networking projects. It became easier for the researcher to use this smaller set in the model. That means the model was used as a tool to break the complexity of predicting the success of a computer networking

Internal and external validation were done (chapter seven). For the internal validation, the hold out method was employed in which the whole data was split into two subsets; one of the subsets was used to build the model and the second one to test it. Splitting data into the train sample and the test sample was done prior to building the model to remove any possible bias by the researcher. For the external validation, the researcher used the Receiver operating instructions (ROC) curve and the Kolmogorov- Smirnov Test. The ROC curve was prefered due to its visual nature in which the area under the curve is used to indicate the measure of validity (Salija, Bilandzic & Stanic 2017). The higher the value, the better the model. The results were discussed in chapter six.

3.9 Discriminant analysis

Discriminant Analysis (DA) is sometimes used in place of logistic regression analysis especially when the sample size is very small and the assumptions are met (Ayinla & Adekunle 2015). The term is generally interpreted as a unified approach in the solution of a research problem involving a comparison of two or more populations characterised by multi-response data. DA establish significant group differences, explain these differences and utilises multivariate information from the samples studied in classifying a future individual belonging to one of these groups (Ayinla & Adekunle 2015). The objective of a DA is to classify objects by a set of independent variables into one or more mutually exclusive and exhaustive categories.

Discriminant analysis was applied to the real world project data collected to test the developed model. This was done to compare results with those from the logistic analysis to determine whether the binary value assumption for project success was meaningful. DA comes in different forms including multiple discriminant analysis, linear discriminant analysis and K-NNs discriminant analysis. However, there is no best discrimination method (Ayinla & Adekunle 2015). In this regard the researcher chose to use linear discriminant analysis.

In preparing the data for DA, the researcher ensured the following conditions:

1. Having an adequate sample
2. Having an independent random sample
3. Observations were independent of one another.
4. Dividing the sample

In evaluating the DA results there are three questions to ask:

1. Which independent variables are good discriminators?
2. How well do these variables discriminate among the two groups?
3. What decision rules should be used for classifying individuals?

To analyse the model, the group of original ratios is divided into **n** general dimensions. In this study a stepwise approach was employed. The results of the discriminant analysis were compared with those from the Logistic regression analysis in the discussion of results section.

3.10 More types of statistical analyses employed

Categorical regression

Logistic regression used in this study is a special case of a general linear regression model. The general linear model is a stretchy statistical model that integrates normally distributed dependent variables and categorical or continuous independent variables. This framework is useful for comparing the effect of many variables on different continuous variables. It is a compact way of representing multiple multivariate regression models. Therefore it is not an independent statistical linear model.

The important difference between the general linear model and the logistic regression is that logistic regression is used when the dependent variable is binary in nature whereas linear regression is used when the dependent variable is continuous. General linear regression focuses on how to forecast a categorical outcome when there are multiple predictors, which may or may not be responsible for that outcome.

Categorical/nominal

A categorical or nominal variable is the one for which the responses differ according to type or kind e.g. group membership (gender, marital status etc.). The use of categorical independent variables in regression analysis involves the application of coding methods. Coding methods refer to ways in which membership in a group can be represented in a mutually exclusive and exhaustive manner. Coding methods include effect and dummy coding. In general 1 is used for inclusion and 0 for exclusion e.g. 1 for male and 0 for female (Alkharusi 2012). This was the main coding used for the data before it was entered into SPSS.

Ordinal regression

An ordinal measure includes ranks within the collected data e.g. Likert scale measures that may be rated on a five point scale. Usually, variables of interest are ordinal i.e. values can be ranked without knowing the real distance between categories. Survey respondents usually are given choices on a scale from strongly agree to strongly disagree. Ordinal categorical variables can be used as predictors or factors in statistical procedures. In this study many of the questionnaire items were ranked and the data coded categorically on a scale of 1 to 5. This made the statistical analysis easier and more meaningful. It worked well since logistic regression is an instance of general linear regression.

3.12 Chapter summary

The researcher outlined the methodology being the blue-print of how the research was carried out. The chapter included the research paradigms, methodology, tools and techniques of data collection and how the collected data was analysed. The study was done from a positivist and critical analysis perspectives and used a mixed research design which comprised of qualitative and quantitative designs. Major tools and techniques included meta-synthesis analysis, logistic regression analysis, literature search and simulation. The population and sample of the research were also explored and documented.

Chapter Four: Meta-synthesis analysis of ICT projects' CSFs

4.0 Introduction

This section outlines the process used in this study to determine ICT projects' CSFs. The researcher realised that there was a huge number of research articles on the subject. However, those research articles all seemed to generalise ICT projects. The researcher further realised that ICT projects are many and varied, so there was need to use the already existing research findings to build a consolidated set of ICT projects CSFs. The resulting set was then used as a basis for the construction of a CSF model for computer networking projects in Zimbabwe, which was the thrust of the research. The CSF model was used to develop the logistic regression analysis model for the prediction of computer networking projects success in Zimbabwe.

4.1 The meaning of meta-synthesis

Meta-synthesis incorporates a diversity of methods to synthesise qualitative research studies in a certain field of study. It synthesises groups of qualitative research to create new knowledge and to give direction to what we already know about particular occurrence (Paterson et al. 2009). It is a deliberate and comprehensive approach to analysing data involving different qualitative studies. The process allows researchers to formulate a specific research question and then look for, choose, evaluate, summarise and aggregate qualitative evidence to answer the research question (Chanail et al.2018:21; Erwin, Brotherson & Summers 2011:1). Meta-synthesis develops overarching interpretations originating from the collective interpretation of the original studies in the synthesis by going beyond the results of each study to make the whole into an artefact greater than the individual components (Lachal, Reva-Levy, Orri & Moro 2017:2). In other words, the procedure uses thorough qualitative approaches to synthesise existing qualitative studies to build better meaning via an interpretive process (Erwin, Brotherson & Summers 2011:1).

In this study, the researcher decided to employ meta-synthesis analysis due to the realisation that many lists exist that contain different ICT projects' CSFs. Instead of embarking on a fresh research to identify ICT projects' CSFs, the researcher decided to use the existing research results to build new knowledge on these factors. All the researches considered were from the ICT field. The main research question was: what are the critical factors for the success of ICT projects?

Various research articles were searched from literature and the researcher selected, appraised, summarised and combined qualitative evidence to answer the research question. The researcher thus analysed the existing findings to develop common themes and used them to identify factors critical to ICT project success.

4.2 The difference between meta-synthesis and meta-analysis

The distinction between meta-synthesis and meta-analysis is that the latter is a statistical procedure that tries to assimilate a group of quantitative research, often focusing on minimising the results to a standardised metric (Erwin, Brotherson & Summers 2011:2). Meta-synthesis is a method of qualitative research synthesis that gives interpretive findings from assimilation and comparisons of results from a group of qualitative research (Erwin, Brotherson & Summers 2011:2).

There is a thin line between meta-synthesis analysis and systematic literature review (SLR). The latter is a review of a clear research question by using systematic and explicit methods to identify, select and critically appraise relevant research and how to collect and analyse data from the studies included (Siddaway, Wood & Hedges 2019). On the other hand qualitative meta-synthesis aims at synthesising qualitative studies on a given topic for purposes of locating key themes, concepts or theories that provide novel or more powerful explanations for the phenomenon under review. The later does not involve statistical analysis. In this study the two were viewed as sharing all other aspects except the fact that SLR involves quantitative analysis whereas meta-synthesis is limited to qualitative analysis.

4.3 Why the researcher used meta-synthesis analysis

This research used meta-synthesis to build a set of ICT projects' CSFs from a variety of articles on that subject. The researcher was motivated by the fact that there were varied lists of ICT project critical success factors, which could possibly have been subjective to a number of different factors that include differences in the setting of the research and the type of the ICT project under study. The researcher noted that in most cases the term ICT was used as a blanket term for different projects though they all belong to the ICT domain. Meta-synthesis was used in this research because synthesising a unified group of qualitative research helped to determine universal themes as well as comparing and contrasting different types of studies on ICT projects' CSFs. This gave the researcher profound intuitions that could not be obtained from one study. The research did not take the meta-synthesis approach as an assimilated literature review of the ICT projects' critical success factors or a secondary analysis of primary data from a body of selected research studies but as an interpretation of results from the included studies (Erwin, Brotherson & Summers 2011). The reason behind this was the need to move away from knowledge creation to knowledge utilisation due to the rapid increase in the volumes of research results (Erwin, Brotherson & Summers 2011). It was not necessary to carry out a completely new study on ICT projects' CSFs when large volumes of research work on the subject were available.

Qualitative meta-synthesis is useful in identifying gaps in research, to give direction to the development of original studies and to offer evidence for the construction, implementation and assessment of interventions in human livelihoods (Lachal et al. 2017). This process of assimilating and interpreting important data from different qualitative studies enabled the research to have an exclusive and important contribution to minimising the gap between research and practice. It also enabled the development of a framework to explain the common ICT projects' CSFs and deepen the understanding of critical success factors for computer networking projects (Erwin, Brotherson & Summers 2011).

4.4 The meta-synthesis process

The steps followed in the meta-synthesis analysis were derived from Lachal et al. (2017) and Erwin, Brotherson and Summers (2011). The process of meta-synthesis comprises of discrete steps. The succeeding is a description of the steps that the researcher followed in performing the meta-synthesis analysis in this research:

Step 1: Formulation and definition of the research question

The first step in any investigation is the identification of the problem or question to be answered. In this meta-synthesis analysis the research question was:

What are the factors critical to the success of ICT projects?

Step 2: Conducting a comprehensive search of the literature

The second step was conducting a comprehensive search of the literature on ICT projects' CSFs. This step began by defining the selection criteria for the studies or articles. One of the issues in conducting qualitative meta-synthesis is the question on how the investigators established the value of individual research studies included in the qualitative meta-synthesis, i.e. the selection criteria (Erwin, Brotherson & Summers 2011:6). The researcher overcame this challenge by carefully defining and implementing systematic inclusion and exclusion criteria because there was no consensus on criteria to apply in qualitative research.

For this purpose, the STARLITE approach was used as indicated in Table 4.1.

Table 4. 1: **The STARLITE principle**

PRINCIPLE	APPLICATION
S- Sampling strategy	Only articles with a comprehensive sampling strategy were considered for the analysis
T- Type of study	Only studies that were aimed at studying the critical success factors for ICT projects were included
A- Approaches	Electronic sources were searched. Citation snowballing was employed to broaden the number of articles in the initial search
R- Range of years	Articles published between 2010 and 2019 inclusive were considered for inclusion into the first round of research for the reason of examining the research in the recent past to show the current state of affairs in the CSFs for ICT projects.
L- limits	Only English articles were included
I- Inclusion & exclusions	• The purpose of the research was supposed to focus on the determination of ICT projects' CSFs. • The research questions were expected to be clear and focus on identifying ICT projects' CSFs. • Only researches whose data was collected through survey (interviews and questionnaires) were compared and contrasted. Were the data collection and analysis techniques suitable for the research question? Only those studies whose data collection methods were suitable were considered for meta-analysis. • The results compared were only those that provided lists of ICT projects' CSFs. Claims from the results were expected to be supported by sufficient evidence.
T- Terms used in the search	CSFs for ICT projects/ information systems projects/computer science projects/software development projects/networking projects/database development projects/ software upgrade projects/ ERP projects/ computer hardware projects/ critical success factors for ICT projects' success
E- Electronic sources	• Google Scholar, EBSCOHOST, ELSEVIER, EMERALD, ACM and IEEE. These were chosen to provide a variety of journal article sources. Researchers publish in different journals and some prefer publishing under the same types of journal that may be under the same database. Searching different databases ensured that articles with different strengths could be found resulting in comprehensive information being obtained. In addition, the researcher had access to these databases through the institution.

Step 3: Quality assessment

The researcher should outline the research strategy used, the screening process of articles and the eligibility or selection criteria (Hossain et al. 2017). The researcher determined the similarities amongst studies. This was achieved through the use of the stated research purposes, research questions, data collection techniques, data analysis and the kind of findings reported (in the same way as the STARLITE principle). Here, cautious evaluation of studies was conducted for possible inclusion using the criteria defined in step two. The CASP criteria was used that provided weighting on three levels (not met, met and partly met). The researcher determined which studies to include and what features to account for. A total of one hundred and fifty-five articles were initially considered for this study. All the one hundred and fifty-five articles were written in the English language and had comprehensive sampling done. Table 4.2 indicates the quality assessment results of the articles produced.

Table 4. 2: Table 4.2: Quality assurance criteria

Criteria	Met	Partially met	Not met
Publication (2010 – 2019)	133	1	47
The purpose of the research focused on the determination of ICT projects' CSFs.	39	57	36
Data was collected through survey (interviews and questionnaires); Data collection and analysis techniques suitable for the research question	19	11	9
Results provide lists of ICT projects CSFs. Were the claims in the results supported by sufficient evidence?	13	1	5
Clear research question	13	0	0
The publication was reputable (if not found on the Beal's list: https://beallslist.weebly.com/)	13	0	2
Final number of articles included in the meta-synthesis analysis	**11**		

The list of the final articles included in the study

Table 4.3 indicates the final articles selected for the meta-synthesis analysis.

Table 4. 3: **Selected articles**

Article	Code
Yeoh W and Koronios A (2010) Critical success factors for business intelligence systems, journal of computer information systems, Vol 50(3) pp 23-32	A1
Nasir M. H. N and Sahibuddin S (2011) critical success factors for software projects: A comparative study, scientific research and essays Vol. 6(10) pp2174-2186	A2
Sudhakar G. P (2012) A model of critical success factors for software projects, journal of enterprise information management vol. 25(6) pp 537-558	A3
Imtiaz A et al.(2013) critical success factors of information technology projects, world academy of science, engineering and technology international journal of computer and systems engineering, Vol. 7(12)	A4
Joseph N and Marnewick c (2014) structured equation modelling for determining ICT project success factors, project management institute research and education conference, Phoenix, AZ New Square, P A Project management institute	A5
Montequin V. R et al.(2014) analysis of the success factors and failure causes in information and communication technology (ICT) projects in Spain, international conference on project management, Procedia technology Vol. 16(2014) pp 992-999	A6
Nyandongo K. M (2018) critical success factors for information technology (IT) projects in South Africa, international association for management of technology IAMOT 2018 conference proceedings	A7
Komai S, Saidi H, and Nakanishi H (2007). Study on the critical success factors in IT system implementation. Penerbit UTM Press. Vol. 9(2017)31-38	A8
Shah, M. H, Braganza A and Morabito V (2007). A survey of critical success factors in e-Banking: an organisational perspective. European journal of information systems. Vol. 16(2007)	A9
Guntur M, Purwandari B and Raharjo T (2008). Critical success factors for information systems development: a case study in e-government. ACM (2018) 20-22	A10
Huang G, Kurnia S and Linden T (2018). A study of critical success factors for enterprise systems implementation by SMEs. 22nd Pacific Asia Conference on Information systems. Japan.	A11

Table 4. 4: **Focus area and setting of the selected researches**

ARTICLE CODE	RESEARCH FOCUS	ICT AREA ADDRESSED	SETTING
A1	Business intelligent systems	Software	Australia
A2	Software projects	Software	Malaysia
A3	Software projects	Software	India
A4	Information technology	General	Malaysia
A5	ICT projects	General	South Africa
A6	ICT projects	General	Spain
A7	Information Technology	General	South Africa
A8	IT systems development	IT	Malaysia
A9	e-Banking	WebiS	UK
A10	e-Governance	WebiS	Indonesia
A11	ERP	ERP	Europe

Step 4: Extracting and presenting formal data

At this stage the researcher should choose and apply meta-synthesis approaches to assimilate and analyse qualitative research results and evaluate relationships in and across study results (Erwin, Brotherson & Summers 2011). The researcher used thematic analysis for extracting and reporting data. The selected articles were coded and themes identified and synthesised into specific ICT projects' CSFs.

Data analysis and coding

Data analysis in meta-synthesis is the most subjective part of this type of study (Lachal et al. 2017:6). To minimise the problem of subjectivity, the researcher used Atlas.ti version 8.0 software to do the analysis of the selected articles. The choice of a computer assisted qualitative data analysis (CAQDAS) software depended on the researcher (Mnkandla 2016) and its relevance to the data analysis needed. Atlas.ti is a formidable system for the qualitative analysis of huge groups of textual, graphical, audio and video (Friese 2019). It provides a diversity of tools including those achieving tasks to do with data that is difficult to analyse through arithmetic methods such as in quantitative analysis (Friese 2019). Tools offered by Atlas.ti include managing, extracting, comparing, exploring and reformulating meaningful pieces from huge quantities of data in an ingenious and versatile but organised manner. In this study, data from the articles were read and reread with the objective of appraising, familiarising, identification, extraction, recording organising, comparing, relating, mapping, stimulating and verifying i.e. read with the intent to collate a synthesisable set of accounts (Lachal et al. 2017:6).

Each document was coded as a whole, line by line and the codes were categorised into themes. The coding was done in three stages namely line-by-line coding of the initial data (articles selected), grouping codes and analysing and reporting the findings. In line-by-line coding, the coding involved condensing text from the findings and discussion sections of individual articles into at least one expressive issues to take meanings (Hossain et al. 2017). A total of seven articles were coded and the findings indicated in Table 4.5.

Table 4. 5: Article analysis results

Article Code	Major findings	Researcher's comments
A1	Business intelligent systems implementation is an intricate undertaking that requires a lot of resources. Organisations that observe the CSFs from a business perspective are better placed to attain better results.	CSFs are significant in enhancing project success. One of the important aspects is the availability of adequate resources.
A2	There has been no far-reaching study on varying project sizes in In different domains or across countries.	There is a gap in literature in the form of lack of studies on CSFs based on project size, domain and country.
A3	CSFs fall into different categories.	When studying and using CSFs it is important to categorise them for easy interpretation and application.
A4	The success of ICT projects depends on innumerable factors and it is significant to establish those that are critical.	This points to the serious importance of research on CSFs in ICT projects.
A5	ICT project performance rates have not improved over the past decades.	This further indicates the importance for more research on CSFs for ICT projects.
A6	The biggest challenge in project management is establishing what is necessary to do in order to attain success. Many lists of success factors appear in literature with no general consensus about them due to the fact that they rely on the nature of the study and type of the project.	Emphasises the importance of CSFs. There is no agreement on the CSFs because they depend on different factors. Therefore, CSFs for ICT projects have to be interpreted according to these different factors.
A7	Project management should be contextualised, CSFs should be related to different settings, industries and environments.	Context is critical to the study, interpretation and application of CSFs for ICT projects.
A8	Five most critical success factors for IT systems development were clear project objectives, team work, customer/user involvement, team technical skills and staff selection.	These five identified critical factors all relate to the project team as the most influential in determining project performance.
A9	Electronic banking is a key aspect for many SMEs in the financial services industry. CSFs include quick responses and customer satisfaction.	The focus was more on the customer than the project management itself.
A10	CSFs include business process reengineering, systems integration, planning, scheduling, team skills, and support from top management,	The CSFs relate to the project team, organisational culture and senior management.

	communication and organisational culture.	
A11	Narrowed the list of CSFs to make it practical and remove confusion from SMEs.	The shorter the list of CSFs the more useful it is to the SME.

Implications to the study

The major findings from these seven articles studied had very useful implications to the current study. Most importantly, the researcher realised that research on CSFs was done disproportionately in terms of countries and ICT domains. In essence, there was no research done for CSF for ICT projects in Zimbabwe up to date. In addition, no research was found in literature of the CSFs for the computer networking projects domain. The interpretation of CSFs need to be done in light of context and domain, implying that in Zimbabwe so far, any reference to CSFs may not produce best results since they would be applied in the wrong context. The current research, therefore, provides the first reference point in Zimbabwe and in the computer networking domain. The provision of a set of CSFs for computer networking projects in Zimbabwe is the first contribution of this study.

Building themes

Analysis of articles using Atlas.ti produced themes in the form of critical success factors for ICT projects. Figures 4.1, 4.2 and 4.3 give graphic illustrations of some of the network diagrams generated from Atlas.ti coding.

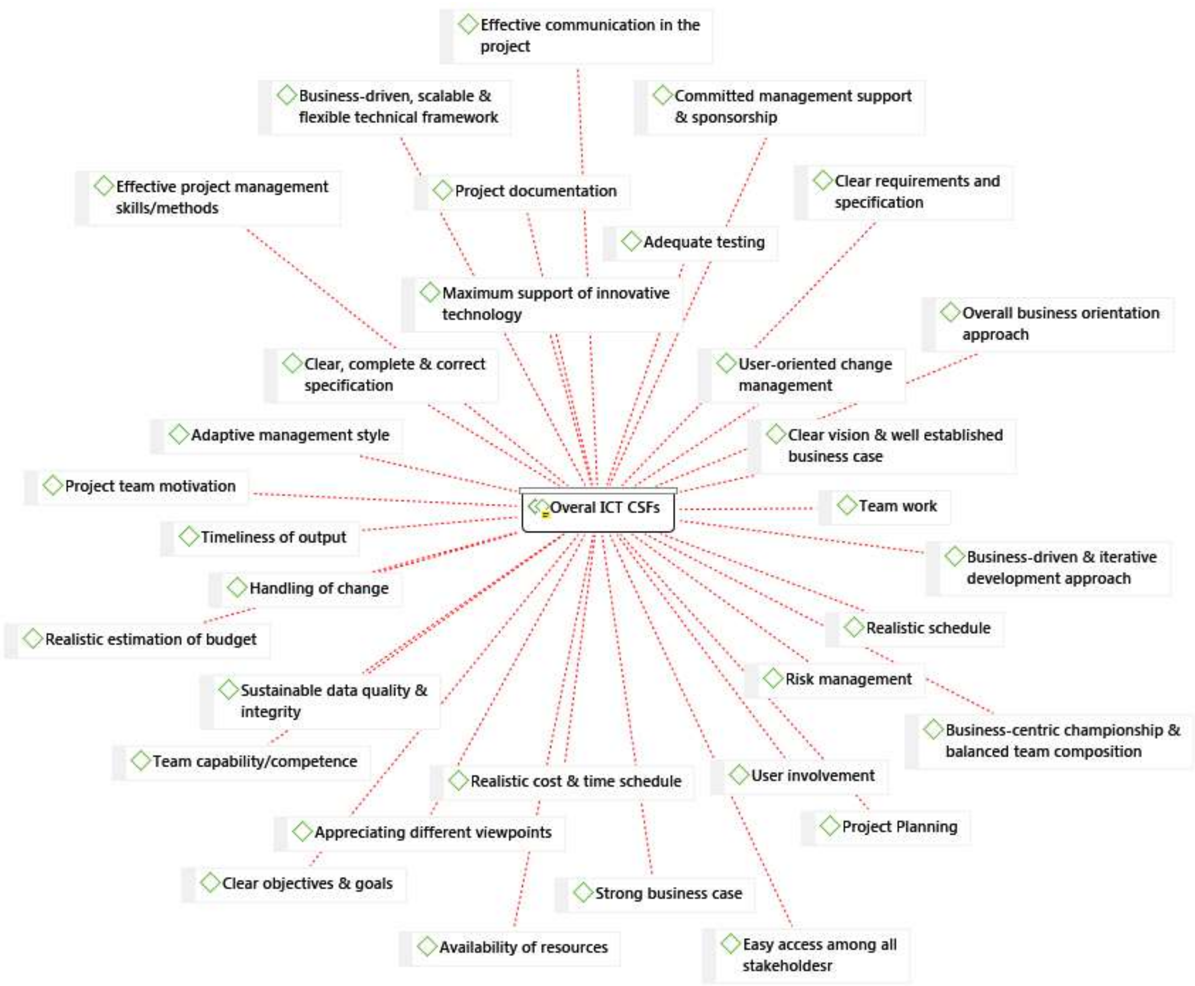


Figure 4. 1: Overall ICT critical success factors

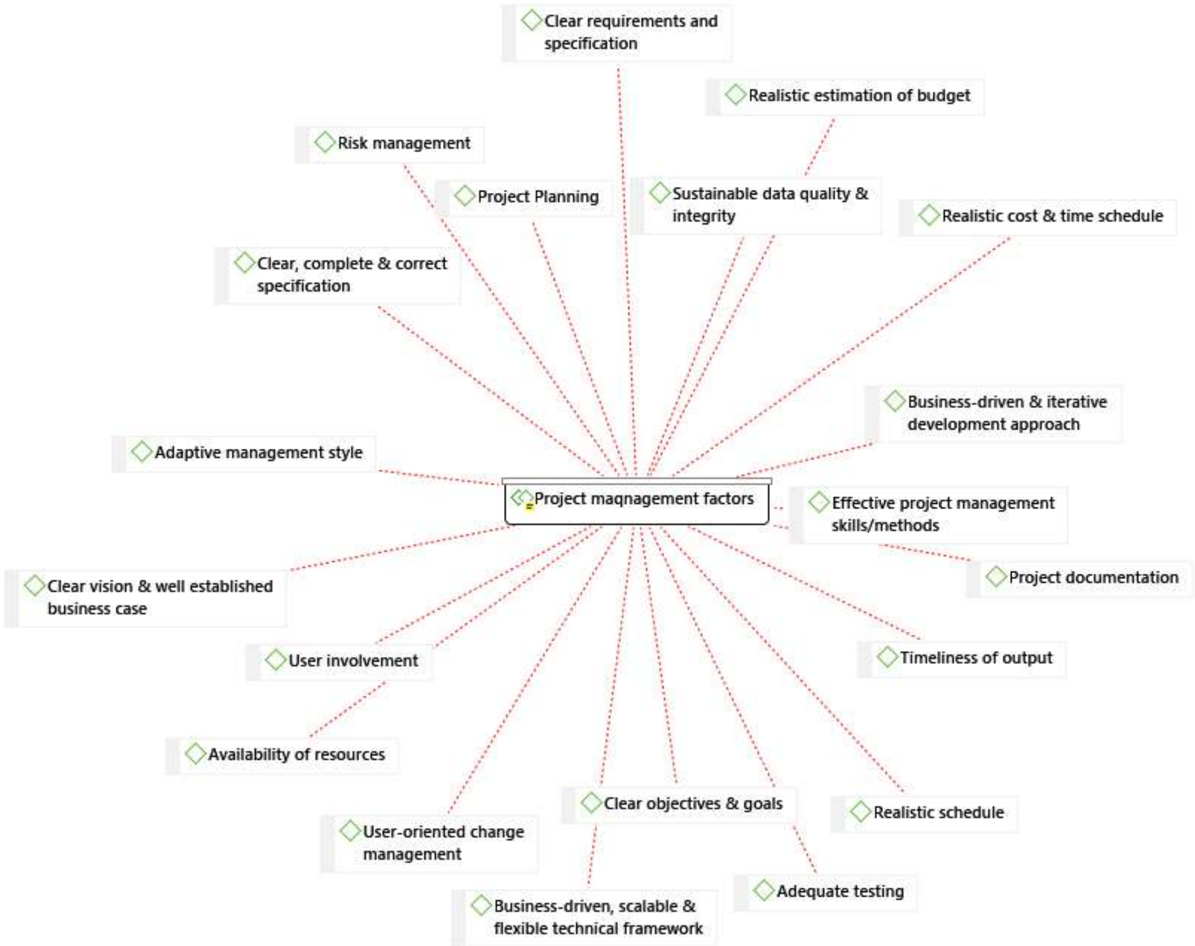


Figure 4. 2: Project management factors

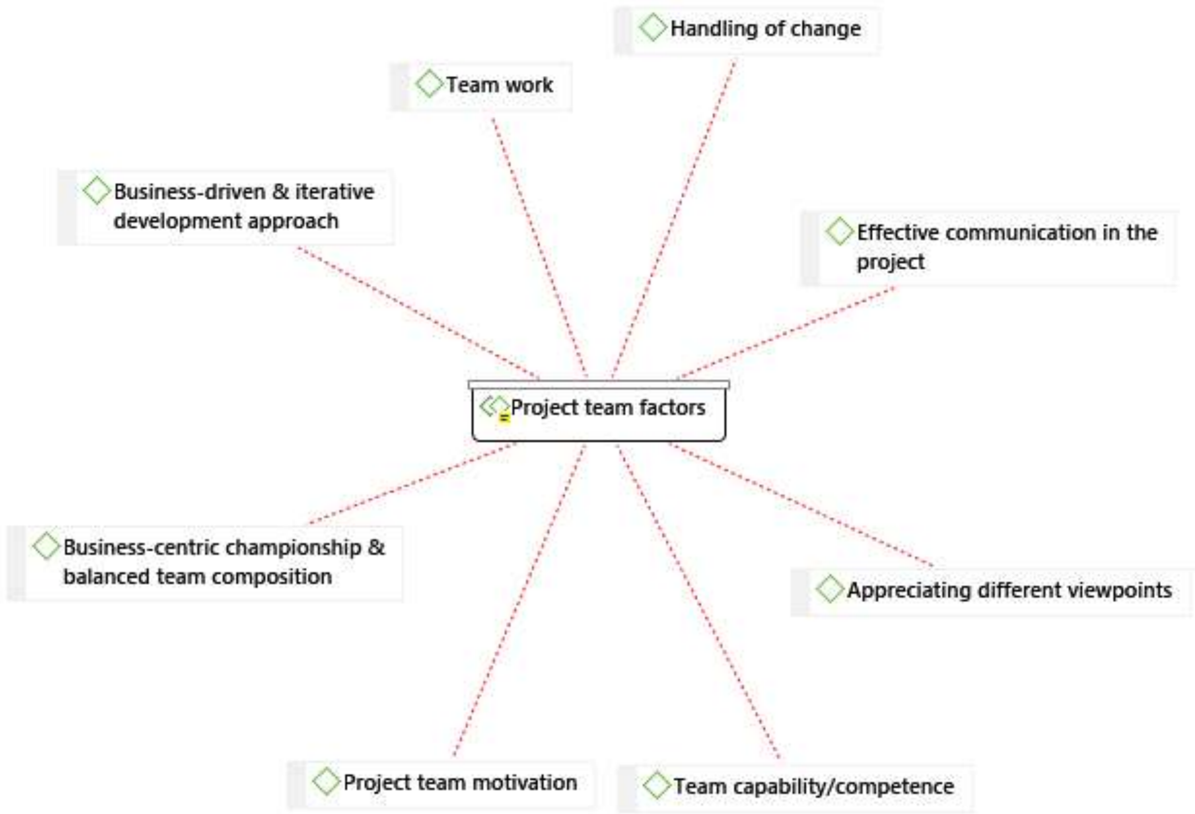


Figure 4. 3: Project team factors

The researcher put the CSFs against the articles in which they appeared. The resultant matrix indicated the most frequently appearing factors and grouped them together as the identified critical success factors. Table 4.6 shows the results.

Table 4. 6: **CSFs for ICT projects in the selected articles**

Critical Success Factor	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
Committed management support & sponsorship	√	√	√	√	√					√	
Clear vision & well established business case	√							√		√	√
Business-centric championship & balanced team composition	√							√		√	
Business-driven & iterative development approach	√										
User-oriented change management	√							√			
Business-driven, scalable & flexible technical framework	√										
Sustainable data quality & integrity	√										
Overall business orientation approach	√										
Clear requirements and specification		√									
Clear objectives & goals		√		√	√	√		√		√	√
Realistic schedule		√									
Effective project management skills/methods		√	√				√				
Effective communication in the project			√	√	√	√				√	
User involvement			√	√	√			√	√		
Accuracy of the output			√								
Team capability/competence			√	√			√	√		√	
Project Planning			√							√	√
Handling of change					√						
Realistic cost & time schedule						√				√	
Clear, complete & correct specification						√					
Availability of resources							√				
Strong business case							√				
Team work							√				

Analysis of the relationships among the themes and reporting of the findings

The researcher analysed, compared and contrasted the relationships found in the results of the selected studies. From Table 4.6, the researcher realised that ICT projects' CSFs identified were contextual and depended on the ICT domain.

This explained why the researchers produced different sets of CSFs. Four of the eleven articles focused on ICT projects in general. This makes the results weak since research on CSFs should be contextual in terms of the domain of ICT (Nasir & Sahibuddin 2011). There has been no widespread studies on varying project sizes in different areas and across countries (Sudhakar 2012). The remaining seven articles focused on software development and WebiS projects. These studies were more specific than the other four but suffered the limitation of environment. These studies were carried out in different environments, *viz*., Malaysia, Australia, UK, Indonesia, India, Europe, South Africa and Spain. In terms of context, it is clear that all these researches were done in different settings and there was little chance that they could produce the same results. This scenario contributes to the fact that ICT project performance rates have not improved over the past decades (Montequin et al. 2014). In the final analysis, a huge amount of lists of success factors appear in literature with no general consensus about them due to the fact that they depend on the nature of the study and type of the project. This study extracted the most recurring factors from these various studies to produce a more encompassing list that can at least improve the ICT project management in different contexts. However, no claim can be made on this set's possible applicability.

Table 4.7 indicates the resultant list of ICT projects' CSFs derived from meta-synthesis analysis.

Table 4. 7: **Frequency of CSFs in the selected articles**

CRITICAL SUCCESS FACTOR	FREQUENCY OUT OF 11
Clear objectives & goals	7
Committed management support & sponsorship	6
Effective communication in the project	5
User involvement	5
Team capability/competence	5
Effective project management skills/methods	3

It is therefore critical for ICT project managers to carefully consider these six critical success factors. The importance of top management was very clear from these studies. No project can succeed where there is no executive support. These are the people responsible for authorising functions such as resource mobilisation, project products approval, among others.

The manager has to assemble a very competent team for the project. Once this is accomplished, objectives of the project should be set, clarified and communicated to all stakeholders. Communication, therefore, is one of the critical issues to consider. The effort can be fruitless if the manager and his/her development team does not involve the user of the system. It is the user who shall interact with the product, hence, the user input is critical for improved benefit from the project and the sustainability of the project results.

These identified ICT projects' CSFs were compared with those from the survey done in Zimbabwe as part of the study. The process and findings of the survey were given and discussed in chapter five. The comparison aimed at the determining of ICT projects' CSFs in the Zimbabwean context.

Step 4: Reflect on the process

In carrying out meta-synthesis analysis, the researcher has to be self-reflective and address issues of credibility and trustworthiness (Erwin, Brotherson & Summers 2011). At this stage the researcher considered issues of limitations of the study. The seven articles considered were the most suitable considering the criteria used in this research. Otherwise, a different set of articles could have been obtained as well. This meant that the results of the meta-synthesis analysis could have been a bit different. Credibility and trustworthiness of the results hinged on the fact that the articles themselves were from reputable journals. All the articles considered were screened using the Beal's list of discredited journals. Only the articles not listed were considered in the study.

In any meta-synthesis study, the question of how the researchers synthesise the researches maintaining the importance and reliability of individual studies always arise (Erwin, Brotherson & Summers 2011:6). In other words, the issue is how the researcher maintains the good depiction and setting which are pillars of qualitative practice. The researcher addressed this important aspect by including in the report of the results, an outline of information on the context of articles to preserve it (Table 4.4). Though the resultant list of CSFs was different from the initial lists from literature, the domain of ICT projects and the country in which the study was carried out were documented. It followed that the CSFs can still be traced back to the original studies.

Step 5: Presenting synthesis results

The data in meta-synthesis analysis was presented systematically using tables, charts and figures (Lachal et al. 2017; Erwin, Brotherson & Summers 2011). In this study the presentation included identification of the study articles, the country of origin of the article and nature of respondents (domain of ICT project). These aspects were depicted in Tables 4.4 to 4.7.

4.5 Chapter summary

This chapter outlines the process of meta-synthesis analysis carried out as part of the research and the findings. The final deductions from the articles finally analysed produced six ICT projects' CSFs. The following were the ICT projects' CSFs in their order of strength were: committed management support & sponsorship, clear objectives & goals, effective communication in the project, effective project management skills/methods, user involvement and team capability or competence. These factors were compared with factors found to be critical to ICT project management in Zimbabwe as presented in the next chapter. Further, they were compared with those found to be critical to computer networking projects in Zimbabwe in chapter eight.

Chapter Five: Presentation and analysis of data

5.0 Introduction

The chapter presents the data obtained in the study. This was done in stages according to how the research was done. First is the presentation and analysis of data on ICT projects' CSFs in general obtained from the meta-synthesis analysis. Second is the presentation and analysis of data on computer networking projects CSFs (From questionnaire and interviews). Third is the discussion of these results comparing the CSFs from meta-synthesis analysis and interviews from chapter four and those obtained from the exploratory factor analysis from SPSS.

5.1 ICT projects' CSFs in Zimbabwe

In chapter four the researcher presented the process and results of meta-synthesis analysis on ICT projects' CSFs. All the studies analysed were conducted outside the country. The researcher used the studies to determine ICT projects' CSFs as reported from other countries. This section reports on the CSFs from the meta-synthesis analysis. At the end of this chapter, these results were compared with those obtained locally. The idea was to begin from the known to the unknown. The variables used in the data collection and their explanations are indicated in Table 5.1.

Table 5. 1: Variable explanation

Code	Variable name	Meaning
A1	Oneness of the project team	Members of the team work together harmoniously
A2	Team members with high competence and expertise	Well trained and experienced staff for the intended job
A3	Motivated team members	Members who are happy in doing their work without being forced.
A4	Coherent self-organising team	United members who have self-control and work under minimum supervision
A5	Project goals awareness	Educating all stakeholders on the goals of the project
A6	Access to innovative, talented and sufficient people	Members know where to get information from and have those people ready to provide the relevant information
A7	Skills transfer to new members	Ability of old members in imparting skills to the less experienced
A8	Pursuing simple design	Members being able to correctly follow simplified designs for the project work.
A9	Rigorous refactoring activities	Members engage in deducing trends from given processes
A10	Project team in one place	Members of the project team work from the same area

A11	Appropriate technical training of them	Members where adequately trained in their work
A12	Projects with small team	Fewer members working on an individual project
A13	Projects with no multiple independent teams	Project whose members are not grouped into smaller teams working on their own
A14	Clear realistic goals	The goals of the project are precise and achievable
A15	Knowing client needs	Team members identify and understand what the customer wants from the project.
A16	Project size complexity	How intricate the project is with respect to size
A18	Project team in different areas	Members working on a project not situated in one area
B19	Cooperative organisational culture	Members of the organisation being able to share ideas and help each other
B20	Oral culture placing value on face-to-face Communication	Informal way of working together and share ideas and information without necessarily writing the rules down as policy.
B21	Organisation adaptation	The ease with which the organisation changes to suit new demands
B22	Good customer relationship	Organisational members' willingness to work well with customers
B23	Honouring regular working schedule with no overtime	Working within set deadlines
B24	Strong customer commitment and presence	Being available for customers when they are in need on service
B25	Customer having full authority	Giving the highest priority to the customer
B26	Flexible approach to change	Ability to adjust in different ways when there is change
B27	Adequate budget	Enough finances for the project
B28	End user involvement and commitment	Roping in the final user who in turn has to be committed to the project
B29	Clear communication channel	Members should know in advance who to approach given certain situations.
B30	Equipment support	Provision of resources when needed for the project
B31	Economic standing of the organization in funding Small project	The extent to which the organisation is able to provide money for small projects
B32	Sound basis for project	A good reason to engage in the project work
B33	Outsourcing the project	Contracting people external to the organisation
B34	Economic standing of the organisation in funding large projects	The extent to which the organisation is able to provide money for huge projects
B35	Adequate resources	Enough resources to sustain the project
B36	Strong support from senior management	Willingness of top managers in approving and funding the project
B37	Committed sponsor	The extent to which the sponsor of the project undertakes to pay for the project
C38	Committed manager	A manager who has the project at heart

C39	Managers with light touch	Managers who give members room to work on their own
C40	Taking account of past experience and learning from it	Members considering previous failures and successes in developing new insights
C41	Effective team building or motivation	Better ways of constituting the team and provide a conducive working environment
C42	Training provision	Providing training opportunities for the members
C43	Appreciating effect of human error	Tolerance to common mistakes
C44	Considering and appreciating multiple viewpoints	Accepting that people think differently and willing to accept other's ideas
C45	Effective leadership conflict resolution	Better ways of dealing with misunderstandings among members.
C46	Effective monitoring & control	Better ways of identifying deviations from the plan and making adjustments
C47	Strong detailed planning	Comprehensive plan that produces desired results
C48	Correct choice past experience & methodology	Accurately choosing what to take forward from previous projects
C49	Monthly project reviews	Reports of reflections on the work done each month.
C50	Use of website for communication	Sharing information and ideas using a website
C51	Realistic schedule	A plan of action that is achievable
C52	Project nature non-life critical	A project that does not pose serious harm to life
C53	Project type or variable scope	Pronouncement of the boundaries of the project, what it is intended to cover
C54	Project manager technical background	The manager's technical skills acquired and experience
C55	Right amount of documentation	Documents made for the project are the correct ones and minimal for the project to complete
C56	Deliver most important features first	Prioritising those parts of the project that produce the critical functions.
C57	Project manager communication skills	The extent to which the manager can communicate with stakeholders
C58	Strong communication face-to-face	Ability to share ideas and information from one person to the other directly
C59	Projects with dynamic accelerated schedule	Projects with changing features and have to be finished in shorter times
C60	Projects upfront cost evaluation done	Projects whose costs are done and validated before the project is done
C61	Having a clear project boundary	Defining what the project must do
C62	Competent project manager	Manager who has adequate expertise to run the project
C63	Projects with upfront risk analysis done	Risk management is done before the project is carried out

C64	Effective management of risk	Proper handling of anticipated risks in the event that they manifest
C65	Identify project source	Knowing the problem or opportunity that called for the commencement of the project
C66	Size & duration of project	Number of components of the project and time set for carrying out the project
C67	Project uniqueness	The specific characteristics that differentiates the project from others
C68	Design review with stakeholders	Having a relook at the project design together with the relevant stakeholders
C69	Design review with project team & top management	Having a relook at the project design together with team members and senior managers
D70	Support from stakeholders	Buy in from stakeholders
D71	Political & social stability	The conduciveness of the political and social environment
D72	Environmental influences	The extent to which the project is affected by surrounding circumstances
D73	Proven & familiar technology	Technology used is tried and tested
D74	Competitor technologies	Which other available technologies can achieve the same
D75	Reliability of subcontractors	To what extent do subcontracted companies do a good job
D76	Good performance by suppliers or contractors or Consultants	The ability by suppliers and consultants to do the expected job

5.1.1 Demographic data presentation

A questionnaire was administered online to two hundred project practitioners in Zimbabwe. One hundred and ninety-two responses were obtained indicating a response rate of 96%. The researcher considered it a very good response rate. Tables 5.2 to 5.6 give a summary of the respondents' characteristics in terms of gender, educational qualifications and work experience.

Table 5.2 indicates that 75% of the respondents were male as compared to 25% female. Though the majority of these respondents were male, the number of females who participated was encouraging.

Table 5. 2: Gender

	Frequency	Percentage
Male	144	75
Female	48	20
Total	192	100

Table 5.3 indicates that the majority of the respondents held an undergraduate degree qualification (57%), followed by those with masters' degree qualification contributing 25%. Most of the respondents representing the ICT project management domain had sound qualifications in the ICT discipline. Due to the dominance of these qualified people, project management concepts should be easy to grasp and implement.

Table 5. 3: Qualifications

	Frequency	Percentage
Diploma	26	13.5
Undergraduate	110	57.3
Masters' degree	48	25.0
PhD	8	4.2
Total	192	100.0

Table 5.4 shows the employment grades of the respondents. Middle and low levels of management dominated in this study with a total percentage contribution of 78%. These were expected to be the professionals directly responsible for managing the greater part of the ICT projects. The distribution of the management grades among the respondents gave the researcher confidence in their responses.

Table 5. 4: Employment grade

	Frequency	Percentage
Senior management	15	7.8
Middle management	73	38.0
Low level management	77	40.1
Technician	27	14.1
Total	192	100.0

Table 5.5 shows the time the respondents were in their current organisation. The reason for extracting this information was the assumption of the researcher that the experience that a person has with the organisation has a bearing on that person's productivity. Of all the respondents, 55% had stayed over ten years in their respective organisations and 32% over five years. This showed that most of the respondents had stayed long enough in their organisations such that their decisions and performance were no longer affected by their adaptation to the organisational culture.

Table 5. 5: Experience in the organisation

Years	Frequency	Percentage
1-4	75	39.1
5-10	62	32.3
Above 10	55	28.6
Total	192	100.0

Table 5.7 indicates the respondents' experience in working with ICT projects. The assumption was that the more experience a practitioner had in ICT project management, the more accurate that person's judgement on the criticality of a factor. In this study, about 55% of the respondents had at least five years of ICT experience. This increased the level of confidence the researcher attached to the identified critical success factors. Table 5.6 shows the covariance between years of experience and the identified CSFs. All the covariance values under column F in the table are all significantly greater than 0.01 indicating the strength of the experienced practitioners in identifying how critical a factor is in determining success.

Table 5. 6: Covariance for experience against responses

	A	B	C	D	E	F
A						0.063
B						0.070
C						0.058
D						0.097
E						0.083

Key
A: Team members with high competence
B: Clear objectives and goals
C: Effective communication
D: Committed management support
E: Effective project management skills
F: Experience in networking projects

Table 5. 7: Experience in ICT project management

Years	Frequency	Percentage
1-4	85	44.3
5-10	64	33.3
Above 10	43	22.4
Total	192	100.0

5.1.2 Cronbach's alpha coefficient

The variables that comprised the research instrument were divided into four categories, A-D. Cronbach's alpha coefficient was determined for each category. The individual variable contributions to the category's alpha value was used to eliminate those variables whose removal would increase the Cronbach's alpha value. Goforth (2015) noted that what makes a good alpha (α) coefficient in research is arbitrary. In this research, the threshold value for Cronbach's alpha was 0.7 for reasonable results to be obtained (Namdeo & Rout 2016; Taber 2018; Inal et al. 2017; Tavakol & Dennick 2011).

The initial value for the Cronbach's alpha for category A was 0.793. Repetitive computations of the Cronbach's alpha value for category A produced an improved alpha value of 0.802 after removing variable A17 (Table 5.8). Table 5.9 shows the variables in category A and their respective Cronbach's alpha contribution if deleted. It is clear from the table that all the remaining variables would reduce the alpha value if deleted indicating that they were all significant.

Table 5. 8: Category A Cronbach's Alpha

Cronbach's alpha	Number of items
0.802	18

Table 5. 9: Item-total statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
A1	39.49	97.400	.532	.784
A2	39.74	98.899	.478	.787
A3	39.93	97.344	.536	.783
A4	39.86	100.133	.461	.789
A5	39.86	98.349	.448	.789
A6	39.96	103.881	.287	.799
A7	39.59	100.386	.445	.790
A8	39.38	103.713	.257	.801
A9	39.34	101.313	.379	.793
A10	39.66	102.954	.293	.799
A11	39.62	100.852	.360	.795
A12	39.54	101.891	.315	.798
A13	39.38	103.622	.252	.802
A14	40.23	102.670	.333	.796
A15	40.01	102.185	.326	.797
A16	39.86	99.268	.470	.788
A18	39.67	100.048	.418	.791
B19	39.65	102.096	.326	.797

Table 5.10 shows the Cronbach's alpha value for category B. The overall initial value was 0.809 which later improved to 0.820 (Table 5.11) after eliminating variables B23, B29 and B38. The Cronbach's alpha value for the category improved by continual elimination of the variables whose inclusion lowered the overall category value but whose removal increased the Cronbach's alpha value as shown in Table 5.11.

Table 5. 10: Category B Cronbach's alpha

Cronbach's alpha	Number of items
0.820	19

Table 5. 11: Category B Item-total statistics

Item	Scale mean if item deleted	Scale variance if item deleted	Corrected item total correlation	Cronbach's alpha if item deleted
B20	41.68	110.814	0.35	0.814
B21	41.35	105.539	0.589	0.802
B22	41.82	108.680	0.440	0.810
B24	41.54	107.271	0.514	0.806
B25	41.13	113.473	0.214	0.822
B26	41.64	112.668	0.285	0.818
B27	41.54	106.101	0.421	0.811
B28	41.84	112.393	0.294	0.817
B30	41.65	102.016	0.512	0.807
B31	41.59	108.403	0.423	0.811
B32	41.52	105.687	0.445	0.809
B33	41.41	114.137	0.199	0.822
B34	41.28	106.831	0.479	0.807
B35	41.79	104.367	0.551	0.803
B36	41.66	106.589	0.437	0.810
B37	41.50	109.805	0.366	0.814
B39	41.67	114.360	0.207	0.822
B40	41.67	111.211	0.383	0.813
B41	42.10	110.261	0.456	0.810

Table 5.12 shows the Cronbach's alpha value for category C. The overall initial value was 0.879 which later improved to 0.883 after eliminating variables C52 and C55. Table 5.13 shows the item total statistics for the individual variables.

Table 5. 12: Category C Cronbach's Alpha

Cronbach's alpha	Number of items
0.883	26

Table 5. 13: Category C Item-total statistics

Item	Scale mean if item deleted	Scale variance if item deleted	Corrected item total correlation	Cronbach's alpha if item deleted
C42	56.60	216.680	0.584	0.875
C43	56.61	229.554	0.287	0.882
C44	56.72	222.589	0.560	0.876
C45	56.71	224.144	0.440	0.879
C46	56.82	228.149	0.421	0.879
C47	56.57	218.300	0.537	0.876
C48	56.83	220.484	0.497	0.877
C49	56.76	215.958	0.552	0.876

C50	56.39	231.256	0.245	0.883
C51	56.79	218.647	0.589	0.875
C53	56.44	220.311	0.496	0.877
C54	56.57	223.369	0.461	0.878
C56	56.55	217.767	0.573	0.875
C57	57.00	226.364	0.421	0.879
C58	56.78	222.610	0.494	0.877
C59	56.81	226.698	0.380	0.880
C60	56.70	228.606	0.335	0.881
C61	56.56	226.012	0.359	0.881
C62	56.70	226.138	0.414	0.879
C63	56.91	224.185	0.472	0.878
C64	56.67	221.067	0.456	0.878
C65	56.91	231.195	0.254	0.883
C66	56.67	219.666	0.521	0.876
C67	56.74	227.103	0.395	0.880
C68	56.71	224.903	0.430	0.879
C69	56.80	229.467	0.340	0.881

Table 5.14 shows the Cronbach's alpha value for category D. The overall initial value was 0.644 which later improved to 0.651 after eliminating variable D73. The item total statistics for the individual variables are shown in Table 5.15.

Table 5. 14: Category Cronbach's Alpha

Cronbach's alpha	Number of items
0.651	6

Table 5. 15: Category D Item-total statistics

Item	Scale mean if item deleted	Scale variance if item deleted	Corrected item total correlation	Cronbach's alpha if item deleted
D70	11.69	13.954	0.321	0.633
D71	11.92	15.120	0.339	0.623
D72	11.52	13.738	0.399	0.601
D74	11.45	13.516	0.409	0.597
D75	11.66	14.581	0.347	0.620
D76	11.68	13.129	0.476	0.572

After the tests for reliability in categories A to D, the overall Cronbach's alpha was initially 0.945 which improved to 0.949 after eliminating variables A6, A8, A10, A12, 13,B25, B26, B28, B33, B38, B39 and C65. Table 5.16 illustrates the overall Cronbach's alpha value. The value of 0.949 was very significant and indicated that the instrument was reliable.

Table 5.16: Overall Cronbach's alpha

Table 5. 16: Overall Cronbach's alpha

Cronbach's alpha	Number of items
0.949	58

5.1.3 Validity test

Kaiser-Meyer-Olkin (KMO) index

KMO is a measure of sampling adequacy for a set of items (Taherdoost, Sahibuddin & Jalaliyoon 2016). It is a relative measure of the degree of correlation which shows whether it is sensible to analyse a correlation matrix or not i.e. the power of the relationship among variables (Arifin 2017; Chetty & Goel 2015). The KMO value was 0.756 which is acceptable for meaningful analysis (Arifin2017, Chetty & Goel 2015). Bartlett's test produced a value of 0.00 indicating that the matrix was not an identity matrix. This significant result was <0.05 indicating that the matrix was not an identity matrix i.e. the variables do relate to each other adequately or running a worthy exploratory factor analysis (Krishnan 2011;Williams, Onsman & Brown 2012). The KMO value and Bartlett's test of sphericity indicated that the item correlation matrix was not an identity matrix and therefore, the researcher moved forward with the factor analysis (Taherdoost, Sahibuddin & Jalaliyoon 2016).

Table 5. 17: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of sampling adequacy		0.756
Bartlett's Test of Sphericity	Approx. Chi-Square	12465.720
	Df	2016
	Sig.	0.000

Determining the number of factors

The researcher did not know in advance the number of factors to use, therefore, he first performed the analysis using the principal component analysis without specifying the number of factors. There were many ways of determining the number of factors that included Kaiser Eigenvalue >1, Cattell's Scree test, parallel analysis and the percentage variance described (Arifin 2017; (Taherdoost, Sahibuddin & Jalaliyoon 2016; Yong & Pearce 2013:6).

Multiple criteria for factor extraction were employed (Taherdoost, Sahibuddin & Jalaliyoon 2016). Kaiser Eigenvalue >1, Cattell's Scree test and the percentage variance explained were used to determine the number of factors. The researcher used the three techniques together for cross validation of the techniques. Using more than one technique improves on the weaknesses of an individual method by the other. The results are therefore expected to be robust.

The initial analysis produced twenty-one components. The factor analysis was rerun restricting the factors to twenty-one. The process was repeated until the researcher remained with only four factors. Factor loadings were then used to select variables. The final run of the factor analysis that produced four factors is shown in Table 5.18.

Communalities

A communality indicates the degree to which an item correlates with all other items (Krishnan 2011) i.e. it is a table that indicates how much of the variance in the variables has been accounted for by the extracted factors (Chetty & Goel 2015). It is the percentage of item variance explained by the extracted factors (Arifin 2017). The cut-off value in this research was 0.5 i.e. 50% of item variance explained (Arifin 2017; Chetty & Goel 2015). Table 5.16 indicates that only eleven variables had acceptable communalities. These were B27 with 59%, B32, 59%, C42, 57%, C44, 54%, C47, 65%, C51, 57%, C53, 53%, C59, 52%, C67, 50%, D70, 60% and D74, 60%. These eleven variables were tracked down to the factor analysis results.

Table 5. 18: Communalities

	Initial	Extraction
A1	1.000	.427
A2	1.000	.399
A3	1.000	.424
A4	1.000	.487
A5	1.000	.480
A6	1.000	.228
A7	1.000	.407
A8	1.000	.210
A9	1.000	.482
A10	1.000	.244
A11	1.000	.406
A12	1.000	.267
A13	1.000	.176
A14	1.000	.321
A15	1.000	.458

A16	1.000	.485
A17	1.000	.053
A18	1.000	.432
B19	1.000	.457
B20	1.000	.392
B21	1.000	.482
B22	1.000	.404
B23	1.000	.258
B24	1.000	.321
B25	1.000	.309
B26	1.000	.462
B27	1.000	.580
B28	1.000	.320
B29	1.000	.122
B30	1.000	.499
B31	1.000	.412
B32	1.000	.586
B33	1.000	.306
B34	1.000	.453
B35	1.000	.386
B36	1.000	.499
B37	1.000	.235
C38	1.000	.352
C39	1.000	.194
C40	1.000	.405
C41	1.000	.399
C42	1.000	.573
C43	1.000	.438
C44	1.000	.537
C45	1.000	.424
C46	1.000	.259
C47	1.000	.651
C48	1.000	.455
C49	1.000	.424
C50	1.000	.272
C51	1.000	.572
C52	1.000	.093
C53	1.000	.527
C54	1.000	.437
C55	1.000	.065
C56	1.000	.381
C57	1.000	.420
C58	1.000	.425
C59	1.000	.524
C60	1.000	.224
C61	1.000	.298

C62	1.000	.407
C63	1.000	.454
C64	1.000	.439
C65	1.000	.182
C66	1.000	.456
C67	1.000	.503
C68	1.000	.344
C69	1.000	.345
D70	1.000	.603
D71	1.000	.185
D72	1.000	.266
D73	1.000	.243
D74	1.000	.596
D75	1.000	.452
D76	1.000	.476

Extraction Method: Principal Component Analysis.

Variance explained

Table 5.19 shows that the eleven variables explained about 58.6 % of the total variance. This was considered a good indication that the variables have a significant effect on the performance of a computer networking project, hence have to be carefully managed if the project is to succeed. The minimum threshold in this research was 50% (Arifin 2017; Chetty & Goel 2015).

Table 5. 19: Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	14.909	19.617	19.617	14.909	19.617	19.617
2	4.260	5.606	25.222	4.260	5.606	25.222
3	3.812	5.016	30.239	3.812	5.016	30.239
4	3.584	4.716	34.954	3.584	4.716	34.954
5	3.096	4.073	39.027	3.096	4.073	39.027
6	2.884	3.795	42.822	2.884	3.795	42.822
7	2.796	3.679	46.501	2.796	3.679	46.501
8	2.600	3.421	49.922	2.600	3.421	49.922
9	2.401	3.159	53.080	2.401	3.159	53.080
10	2.142	2.819	55.899	2.142	2.819	55.899
11	2.062	2.713	58.612	2.062	2.713	58.612
12	1.949	2.564	61.177	1.949	2.564	61.177

13	1.778	2.339	63.516	1.778	2.339	63.516
14	1.685	2.217	65.732	1.685	2.217	65.732
15	1.595	2.099	67.831	1.595	2.099	67.831
16	1.523	2.004	69.836	1.523	2.004	69.836
17	1.442	1.897	71.733	1.442	1.897	71.733
18	1.430	1.882	73.615	1.430	1.882	73.615
19	1.321	1.738	75.353	1.321	1.738	75.353
20	1.265	1.665	77.018	1.265	1.665	77.018
21	1.134	1.492	78.510	1.134	1.492	78.510
22	1.107	1.457	79.967	1.107	1.457	79.967
23	1.024	1.348	81.315	1.024	1.348	81.315
24	.974	1.282	82.596			
25	.912	1.200	83.797			
26	.869	1.143	84.940			
27	.834	1.097	86.037			
28	.810	1.066	87.103			
29	.732	.964	88.067			
30	.692	.911	88.978			
31	.622	.819	89.797			
32	.567	.745	90.542			
33	.559	.735	91.277			
34	.550	.724	92.002			
35	.522	.687	92.689			
36	.463	.609	93.298			
37	.455	.599	93.896			
38	.410	.539	94.436			
39	.376	.494	94.930			
40	.344	.453	95.383			
41	.326	.429	95.812			
42	.314	.413	96.225			
43	.289	.380	96.605			
44	.277	.365	96.970			
45	.251	.330	97.300			
46	.222	.292	97.593			
47	.208	.274	97.867			
48	.189	.249	98.116			
49	.169	.222	98.338			
50	.154	.202	98.540			
51	.133	.175	98.715			
52	.132	.174	98.889			
53	.113	.148	99.037			
54	.099	.130	99.167			
55	.094	.123	99.290			

56	.085	.112	99.402			
57	.071	.093	99.496			
58	.063	.083	99.578			
59	.055	.073	99.651			
60	.049	.065	99.715			
61	.041	.054	99.770			
62	.036	.047	99.817			
63	.032	.042	99.859			
64	.027	.036	99.895			
65	.020	.027	99.922			
66	.016	.021	99.943			
67	.015	.020	99.964			
68	.009	.012	99.976			
69	.008	.011	99.986			
70	.005	.006	99.993			
71	.004	.006	99.998			
72	.001	.002	100.000			
73	2.229E-17	2.932E-17	100.000			
74	-1.446E-16	-1.903E-16	100.000			
75	-5.109E-16	-6.722E-16	100.000			
76	-1.233E-15	-1.622E-15	100.000			

Extraction Method: Principal Component analysis.

Component matrix

In this research a component matrix was developed using SPSS version 23.0. The matrix was used to select variables in each category represented by each of the four factors extracted.

Factor one initially had fifty six variables loading onto it compared to the other three. The researcher decided to take the top ten from the list (Table 5.20). These were compared with the eleven variables indicated as acceptable from the communalities table (Table 5.18). Of these eleven variables, nine loaded to factor one from Table 5.20. The other two loaded to factor two. Factor four was dropped out since it had very weak loadings of 0.345, 0.385, 0.297 and 0.266. Eventually factor one remained with variables B27, B32, C42, C44, C47, C51, C53, C67 and

D70; factor two remained with A6, B25, C43, C59 and D74; factor three remained with B28, C38 and D26. All in all seventeen factors were retained.

Table 5. 20: Component matrix

	Component			
	1	2	3	4
A1	.574	-.295	-.037	.097
A2	.562	-.287	-.003	-.015
A3	.534	-.250	.193	.196
A4	.452	-.342	.340	.225
A5	.574	.286	-.100	-.241
A6	.228	-.407	.083	.058
A7	.494	.370	.157	.030
A8	.246	-.273	.272	-.035
A9	.525	.444	.046	.082
A10	.253	-.080	.366	.201
A11	.446	.291	.339	-.083
A12	.262	-.279	.200	-.284
A13	.257	.012	.315	.100
A14	.430	-.161	-.281	-.176
A15	.520	-.217	.015	-.374
A16	.544	.329	-.041	.280
A17	.146	.110	.069	-.122
A18	.417	-.126	.045	.490
B19	.534	.339	-.239	-.027
B20	.478	-.051	.117	-.383
B21	.608	.299	-.054	-.144
B22	.573	-.089	.213	.150
B23	.175	.232	-.234	.345
B24	.531	-.024	.133	.145
B25	.189	.472	-.129	-.185
B26	.201	.051	.501	.410
B27	.614	-.133	-.346	-.256
B28	.248	.210	.460	.043
B29	.139	-.221	-.205	.107
B30	.644	.064	.276	-.061
B31	.445	.437	-.153	.016
B32	.541	-.335	.407	-.123
B33	.169	.304	-.192	.385
B34	.566	-.129	.096	.327
B35	.573	.207	-.016	-.121
B36	.516	-.014	.022	.482

B37	.386	-.020	.168	-.239
C38	.193	-.185	-.472	.240
C39	.220	.187	.151	-.297
C40	.527	-.309	-.176	.007
C41	.481	.344	-.211	-.069
C42	.627	-.349	-.174	.168
C43	.381	.416	.094	-.333
C44	.624	.012	-.284	.259
C45	.484	.004	.391	-.192
C46	.466	.074	.064	.181
C47	.593	-.158	-.363	-.377
C48	.547	.154	-.068	.358
C49	.570	-.238	-.012	-.207
C50	.316	.387	.120	-.093
C51	.671	-.142	.319	-.006
C52	.225	-.105	.123	-.128
C53	.592	.365	-.136	.155
C54	.519	-.380	-.088	.125
C55	.108	.104	.164	-.125
C56	.564	-.206	-.141	-.007
C57	.495	-.017	.418	.016
C58	.534	-.088	-.219	-.290
C59	.421	.421	-.209	.354
C60	.352	-.230	-.215	.038
C61	.455	-.012	.189	-.234
C62	.420	-.372	-.046	.299
C63	.532	.118	.012	-.397
C64	.495	-.200	-.366	.141
C65	.260	.143	.154	-.266
C66	.504	-.394	.199	-.089
C67	.517	.473	.087	.063
C68	.505	-.118	-.208	-.180
C69	.427	.244	.196	.254
D70	.494	-.311	-.397	.324
D71	.307	.139	-.232	-.133
D72	.502	.039	.022	-.107
D73	.303	.380	.029	.079
D74	.462	-.566	-.131	-.212
D75	.423	.475	-.218	-.004
D76	.410	.020	-.439	-.339

Extraction Method: Principal Component Analysis.
4 components extracted.

Rotated component matrix

The rotated component matrix (Table 5.21) was used to maximise high item loadings and minimising low item loadings, thereby producing a more interpretable and simplified solution (Williams, Onsman & Brown 2012:10: Yong & Pearce 2013:6). The rotational technique used was Varimax rotation (Williams, Onsman & Brown 2012). The technique produced factor structures that were uncorrelated by minimising the number of variables that had high loadings on each factor and made small loadings even smaller (Yong & Pearce 2013).

After rotation, factor one remained with B27, C42, C44, C47, D70 and D74; Factor two remained with A9, A16, B31, C59, C67, and D75; factor three remained with A4, B26, B32 and C51; Factor four resurfaced with loading from B20, C43, C45 and C63.

Table 5. 21: Rotated component matrix

	Component			
	1	2	3	4
A1	.534			
A2	.509			
A3			.530	
A4			.633	
A5				
A6				
A7				
A8				
A9		.615		
A10				
A11				
A12				
A13				
A14	.517			
A15				
A16		.619		
A17				
A18				
B19		.582		
B20				.550
B21		.503		
B22				
B23				
B24				
B25				
B26			.635	
B27	.653			
B28				
B29				
B30				
B31		.602		
B32			.535	
B33				
B34			.515	
B35				
B36				
B37				
C38				
C39				
C40	.594			
C41		.539		
C42	.668			
C43				.537
C44	.517			
C45				.515
C46				
C47	.671			
C48		.517		
C49				
C50				
C51			.544	
C52				
C53		.659		
C54	.575			
C55				
C56	.539			
C57			.517	
C58	.511			
C59		.696		
C60				
C61				
C62				
C63				.572
C64	.609			
C65				
C66				
C67		.617		
C68				
C69				
D70	.680			
D71				
D72				
D73				
D74	.686			
D75		.632		
D76				

Principal component analysis was used as the extraction method and the rotation technique was varimax with Kaiser Normalisation. The rotation converged in thirteen iterations.

Cattell's Scree test

The Cattell's Scree test produced the graph plotted in Figure 5.1. The graph clearly indicated four factors which agreed with the Principal component factor analysis.

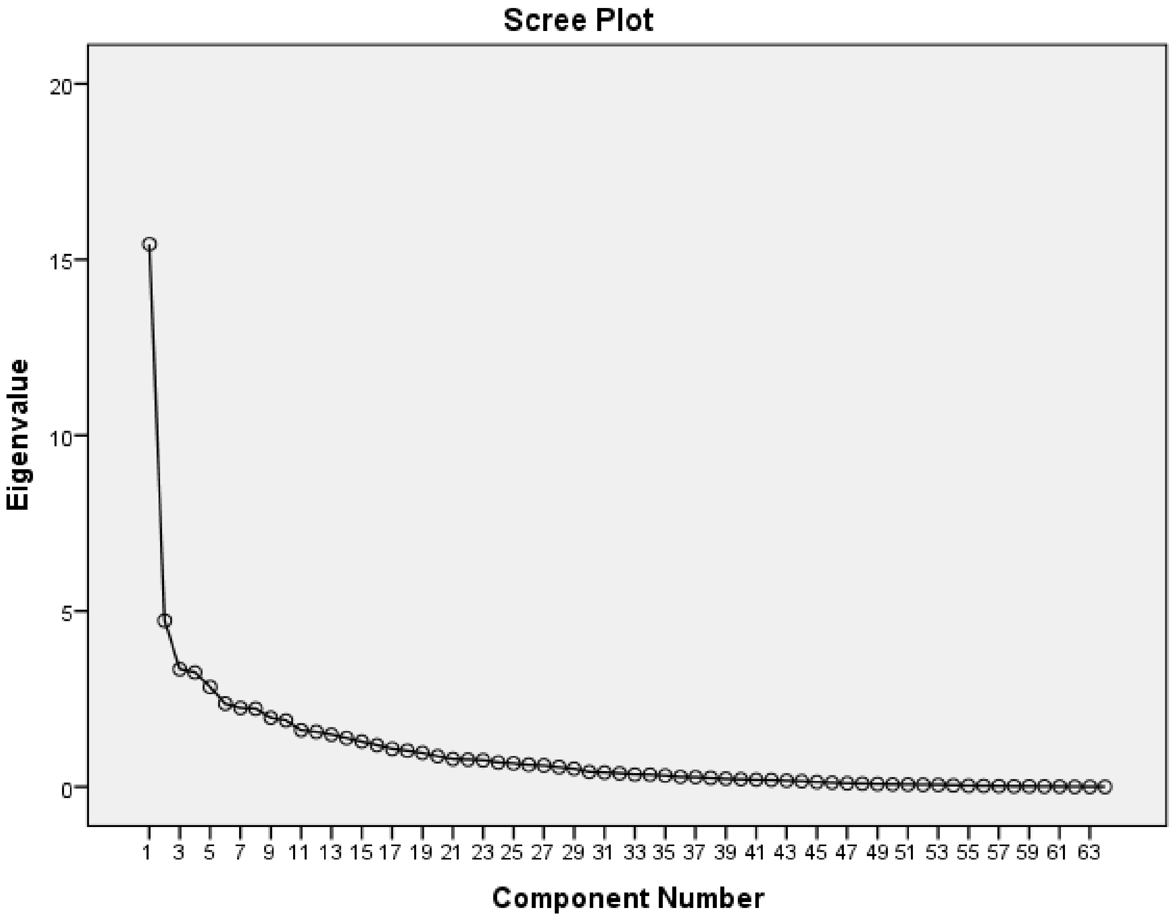


Figure 5. 1: Scree Plot

The resultant CSFs for ICT projects in Zimbabwe

The four factors and their associated variables formed the categories of the identified CSFs and the variables under each category.

Category 1: Project planning

1) Adequate budget
2) Training provision
3) Considering and appreciating multiple viewpoints

4) Strong detailed planning
5) Support from stakeholders

Category 2: Project characteristics

1) Rigorous refactoring activities
2) Project size complexity
3) Adequate funding
4) Projects with dynamic accelerated schedule
5) Project uniqueness
6) Competitor technologies

Category 3: Project team

1) Coherent self-organising team
2) Flexible approach to change
3) Sound basis for project
4) Realistic schedule

Category 4: Project process

1) Direct communication
2) Appreciating effect of human error
3) Effective leadership conflict resolution
4) Prior risk analysis

5.2 CSFs for Computer networking projects in Zimbabwe

This second part of the results presentation focuses on the interviews carried out to establish the CSFs for computer networking projects. The researcher did not find any literature on critical success factors specifically for computer networking projects. Thus, it was necessary to establish them. The factors were critical since they formed the basis for the development of the logistic regression analysis model.

Logistic regression retains a huge number of features of linear regression in its analysis of binary outcomes (Stoltzfus 2011). Logistic regression isolates, through repetitive cycles, the strongest linear combination of independent variables that increases the chances of detecting the observed outcome called maximum likelihood estimation (Stoltzfus 2011).

In this study, the researcher noted that logistic regression analysis combines aspects of contingency tables analysis and ordinary least squares multiple regression analysis. Thus, instead of using the two approaches separately, logistic regression analysis achieves the same in one shot. Logistic regression analysis overcomes the shortfalls of the two traditional statistical traditions which are the failure to handle predictors measured at a continuous interval or ratio scale level and handling of dichotomous, nominal or ordinal dependent variables.

The researcher found it very appropriate to apply this method for these reasons. In this research the method was applied to predict possible computer networking project success from the critical success factors.

This section is dedicated to the presentation and analysis of data pertaining to CSFs for computer networking projects gathered from interviews.

5.2.1 Gender

A total of two hundred questionnaires were sent to the selected respondents. One hundred and eighty completed questionnaires were returned to the researcher accounting for a 90% response rate. The distribution of respondents by gender was one hundred and fifty-four males (85.6%) and twenty-six females (14.4%) as indicated in Table 5.22. Effort was made to balance on the gender aspect but it seemed the computer networking industry itself had less female practitioners which heavily impacted on the research's gender balance. However, the females were adequately represented in the study.

Table 5. 22: Gender

	Frequency	Percentage
Male	154	85.6
Female	26	14.4
Total	180	100.0

5.2.2 Qualification

Table 5.23 shows the nature of the one hundred and eighty respondents in terms of their qualifications. The qualification aspect was important in the research since the researcher wanted also to identify the level of competence and expertise among the computer networking practitioners as it was anticipated to have much influence on project success. There was a fair balance in the practitioners holding diploma, undergraduate and masters' degree qualification with frequencies of 60, 58 and 57 respectively. This indicated that the respondents had acceptable qualifications required in the computer networking industry.

Table 5. 23: Qualification

	Frequency	Percentage
Diploma	60	33.3
Undergraduate	58	32.2
Masters' degree	57	31.7
PhD	5	2.8
Total	180	100.0

5.2.3 Employment category (Level)

This research considered only computer networking project practitioners as the respondents. However, there was need to categorise the respondents according to their level or position in the organisation. This was meant to establish the nature of duties the practitioners had. Only six respondents were from senior management, and thirty-seven from middle management. Most respondents (90%) were in the lower management level (Table 5.24). This level included supervisors and team leaders. These were the people who directly influence the progress of projects on a daily if not hourly basis. The low level management work with technicians. The distribution of the respondents by their positions provided a fertile basis for authentic and reliable results in terms of the factors critical to computer networking projects.

Table 5. 24: Employment level

	Frequency	Percentage
Senior management	6	3.3
Middle management	37	20.6
Low level management	90	50.0
Technician	47	26.1
Total	180	100.0

5.2.4 Time in the organisation

The researcher decided to include the period each respondent was in his/her current organisation. The reason was that those who were in the organisation for a considerable length of time would have acquainted themselves with the culture of handling and running projects as part of their organisational culture. The majority of the respondents (97.8%), had served for more than five years in their organisation (Table 5.25). This indicated that almost all the respondents in this survey had adequate knowledge and experience of working under their respective organisations and were, therefore, expected to have a clear understanding of the ways their projects were handled.

Table 5. 25: Time in the organisation

Years	Frequency	Percentage
1-4	5	2.8
5-10	85	47.2
Above 10	90	50.0
Total	180	100.0

5.2.5 Time in computer networking projects

Being in an organisation for a long period may not necessarily expose one to computer networking projects. It was found critical also to consider the length of time a respondent had been in the computer networking fraternity despite the time in the organisation. As an example, one may have spent only one year in the current organisation but with ten years' experience in the computer networking industry, whilst the other person may have one year experience in computer networking projects but ten years in the organisation. In this case, the researcher was more interested in the number of years of experience in computer networking projects than years spent in the organisation. One hundred and seventy out of one hundred and eighty (95%) of the respondents had at least five years' experience in the computer networking project business (Table 5.26). This was a very healthy situation for the research since the responses came from experienced computer networking project practitioners.

Table 5. 26: Time in computer networking projects

Years	Frequency	Percentage
1-4	9	5.0
5-10	71	39.4
Above 10	100	55.6
Total	180	100.0

5.2.6 Factors affecting computer networking projects' success

The questions that comprised the questionnaire were categorised into 4 sections: project team factors, owner organisation factors, project management factors and external factors. A total of 43 factors made up the superset of the factors. The responses were coded and fed into SPSS. The analysis involved computing the frequencies of the responses for each factor using options of strongly agree, agree, not sure, disagree and strongly disagree. Cumulative percentages for these response options were noted and used to identify the critical factors as those with the highest cumulative percentage for strongly agree and agree. The results of the analysis were indicated in Tables 5.27 to 5.64. The deductions from these tables were summarised in Tables 5.65 to 5.68 with associated explanations.

Project team factors

Table 5. 27: Oneness of the project team

	Frequency	Percentage
Strongly agree	74	41.1
Agree	83	46.1
Not sure	18	10.0
Disagree	5	2.8
Total	180	100.0

Table 5. 28: Motivated team members

	Frequency	Percentage
Strongly agree	56	31.1
Agree	91	50.6
Not sure	28	15.6
Disagree	5	2.8
Total	180	100.0

Table 5. 29: Team members with high competence and expertise

	Frequency	Percentage
Strongly agree	57	31.7
Agree	99	55.0
Not sure	15	8.3
Disagree	9	5.0
Total	180	100.0

Table 5. 30: Managers with light touch

	Frequency	Percentage
Strongly agree	43	23.9
Agree	96	53.3
Not sure	32	17.8
Disagree	8	4.4
Total	180	100.0

Table 5. 31: Taking account of past experience and learning from it

	Frequency	Percentage
Strongly agree	54	23.9
agree	92	53.3
Not sure	20	17.8
Disagree	10	4.4
Strongly disagree	3	100.0
Total	180	

Table 5. 32: Effective team building or motivation

	Frequency	Percentage
Strongly agree	59	32.8
agree	94	52.2
Not sure	13	7.2
Disagree	12	6.7
Strongly disagree	2	100.0
Total	180	

Table 5. 33: Project goal awareness

	Frequency	Percentage
Strongly agree	98	32.8
agree	74	52.2
Not sure	4	7.2
Disagree	4	6.7
Total	180	100.0

Table 5. 34: Project manager communication skills

	Frequency	Percentage
Strongly agree	36	20.0
agree	90	50.0
Not sure	41	22.8
Disagree	10	5.6
Strongly disagree	3	1.7
Total	180	100.0

Table 5. 35: Project team in different areas

	Frequency	Percentage
Strongly agree	37	20.6
agree	77	42.8
Not sure	41	22.8
Disagree	19	10.6
Strongly disagree	5	2.8
Total	179	100.0

Table 5. 36: Honouring regular working schedule with no overtime

	Frequency	Percentage
Strongly agree	28	15.6
agree	91	50.6
Not sure	36	20.0
Disagree	20	11.1
Strongly disagree	5	2.8
Total	180	100.0

Table 5. 37: End user involvement and commitment

	Frequency	Percentage
Strongly agree	43	23.9
agree	72	40.0
Not sure	35	19.4
Disagree	23	12.8
Strongly disagree	7	3.9
Total	180	100.0

Table 5. 38: Rigorous refactoring activities

	Frequency	Percentage
Strongly agree	44	24.4
agree	56	31.1
Not sure	46	25.6
Disagree	28	15.6
Strongly disagree	6	3.3
Total	180	100.0

Table 5. 39: Right amount of documentation

	Frequency	Percentage
Strongly agree	47	26.1
agree	67	37.2
Not sure	32	17.8
Disagree	28	15.6
Strongly disagree	6	3.3
Total	180	100.0

Table 5. 40: Appropriate technical training of them

	Frequency	Percentage
Strongly agree	54	30.0
agree	83	46.1
Not sure	25	13.9
Disagree	17	9.4
Strongly disagree	1	0.6
Total	180	100.0

Table 5. 41: Realistic schedule

	Frequency	Percentage
Strongly agree	56	31.1
agree	87	48.3
Not sure	27	15.0
Disagree	10	5.6
Total	180	100.0

Table 5. 42: knowing client needs

	Frequency	Percentage
Strongly agree	66	36.7
agree	85	47.2
Not sure	21	11.7
Disagree	8	4.4
Total	180	100.0

Table 5. 43: Projects with no multiple independent teams

	Frequency	Percentage
Strongly agree	55	30.6
agree	77	42.8
Not sure	33	18.3
Disagree	13	7.2
Strongly disagree	2	1.1
Total	180	100.0

Table 5. 44: Having a clear project boundary

	Frequency	Percentage
Strongly agree	51	28.3
agree	96	53.3
Not sure	24	13.3
Disagree	9	5.0
Total	180	100.0

Owner organisation factors

Table 5. 45: Strong support from senior management

	Frequency	Percentage
Strongly agree	100	55.6
agree	67	37.2
Not sure	5	2.8
Disagree	7	3.9
Strongly disagree	1	0.6
Total	180	100.0

Table 5. 46: Committed sponsor

	Frequency	Percentage
Strongly agree	74	41.1
agree	88	48.9
Not sure	11	6.1
Disagree	6	3.3
Strongly disagree	1	0.6
Total	180	100.0

Table 5. 47: Cooperative organisational culture

	Frequency	Percentage
Strongly agree	59	32.8
agree	84	46.7
Not sure	23	12.8
Disagree	13	7.2
Strongly disagree	1	0.6
Total	180	100.0

Table 5. 48: Oral culture placing value on face to face communication

	Frequency	Percentage
Strongly agree	63	35.0
agree	75	41.7
Not sure	29	16.1
Disagree	12	6.7
Strongly disagree	1	0.6
Total	180	100.0

Table 5. 49: Organisation adaptation

	Frequency	Percentage
Strongly agree	42	23.3
agree	78	43.3
Not sure	40	22.2
Disagree	19	10.6
Strongly disagree	1	0.6
Total	180	100.0

Table 5. 50: Good customer relationship

	Frequency	Percentage
Strongly agree	46	25.6
agree	75	41.7
Not sure	35	19.4
Disagree	20	11.1
Strongly disagree	4	2.2
Total	180	100.0

Project management factors

Table 5. 51: Effective management of risk

	Frequency	Percentage
Strongly agree	51	28.3
agree	83	46.1
Not sure	33	18.3
Disagree	13	7.2
Total	180	100.0

Table 5. 52: Projects with upfront cost evaluation done

	Frequency	Percentage
Strongly agree	39	21.7
agree	94	52.2
Not sure	36	20.0
Disagree	10	5.6
Strongly disagree	1	0.6
Total	180	100.0

Table 5. 53: Projects with upfront risk analysis done

	Frequency	Percentage
Strongly agree	42	23.3
agree	99	55.0
Not sure	34	18.9
Disagree	5	2.8
Total	180	100.0

Table 5. 54: Project manager technical background

	Frequency	Percentage
Strongly agree	40	22.2
agree	100	55.6
Not sure	32	17.8
Disagree	7	3.9
Strongly disagree	1	0.6
Total	180	100.0

Table 5. 55: Use of website for communication

	Frequency	Percentage
Strongly agree	59	32.8
agree	64	35.6
Not sure	36	20.0
Disagree	17	9.4
Strongly disagree	4	2.2
Total	180	100.0

Table 5. 56: Identify project source[91]

	Frequency	Percentage
Strongly agree	63	35.0
agree	75	41.7
Not sure	29	16.1
Disagree	9	5.0
Strongly disagree	2	1.1
Total	180	100.0

Table 5. 57: Support from stakeholders

	Frequency	Percentage
Strongly agree	53	29.4
agree	75	41.7
Not sure	36	20.0
Disagree	14	7.8
Strongly disagree	2	1.1
Total	180	100.0

Table 5. 58: Sound basis for project

	Frequency	Percentage
Strongly agree	57	31.7
agree	87	48.3
Not sure	27	15.0
Disagree	8	4.4
Strongly disagree	1	0.6
Total	180	100.0

5.2.6.3 External factors

Table 5. 59: Equipment support

	Frequency	Percentage
Strongly agree	58	32.2
agree	88	48.9
Not sure	22	12.2
Disagree	9	5.0
Strongly disagree	3	1.7
Total	180	100.0

Table 5. 60: Competitor technologies

	Frequency	Percentage
Strongly agree	55	30.6
agree	83	46.1
Not sure	29	16.1
Disagree	11	6.1
Strongly disagree	2	1.1
Total	180	100.0

Table 5. 61: Reliability of subcontractors

	Frequency	Percentage
Strongly agree	59	32.8
agree	79	43.9
Not sure	32	17.8
Disagree	10	5.6
Total	180	100.0

Table 5. 62: Economic standing of the organisation in funding small projects

	Frequency	Percentage
Strongly agree	90	50.0
agree	71	39.4
Not sure	11	6.1
Disagree	7	3.9
Strongly disagree	1	0.6
Total	180	100.0

Table 5. 63: Economic standing of the organisation in funding large projects

	Frequency	Percentage
Strongly agree	73	40.6
agree	89	49.4
Not sure	10	5.6
Disagree	7	3.9
Strongly disagree	1	0.6
Total	180	100.0

Table 5. 64: Good performance by suppliers or contractors

	Frequency	Percentage
Strongly agree	45	25.0
agree	85	47.2
Not sure	35	19.4
Disagree	11	6.1
Strongly disagree	4	2.2
Total	180	100.0

5.2.7 Factor importance from frequencies

The researcher considered the factors whose cumulative percentages for strongly agree and agree were eighty and above. This was done to show the significance of the factors. The identified factors are summarised in Tables 5.65 to 5.68.

Table 5. 65: Critical project team factors

No.	Factor Description	Cumulative %
1	Oneness of the project team	87.2
2	Team members with high competence & expertise	86.7
3	Effective team building or motivation	85
4	Project goals awareness	95.6
5	Knowing client needs	83.9
6	Having a clear project boundary	81.7

Table 5. 66: Critical owner organisation factors

No.	Factor Description	Cumulative %
1	Strong support from senior management	92.8
2	Committed sponsor	90

Table 5. 67: Critical external factors

No.	Factor Description	Cumulative %
1	Adequate funding	90

In their order of importance, the critical success factors for computer networking projects were ranked and summarised in Table 5.68. The factors were project goals awareness, strong support from senior management, committed sponsor, adequate funding, and oneness of the project team, team members with high competence & expertise, effective team building or motivation, knowing client needs and having a clear project boundary.

Table 5. 68: Summarised critical success factors for computer networking projects

No.	Factor description	Cumulative %
1	Project goals awareness	95.6
2	Strong support from senior management	92.8
3	Committed sponsor	90.0
4	Adequate funding	90.0
5	Oneness of the project team	87.2
6	Team members with high competence & expertise	86.7
7	Effective team building or motivation	85.0
8	Knowing client needs	83.9
9	Having a clear project boundary	81.7

5.3 Presentation of interview data

Interviews were carried out to establish the factors critical to the management of computer networking projects in Zimbabwe. Twenty respondents were conveniently selected from organisations involved in computer networking projects. Purposive sampling was employed since the researcher wanted to interview project practitioners who had adequate knowledge and experience in computer networking projects. The interviews lasted an average of one hour twenty minutes. The researcher used NVivo version 10.0 to analyse the interview data. During the interview the researcher used a smartphone to record the interview responses. Permission to record the interview was sought from each interviewee before the commencement of each interview. All the respondents agreed to be recorded after the researcher gave them assurance that the recordings would be used strictly for the purposes of the research and that their privacy and confidentiality were guaranteed.

After recording the individual interviews, the researcher listened to the voices and transcribed the data into a document interview by interview and question by question. A word document was created for each interviewee and was used as sources in NVivo. The documents were imported from their location on the computer. Nodes were created as containers for different aspects of the interview. The nodes gathered together data by coding different aspects or ideas together. Qualitative coding was done in which the researcher did not only describe the ideas but rather code them interpretively. The researcher created categories for thinking about his data, identified new categories and ideas from the data and also gathered material about those ideas from the interview data in the process. In particular, the researcher created nodes from prior ideas about computer networking projects, coded ideas at existing nodes, created nodes and coded "up" from meanings in the interview data, created and named new nodes "in-vivo", from the words in the data coded from all the sources. All these were guided by the research process diagram developed by the researcher (Figure 5.2). The diagram depicts the start of the interview as in three parts: identifying characteristics of computer networking projects, examining the importance of computer networking projects and the role played by computer networking projects in today's business environment. These three aspects formed the basis of identifying factors critical to the success of computer networking projects (CSFs). Computer networking project success meaning and criteria were then examined. The CSFs and the understanding of project success criteria gave insights into research and development of tools or methods of predicting the success of computer networking projects. The researcher assumed that it was impossible to build a viable project success prediction tool/model/method without a sound and comprehensive criteria for measuring the success of a project and the isolation of specific critical success factors. The next phase would be the examination of risks involved in computer networking projects, prediction shortcomings and enhancing research on critical success factors.

These three combined with project success prediction tools/methods/models led to an effective and viable project success prediction which eventually influence the computer networking project success. NVivo was used to develop the research process diagram from the main aspects of the interview (Figure 5.2).

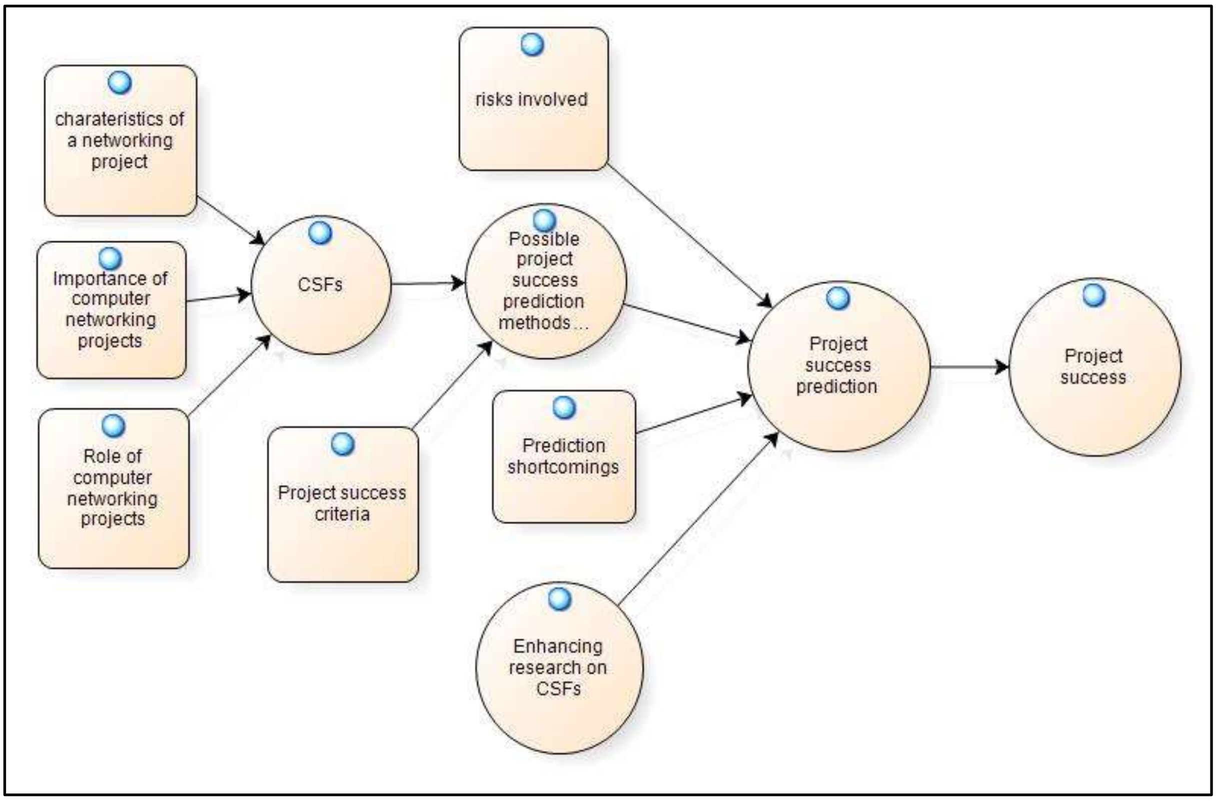


Figure 5. 2: Research process diagram

Relationships were developed among the data coded at various nodes using NVivo. Figure 5.3 is an example of the results of some relationships produced in the process. The figure indicates that project success prediction was associated with possible project success prediction methods/models/tools, prediction shortcomings and enhancing research on computer networking projects' CSFs. In other words, Figure 5.3 shows that improvements in the knowledge and insights into critical success factors coupled with the identification and resolution of prediction tools shortcomings can effectively improve the project success prediction tools/methods/models. In the final analysis the project success prediction is improved. More relationships from the interview data are shown in figure 5.4.

In summary, Figure 5.3 indicates how the success of a computer networking project is associated with skills required in computer networking projects, risks involved, project success criteria, CSFs, methods or tools for success prediction and finally comprehending the usefulness of CSFs in ICT projects research. These and many more relationships were developed thereby improving the themes developed from the interview data.

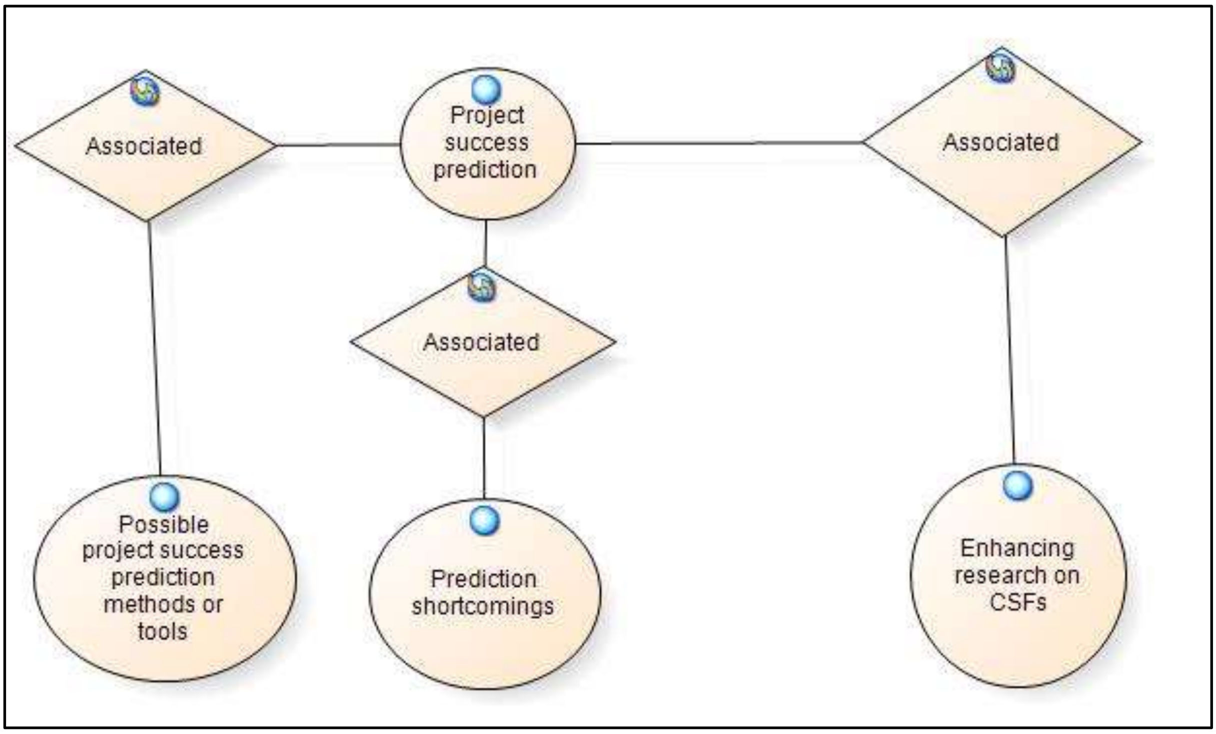


Figure 5. 3: Example of relationship produced

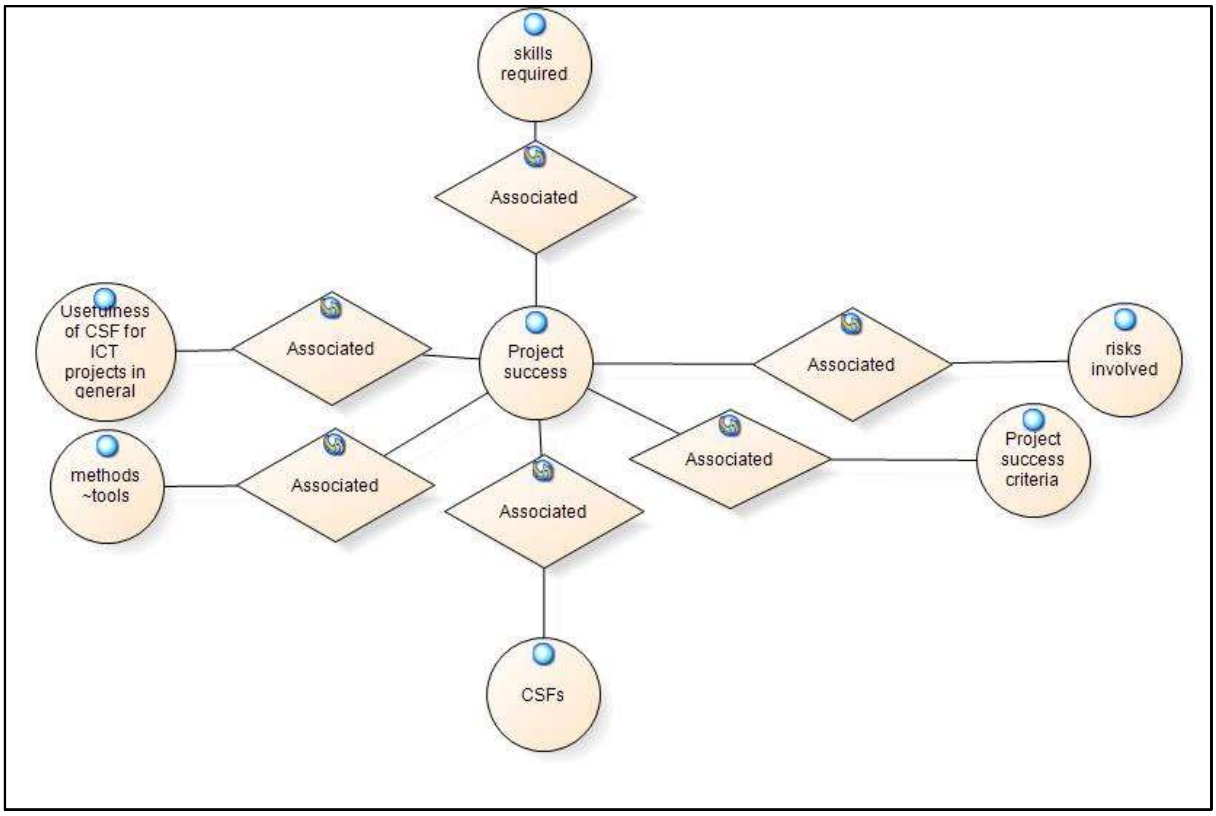


Figure 5. 4: More relationships from NVivo

The interview results were analysed using thematic analysis. Though the NVivo software was used to make the interview data analysis easier, technically the researcher followed a thematic analysis process. This section describes the process of thematic analysis employed at this part of the research. The section begins by looking at the rationale behind the use of thematic analysis in this study.

5.3.1 Rationale and meaning of thematic analysis

Qualitative research encompasses soliciting of people's experiences, views and opinions in their own words (Braun, Clarke & Rance 2014). The most common way of gathering people's words as data is the qualitative interview whereby the researcher presents to the respondent planned and unplanned questions and they provide answers in their own words (Braun, Clarke & Rance 2014:3). Interview data require systematic analysis based on different premises of which the usual approach for analysing qualitative data is to establish persistent characteristics or trends across the data set (Braun, Clarke & Rance 2014:3, Aronson 1995:3). In most cases thematic analysis is commonly used to analysing interviews (Jugder 2016:2, Aronson 1995:3). Thematic analysis is an approach used for methodical examination, analysing and organising and providing intuition into trends of meaning (themes) in a data set (Jugder 2017, Braun & Clarke 2012:1; De Hoyos & Barnes 2014; Evans 2017:3; Maguire & Delahunt 2017). It is a handy, stretchy and increasingly popular method of qualitative data analysis (Braun & Clarke 2012; De Hoyos & Barnes 2014). The method enables the researcher to visualise and draw conclusions from collective meanings and experiences (Braun & Clarke 2012) and its goal is to establish themes (patterns) in the data that are significant or of interest and apply them to answer the research questions (Maguire & Delahunt 2017).

The purpose of thematic analysis is to establish patterns important in a particular research (Braun & Clarke 2012:2; Fernandez 2018:3). The motivation behind using thematic analysis is its being stretchy and handy. A researcher doing thematic analysis has to aggressively make a continuum of choices as to the form of thematic analysis to use and to understand and justify why they want to use the particular form. Approaches to the analysis differ in terms of basic epistemological assumptions about the nature of the enquiry and the selected analytic approaches (De Hoyos & Barnes 2014:7). According to Braun and Clarke (2012) and Braun, Clarke & Rance (2014), forms of or approaches to thematic analysis include:

a) **Inductive** – this is a bottom-up approach to thematic analysis that is influenced by the collected data.

b) **Deductive** – it is a bottom-up approach in which the researcher uses concepts, ideas to the interpretation of the data.
c) **Semantic** – the coding and theme development reflect the precise content of the data.
d) **Latent** – coding and theme development reflect ideas and suppositions underlying the data.
e) **Essentialist** – centres on documenting a supposed reality evident in the data.
f) **Constructionist** – centres on how a certain reality is produced from the data.

In this study, the researcher employed a combination of inductive, latent and constructionist approaches to thematic analysis. Induction was chosen because the researcher was interested in the knowledge and experiences of the people who were practising in the computer networking field rather than bringing ideas from elsewhere. It meant that the themes came from what the respondents said rather than what the researcher had in mind. The latent approach was relevant since the project practitioners had experiences which could bring out less obvious knowledge that could help improve management of computer networking projects. The analysis of the interview data provided some underlying ideas. The constructionist approach to analysing interview data was relevant because the researcher did not get any literature on computer networking projects' CSFs in or outside the country. The constructionist approach meant that the research produced a new reality from the data which formed the set of critical success factors for computer networking projects.

5.3.2 Stages of thematic analysis

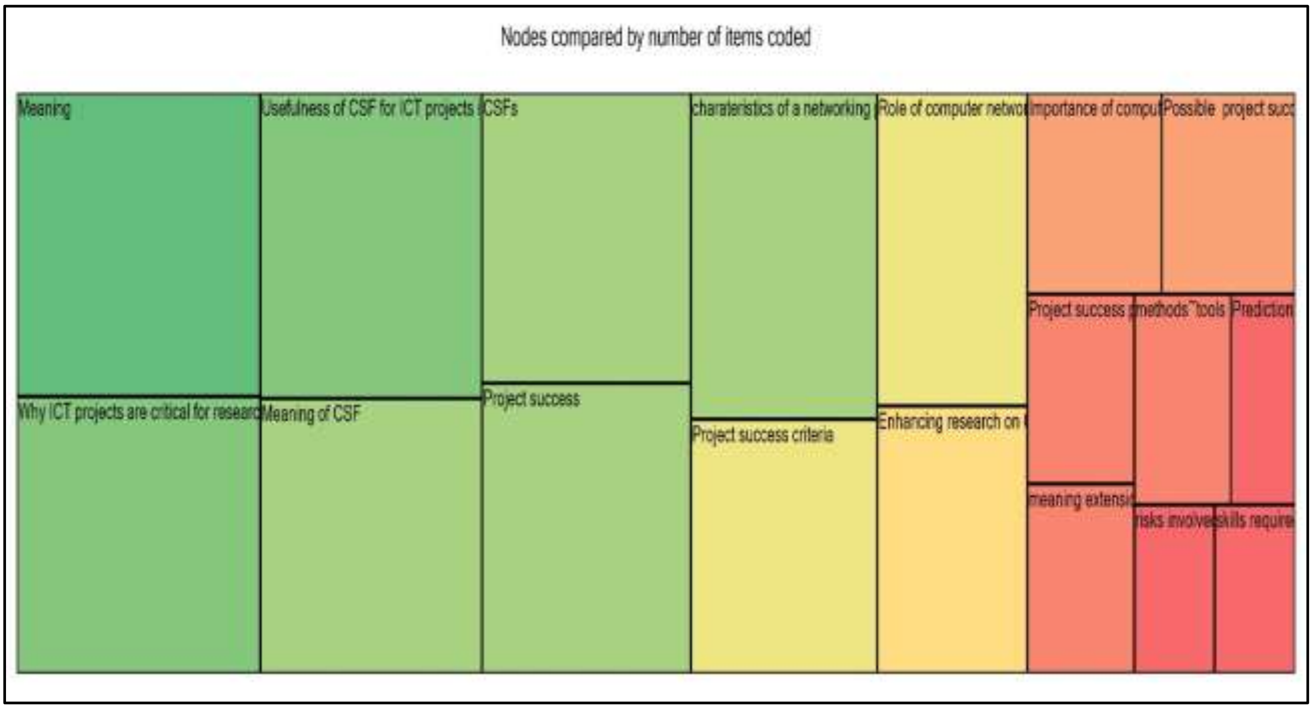
Aronson (1995) identified the steps in thematic analysis as collection of data and its patterns, establishing all data that pertains to the categorised trends, combining and putting associated patterns into subthemes and the development of an authoritative argument for selecting the themes through reading literature related to the topic. However, Braun and Clarke (2012) and Braun, Clarke and Rance (2014) identified six clearer phases for conducting thematic analysis. The researcher followed those six phases in the thematic analysis of the data collected during the interviews. The phases followed were:

1) **Acquainting with the data**. The phase involved the researcher repeatedly reading the data. The reading in this case was the listening to the interview recording repeatedly. Notes were made on paper in the process. The reading was active, analytical and critical aimed at familiarising the researcher with the data.

2) **Creating codes**. The stage marked the beginning of the systematic analysis of the data through coding. Codes were the building blocks of the analysis. The codes established and gave labels for the characteristics of the data with potential or relevance to the research questions. The process was repeated several times for all the data sources in the data set for thoroughness.

   The Tree map (Table 5.69) represents the nodes coded from the interview data as display items in the form of rectangular boxes. The box size indicates the number of the chosen items which were coded by the display items. The colour of the boxes signify how many of the selected scope items were coded by the display items, on a range of low to high. From Table 5.26 it is noticeable that the interviewees who themselves were computer networking project practitioners were mostly acquainted to the meaning of computer networking projects. In addition they were acquainted to the critical position of ICT projects in research, the usefulness of computer networking projects, characteristics of computer networking projects, the role of computer networking projects and the CSFs for computer networking projects. However, less was coded on important aspects such as computer networking project success prediction, prediction tools and methods, enhancing research on critical success factors and risks involved in that type of ICT projects. The scenario pointed to the lack of knowledge and research in Zimbabwe on these aspects. Understanding the meaning of computer networking projects, their characteristics and the CSFs are important to projects' success but leaves much room for resource wastage since failure of a project is likely to be apparent late in the project. Therefore, development and application of project success prediction tools or models have the potential to reduce losses due to the indulgence of resources to a project that will eventually fail. It was the intention of this researcher to build a logistic regression analysis model that predicts computer networking projects' success from identified critical success factors.

Table 5.69: Tree Map of nodes compared by number of items coded



The intensity of coding for each node was different from the rest of the nodes. The intensity of the coding in terms of the number of coded items as well as the number of coding references are summarised in Table 5.69. It can be noticed from the table that the meaning of a computer networking project had the greatest number of items coded followed by usefulness of CSFs in ICT projects in general and the reason why research in ICT projects is considered critical. Among the lowest were skills required for computer networking projects, risks involved, methods and tools for project success prediction, prediction shortcomings, project success prediction, and the importance of computer networking projects.

Table 5. 69: Nodes compared by number of items coded

Nodes	Number of coding references	Number of items coded
Nodes\\characteristics of a networking project	24	9
Nodes\\CSFs	21	9
Nodes\\Enhancing research on CSFs	11	6
Nodes\\Importance of computer networking projects	11	4
Nodes\\Meaning	13	11
Nodes\\meaning extension	12	3
Nodes\\Meaning of CSF	11	9
Nodes\\methods &tools	3	3
Nodes\\Possible project success prediction methods or tools	8	4
Nodes\\Prediction shortcomings	2	2
Nodes\\Project success	14	9
Nodes\\Project success criteria	10	7
Nodes\\Project success prediction	12	3
Nodes\\risks involved	3	2
Nodes\\Role of computer networking projects	21	7
Nodes\\skills required	4	2
Nodes\\Usefulness of CSF for ICT projects in general	36	10
Nodes\\Why ICT projects are critical for research	29	10

3) **Identifying themes**. It is at this phase that the analysis started to take shape. A theme was taken to mean a description that captured something significant about the data in association with the research question and signifies some degree of patterned response or meaning with the data set (Braun & Clarke 2012). Codes that seemed to share some unifying feature were collapsed or clustered together to show and depict a comprehensive and meaningful trend in the data. Themes were made to be distinct, standalone but working together as a whole. Repetitive coding was done in NVivo based on candidate themes and a collection of all the data extracts relevant to each theme was used for reviewing themes. The most common pitfall in thematic analysis is to use interview questions as themes which then reflects the fact that the data was summarised and organised, rather than analysed (Maguire & Delahunt 2017). In this research, themes were derived from the data rather than using the interview questions as themes to avoid the identified pitfall.
4) **Reviewing potential themes**. This was a repetitive process in which the themes were reviewed in line with the coded data and the whole data set.

Importantly, the stage involved examining the quality of the identified themes to see if they were relevant to the study. Large themes were split up whilst other related themes were collapsed into one for clarity.

5) **Defining and naming themes**. The researcher precisely stated what was unique and specific about each theme. The researcher ensured that each theme did not do too much each, was related to other themes but did not overlap, and directly addressed the research questions. The themes provided structure for the analysis since they link up by feeding into each other to build a whole argument.
6) **Producing the report**. The recording and analysis of the interview data was interwoven since the writing proper started by writing the interview guide itself and proceeded right to the production of this write-up. The researcher made an effort to ensure that this write-up was comprised of themes that connected logically and meaningfully, and building on each other to give an intelligible message about the data. The write-up included the themes and patterns identified during the thematic analysis.

5.3.3 Tools and techniques

Generally the tools and techniques used in the collection of qualitative data include in-depth interviews, field notes from observations, diaries and videos; content analysis, thematic analysis, conversational analysis and documentary analysis for data analysis (De Hoyos & Barnes 2014). In this study, the researcher employed in-depth interviews for data collection and thematic analysis for data analysis. These were deemed appropriate for the study.

5.3.4 Themes and patterns identified during the interview data analysis

Theme 1: Computer networking projects come in different forms

Patterns:

1. Designing network algorithms
2. Developing network protocols
3. Securing networks
4. Developing a new network
5. Extending an existing network
6. Designing, analysis and implementation of connectivity among network devices.
7. Computer networking projects are constrained with time and budget.

8. Developing new network technologies.
9. Computer networks can either be wired or wireless.

Theme 2: Computer networks have different purpose from other ICT projects

Patterns:

1. Connection of different devices even globally
2. Data communication and sharing files
3. Digitalisation of many processes is rapidly influencing modern business environment

Theme 3: Computer networking projects have distinct features

Patterns:

1. Computer networks are a subset of ICT projects and form a specific field.
2. Improved security
3. The network is exposed to all sorts of security threats
4. Has a lot of uncertainties
5. Require resources different from other ICT projects
6. Experience different types of risk to those of the other ICT projects.
7. The context of computer networking projects is unique.
8. Specific skills are needed to design and implement computer networking projects.

Theme 4: Every organisation, hence any computer networking project has a specific goal(s)

Patterns:

1. There are factors critical for a computer networking project to achieve its goals.
2. CSFs are important for an organisation to attain its objectives (in part through computer networking projects).
3. Success of a project depends on the CSFs.

Theme 5: There is need to develop critical success factors specifically for computer networking projects

Patterns:

1. Technology is fast changing
2. There are problems in applying the general critical success factors for ICT projects to computer networking projects.
3. There is need for a limited set of CSFs specific to computer networking projects

4. General CSFs for ICT projects have limited applicability to computer networking projects.
5. Specific types of ICT projects require different CSFs.
6. Using a general CSF model for ICT projects leaves gaps in knowledge since the model cannot benefit individual types of projects.
7. The existing theories and techniques need to be adapted and validated to specific ICT projects.

Theme 6: There are specific criteria to measure success of computer networking projects

Patterns:

1. Use of success metrics (scope, schedule, budget, quality, stakeholder satisfaction)
2. The network should be easily accessible
3. There should be efficient use of resources
4. The network should be secure

Theme 7: There is a strong need to carryout research in computer networking projects

Patterns:

There is need:

1. to develop current solutions to networking issues
2. for a diversity of tools and techniques to manage any type of project.
3. for research on mathematical modelling using critical success factors.
4. to carry out research on modelling and forecasting/prediction.
5. to carry out research on specific projects (including computer networks).
6. For paying attention to practical experience and collaborative research.
7. To carry out research in computer networking projects because the projects have a direct influence to modern business through:
   a) E-mailing
   b) Mobile communications
   c) Teleconferencing
   d) ERPs
   e) Backups
   f) Disaster recovery
   g) E-commerce
   h) Marketing, etc.

5.4 Discussion of the results

This section was devoted to the overall discussion of the research results. It encompasses results from Meta-synthesis analysis, questionnaires and interviews. The results from meta-synthesis analysis formed the basis for the questionnaire and interview items. The results from interviews and questionnaire produced CSFs that were used in the logistic regression model developed to predict the success of computer networking projects.

5.4.1 CSFs for computer networking projects

Successful execution of ICT projects, just like other projects is predicted on a set of critical factors (Ugwu 2007). The interviews produced a list of nine factors critical to computer networking projects' success in Zimbabwe as a specific type of ICT projects. Atsu et al. (2009) classified ICT project success factors into economic, cultural and institutional variables. The researcher noted that certain aspects were not covered e.g. project team factors and environmental factors were not covered. The current research identified two other classes of critical success factors namely project team factors and external factors.

Although a total of nine factors were critical to the success of computer networking projects in Zimbabwe, it was noted that the project team factors dominated. These factors were oneness of the project team, team members with high competence & expertise, effective team building or motivation, project goals awareness, knowing client needs and having a clear project boundary. The project team factors were six out of the nine clearly showing their importance in the success of computer networking projects. For instance, it is difficult for a networking project whose team has poor competence and expertise to succeed. It was also noted that project goals awareness was the most dominant factor with a cumulative percentage of strongly agree and agree of 95.6 as rated by the respondents.

This indicated that everything being equal, a computer networking project can never succeed if the project team does not have knowledge of what they need to achieve. This is a very important aspect since in any endeavour, practitioners have to be aware of the project goals otherwise they lose focus, leading to failure of the project.

Despite the dominance of project team factors, it was also noted that much weight was given to strong support from senior management (92.8%), committed sponsor (90%) and adequate funding (90%) which are owner organisation and external factors, respectively. In other words, the team factors can only have effect if the organisation's senior management provides strong support, which culminates in the financing of the projects. It is therefore crucial that project leaders convince their senior management of the importance of their projects as early as possible to garner their support. Consequently, project team factors dominated in terms of numbers whilst the organisational and external factors dominated in terms of weight.

Atsu et al. (2009) examined the implementation of ICT projects in the context of commonly known project success factors and complemented with factors that were worth considering in developing countries' environments. The focus of that study indicated the importance of considering context when applying the CSF model to ICT projects. In other words, it is important to look at specific ICT projects and note that the criticality of a factor depends on the project environment i.e. contextual. Few research focused on evaluating factors that influence ICT project success in the third world countries with most of the reported CSFs being based on studies in developed countries (Atsu et al. 2009)

According to Atsu et al. (2009:3) the top five critical ICT project success factors were:

1) Availability of funds
2) senior management support
3) Training
4) Motivation
5) Proper planning

However, this was a deduction from only one organisation, AB Networks, a telecommunications company in Ghana. Atsu et al. (2009) recommend that research based in other third world countries could produce additional variables. The current research was carried out in Zimbabwe, also a developing country, providing a different context from that of Ghana. The contribution of the current research in this context was addition of the variables: project goals awareness, oneness of the project team, team members with high competence & expertise, knowing client needs and having a clear project boundary. All these identified critical success factors fell into project team factors and project management factors.

The ensuing section carries a discussion of the interview results under the thematic areas identified during thematic analysis of the interview data. The thematic areas were: forms of computer networking projects, the purpose of computer networking projects, distinct features of computer networking projects, the goals of computer networking projects, criteria for measuring the success of computer networking projects and the need to carry out research in computer networking projects.

5.4.2 Forms of computer networking projects

Milis (2002) in agreement with Atsu et al. (2009) propounds that a project is a reaction to a real life challenge or opportunity and it is carried out in a defined setting. Computer networking projects, therefore, are carried out in response to the real life opportunities for businesses and individuals to be connected on a global scale. The context of computer networking project management in this research was Zimbabwe which was specific enough to formulate a standing on critical success factors. As part of this research, interviews were held to develop insights into the management of computer networking projects in Zimbabwe.

The interviews carried out indicated that ICT projects were different and therefore should be treated differently. The computer networking projects themselves were found to be broad and having different forms. The major forms of computer networking projects identified were: designing of network algorithms, developing network protocols, securing networks, developing a new network, extending an existing network, designing, analysis and implementation of connectivity among network devices and developing new network technologies.

For designing network algorithms, it was realised that:

1) Computer networking projects are constrained with time and budget.
2) There was need in computer networking projects to develop new network technologies.
3) Computer networks can either be wired or wireless.

The algorithms developed are used to manage the movement and security of traffic across the network. Mishra and Singh (2012:2) note that the developments in cyber technology provided malicious objects that are a great threat to the cyber world. The complexity of attacks on computer systems is increasing rapidly. Computer networks are complicated due to the high throughput and the multi-uniformity of actions by users on the network (Saravanakumar, Mohanaprakash, Dharani & Kumar 2012:1). This phenomenon justifies the need for research in network security as a type of computer networking projects.

Research in computer networking includes network algorithm design as an inherent component of computer network design. Generally, a computer network design problem is defined as finding appropriate solution involving computer nodes, communication channels and provision of services which fulfil cost and performance requirements (Olejnick 2011:2). Computer network design is the backbone of computer networking projects. The researcher considered project management practitioners involved in all aspects of computer networking projects that included network algorithms, network design and installation. Olejnick (2011:5) sees the network design process as consisting of needs identification, network development and network deployment in which various algorithms are used to model attack signatures and normal behaviour response patterns of a system (Saravanakumar et al. 2012:2).

In this study, all the types of computer networking projects were placed and studied under the umbrella 'computer networking projects'. It was assumed that the needs and conditions of all types of computer networking projects were related but different from other types of ICT projects e.g. software development projects.

5.4.3 The purpose of computer networking projects

An important concept related to information and knowledge society is communication, as information is continuously transmitted and exchanged between needy parties (Pade, Mallinson & Sewry 2004). ICT improves communication since it is an effective tool in sustaining development as it links and facilitates information movement between people (Pade, Mallinson & Sewry 2004). Thus, the results of the research agreed with literature in that it also indicated that a computer network is responsible for the connection of different devices globally. The main purpose of a computer network was thus to communicate data globally thereby enabling sharing of files.

The communication was turning into digitalisation of the data, files and the means of communication. The fact that people can now do business with anyone anywhere proved the importance of computer networks.

5.4.4 Distinct features of computer networking projects

Most research deals with project management ideologies in general and ignores the actual nature of ICT projects, thereby, ignoring the latent changes in the project management approach (Milis 2002). By the same argument, research in ICT tends to focus on the projects in general rather than studying them in their distinct categories. This research isolated and studied only computer networking projects. This was done in order to isolate factors critical specifically to computer networking projects. The researcher identified features that differentiated computer networking projects. From literature, Milis (2002) mentions properties of ICT projects as:

1) Supportive in nature
2) High risk and long lead times
3) Hidden costs and benefits
4) Benefits are indirect and delayed
5) Assessment is challenging
6) Often changing environments.

However, the current study, through interviews identified the following as the main features of computer networking projects which differentiate them from the wider ICT group:

1) Computer networks are a subset of ICT projects and form a specific field.
2) Improved security
3) The network is exposed to all sorts of security threats
4) Has a lot of uncertainties
5) Require resources different from other ICT projects
6) Experience different types of risk to those of the other ICT projects.
7) The context of computer networking projects is unique.
8) Specific skills are needed to design and implement computer networking projects.

The researcher noted that computer networking projects are characterised by a number of uncertainties which exposed to all sorts of security threats as compared to other ICT projects, hence require improved security to protect the network traffic.

The fact that more security is required calls for different types of resources and skills. The computer networking projects, as a result, are carried out in a very different context from other types of ICT projects. As an example, software can be developed by programmers at home or in offices and delivered to a client site for installation, whereas, in the case of computer networking projects, specialists have to install physical devices at specified locations according the design. These devices need to be configured for them to communicate.

5.4.5 The goals of computer networking projects

Interview results indicated that every organisation had goals that needed to be achieved. It was indicated that there were factors critical for a computer networking project to achieve its goals. It followed that goals/targets must be set first and then appropriate critical factors controlled for the goals to be achieved. The critical success factors were described as factors needed for an organisation to attain its objectives (in part through computer networking projects). Therefore, the success of a computer networking project was dependent on the critical success factors.

5.4.6 Criteria for measuring the success of computer networking projects

Milis (2002:34) argues that ICT project success is in itself a probable challenge. There is no agreement on the method of measuring project success. Over the years, researchers have accepted the triple triangle constraint criteria as a standard measure of the projects success (time, cost & specification) (Milis 2002). This approach emphasises the significance of the viewpoint of the project manager. The approaches consider benefits or the user gratification measured in a succeeding phase in the project life cycle (Milis 2002). The time, cost and specification factors are all controlled by the manager. Using the triple triangle tends to ignore the contribution of factors relating to the organisation and team members. The result is an inaccurate representation of the project performance. It consequently means that more research needs to be carried out to improve on the success criteria.

In this part of the research, respondents indicated that the triple triangle is the basis for any project's success interpretation. The following were identified as the computer networking projects' success criteria:

1) Use of success metrics (scope, schedule, budget, quality, stakeholder satisfaction)
2) The network should be easily accessible
3) There should be efficient use of resources
4) The network should be secure

From the list, it is clear that the success metrics build from the traditional triple constraint triangle with the addition of schedule and stakeholder satisfaction. The schedule is inclined to the project manager's efforts whilst the inclusion of stakeholder satisfaction indicated that the respondents were cognisant of the critical role of other stakeholders who are not managers. The stakeholders include the users, developing organisation and the client organisation. A computer network exist as a means of sharing data and information, so in the success criteria the accessibility of the network by users was of paramount importance. Other than its accessibility, a network has to be adequately secured since its traffic in most cases comprise of security critical data. A network spans across different nodes in different places, hence, the success criteria should include a measure of efficient use of resources. The efficient use of resources ensures a quicker arrival at network benefits since the networking costs will be lowered.

5.4.7 The need to carry out research in computer networking projects

The internet is one of the most widely used tools for accessing digital information (Shukla, Verma & Gangele 2012:1). The expansion of the cyber world caused radical changes in society and improved livelihoods as the world is now reachable at the touch of a button (Mishra & Sigh 2012). This is the essence of a computer network. We are now living in a digitalised world in which digital information traverses all parts of the globe. Computer networks are responsible for all this. In recent years, the applications of computer systems and internet service have grown rapidly and exponentially (Lin & Chang 2012: 1). For a stable usage environment, internet service providers have to guarantee that the computer systems retain a good quality of service and satisfy their customer needs all the time.

The need to carry out research in computer networking projects was in tandem with the literature reviewed. Interview respondents pointed out that there was need to develop current solutions to networking issues. The implication was that since the ICT discipline was characterised by rapid changes in technology, there were always issues sprouting each day justifying the need for continued research in computer networking to develop appropriate solutions. The research included the development of a variety of tools and techniques to manage computer networking projects.

Respondents also echoed the need to develop mathematical models using the critical success factor model to help the management of computer networking projects. This research was a step in that direction through the development of a logistic regression analysis model that predicts the success of computer networking projects based on their CSFs. The CSFs were established in this research work as well. The interview results also indicated that there was need to carry out research on specific ICT projects. In that regard the current research focused specifically on computer networking projects. The reason was to remove the confusion brought to specific ICT project managers by the attempt to apply a generic critical success factor model to every ICT project of which each specific type has its own characteristic features. The research revealed that researchers in ICT paid attention to the practical experience of the project practitioners and research collaboration between ICT specialists in industry and academia. The current research attempted to achieve this since the researcher was in academia and all the respondents were in industry.

5.4.8 Comparison of CSFs for ICT projects in Zimbabwe with CSFs from meta-synthesis analysis and computer networking projects in Zimbabwe

The CSFs for ICT projects obtained from meta-synthesis analysis done in chapter four were compared with those obtained from Zimbabwe. The results are indicated in Table 5.70. A clear relationship among the CSFs for ICT projects from literature, those from Zimbabwe and the CSFs for computer networking projects was observed from Table 5.70. All but one CSF derived from meta-synthesis analysis were discovered to be critical in Zimbabwe for ICT projects in general. The only factor found from literature which was not deduced from the Zimbabwean set up was user involvement. A closer look at Table 5.71 shows that the sixteen CSFs for ICT projects in Zimbabwe all fall under the 6 factors from literature. The researcher depicted this fact by classifying the CSFs from Zimbabwe under the factors from literature. As an example, it was deduced from meta-synthesis that one of the CSFs for ICT projects is effective project management skills/methods. The researcher noted that the same factor summarised ten of the CSFs from the Zimbabwean set up (Table 5.70). The interesting part was that the research from the Zimbabwean scenario was more specific. This means that computer networking project managers can find it easier to apply the CSF model since it clearly spells out what need to be considered. In terms of the overall CSFs for ICT projects, the factors from literature apply to Zimbabwe with very minor changes.

In terms of CSFs for computer networking projects in Zimbabwe, the researcher observed that even in Zimbabwe they are different from those for ICT projects in general. There was a general agreement in terms of commitment by and support from senior management, team factors and goals & objectives. Even though computer networking projects are different from general ICT projects, they all need support from the senior management, otherwise they will fail. In addition, both project types demand team-work, hence the need to take team factors seriously. The team factors for computer networking projects included effective team building, motivation and expertise. No project can succeed when the team has questionable expertise or is not motivated. The third critical area identified for all ICT projects including computer networking projects was to make the goals and objectives of the projects clear to all stakeholders. If these are not communicated well or understood by all stakeholders, then there is no way the expected results of the project can be achieved. In computer networking projects, no emphasis was placed on user involvement and communication. These factors were not considered critical since users of a network do not interact with the computer network in the same way they do with systems like software. Computer network users once connected, do not normally worry about the nature of the network. In addition, developers of a computer network work on configurations set and agreed upon resulting in less chances of misconception.

From this research it was established that CSFs for computer networking projects in Zimbabwe differ from those for ICT projects in general. It suggests the existence of a different CSF model for computer networking projects. This research produced a set of computer networking projects' CSFs in Zimbabwe. A different set of CSFs for ICT projects in Zimbabwe was also developed. CSFs for ICT projects in Zimbabwe mirror those from literature obtained from different parts of the world through qualitative meta-synthesis analysis.

Table 5. 70: **Comparison of CSFs from Meta-synthesis and from Zimbabwe**

CSFs from Meta-synthesis analysis	CSFs from Zimbabwe	CSFs for computer networking projects
1. Committed management support & Sponsorship	1. Adequate budget 2. Adequate funding	1. Strong support from senior management 2. Committed sponsor 3. Adequate funding
2. Clear objectives & goals	3. Project size complexity 4. Project uniqueness 5. Competitor technologies	4. Project goals awareness 5. Having a clear project boundary
3. Effective communication in the project	6. Direct communication	6.
4. Effective project management skills/methods	7. Strong detailed planning 8. Considering and appreciating multiple viewpoints 9. Rigorous refactoring activities 10. Projects with dynamic accelerated schedule 11. Flexible approach to change 12. Sound basis for project 13. Realistic schedule 14. Appreciating effect of human error 15. Effective leadership conflict resolution 16. Projects with upfront risk analysis done	7. Knowing client needs
5. Team capability/competence	17. Training provision 18. Coherent self-organising team	8. Solid project team 9. Competent team 10. Effective team
6. User involvement		

5.5 Chapter summary

The researcher presented and analysed data from SPSS and from the interviews conducted. ICT projects' CSFs in Zimbabwe were: project goals awareness, strong support from senior management, committed sponsor, adequate funding, oneness of the project team, competent team, effective team, knowing client needs and having a clear project boundary. The interviews revealed that every computer networking project has specific goals that can only be achieved once the set of identified critical success factors were controlled. The results underpinned the types of computer networking projects and the need for research in computer networking projects. Computer networking projects were found to be critical in the ever-changing prevailing business environment, and thus, deserve more research attention. CSFs for computer network projects in Zimbabwe were different from those for ICT projects.

The next chapter presents the processes followed on the development of the logistic regression analysis model to predict computer networking projects success using the results from this chapter.

Chapter Six: Model Development

6.1 Introduction

This chapter covers the process used to develop the logistic regression analysis model to predict computer networking projects' success in Zimbabwe. The model development was the core contribution of the study. This research followed the process for designing and developing models proposed by Hao Wang (2012). The process was both rigorous and reasonable for adoption in this study. Hao Wang (2012) proposes a process that can be used for modelling. He proposed a guideline for developing logistic regression analysis models that was adopted in this research to build a model to predict computer networking projects' success in Zimbabwe.

The guideline consists of four main processes namely, an understanding of the real word phenomenon or collection of data, model development, making mathematical conclusions and drawing real world conclusions (Figure 6.1).

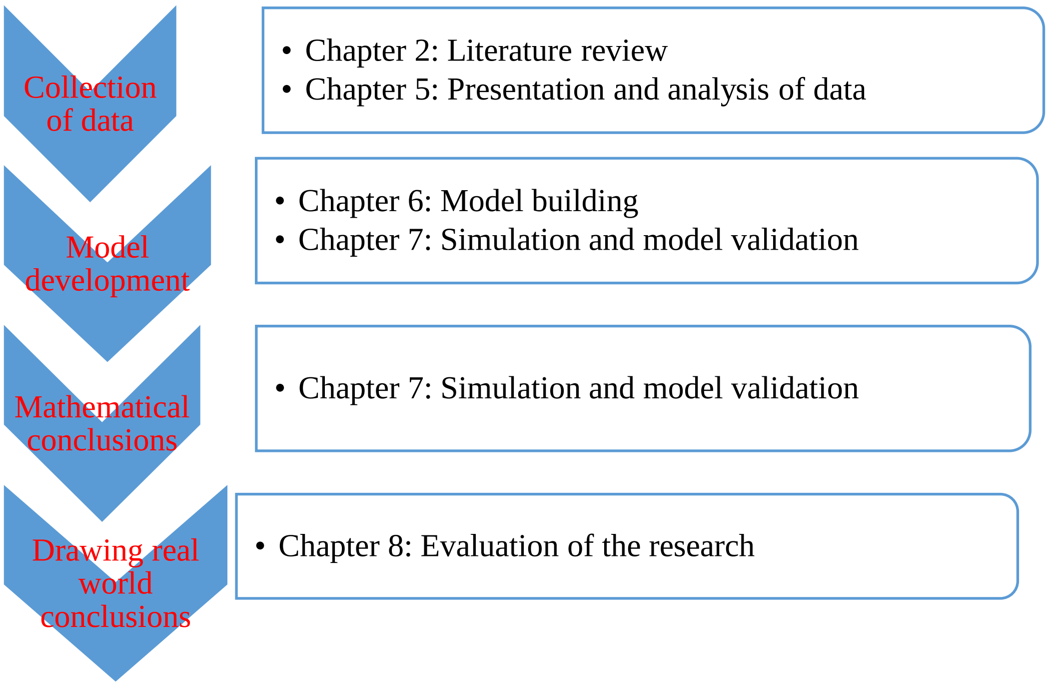


Figure 6. 1: Developing logistic regression models
(Adapted from Hao Wang 2012)

The first step was to define the real world phenomena or data under study. In this case, it pertained to data on ICT projects' CSFs in general (chapters two and four). The researcher went on to carry out a survey to identify ICT projects' CSFs in Zimbabwe (Chapter five) founded on the CSF framework described in chapter four.

Another survey was then done to establish computer networking projects' CSFs in Zimbabwe based on the CSFs for ICT projects in Zimbabwe. This data formed the basis for building the logistic regression analysis model to predict computer networking projects' success in Zimbabwe which is reported in this chapter. Figure 6.2 shows the stages described here.

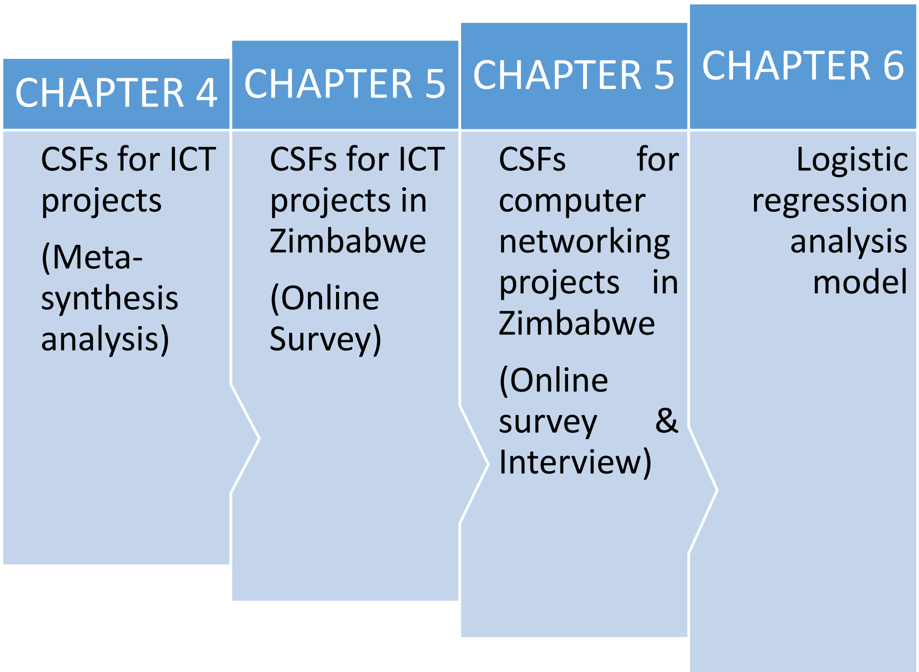


Figure 6. 2: The logistic regression analysis model development stages developed for this research

The researcher noted that since computer networking projects were a specific type of ICT project, it was not wise to assume that they were constrained by the same critical factors as any other ICT project. The researcher then studied CSFs from literature and came up with a collection of as many critical success factors as were possible. Meta-synthesis analysis (chapter four) was applied to identify those critical success factors in order to get a smaller set of factors that made the model development, testing and application reasonable.

It is not advisable therefore for ICT Project Managers to take any list of ICT project management critical success factors at face value. In actual sense, there is need to consider the type of projects before applying the critical success factor model. The researcher realised that there was need for research in other types of ICT projects. The project managers need specific information to use in each type of ICT project.

After establishing the CSFs for ICT projects in general, the researcher went on to develop a questionnaire for computer networking projects practitioners in order for them to suggest those factors they find critical in their specific domain. Initially there were seventy-six variables which were further reduced to eighteen for ICT projects in Zimbabwe (chapter five). Further analysis was done resulting in only five critical success factors specific to computer networking projects in Zimbabwe (Table 6.1). These were then used to develop the logistic regression analysis model to predict computer networking projects' success.

Table 6. 1: CSFs for computer networking projects in Zimbabwe

Factor number	Factor description
1	Committed management support and sponsorship.
2	Clear objectives and goals (project size complexity, project uniqueness and competitor technologies
3	Effective communication in the project (direct communication)
4	Effective project management skills/methods
5	Team capability/competence

Before formulating the logistic regression analysis model, assumptions were made to ground the model.

6.2 Logistic regression assumptions

The assumptions considered here were based on the work of Stoltzfus (2011) and Menard (2010). It is a must that one meets the basic assumptions for conducting logistic regression (Stoltzfus 2011):

1. Independency of error or expected value of error – all sample group outcomes are separate from each other, i.e. no duplicate responses. The expected value of error thus, e = 0. Once data include repeated measures or other correlated outcomes, errors will be similarly correlated, and the assumption is violated (Stoltzfus 2011). The questionnaire used to collect the data initially had forty three questions based on the CSFs for ICT projects from literature. A correlation analysis was made on the research questions. This was an analysis to check if the forty three research questions were consistent. It was found that seven pairs of variables were highly correlated with correlation values of more than 0.65. The items that were correlated were: (1 and 2, 6 and 7, 13 and 14, 23 and 24, 24 and 25, 33 and 34, 40 and 41). In each of these pairs,

one question was removed. After this process only thirty seven questions remained for analysis.

On the rating of items, a one-sample t-test was used to check how respondents were rating the items in the questionnaire. The t-test was done against the **Not Sure** option and all the questions were significant, indicating that the rating is either strongly agree or agree. Respondents agreed that the listed items are important in evaluating the success / failure of computer networking projects.

2. No auto-correlations - it is assumed that there is no correlation among the error terms produced by different values of the independent variables. Mathematically this is expressed as:

   $E(e_i,e_j) = 0$

   Where $E(\mathbf{e_i,e_j})$ represents the expected value of the association (correlation or covariance) between $\mathbf{e_i}$ and $\mathbf{e_j}$. From the previous correlation analysis, all the correlations among the variables in the research instruments were removed, hence no auto-correlations of error terms due to each of the remaining variables were expected.

3. Normality of errors – the errors are normally distributed for each set of values of the independent variables.
4. Homoscedasticity – the variance of the error term, **e**, is the same or constant for all values of the independent variables.
5. Absence of perfect multicollinearity – This means absence of redundancy among independent variables. In case of multiple regression, none of the independent variables is a perfect linear combination of the other independent variables:

   I.e. For any I, $R_i^2 < 1$,

   Where R_i^2 is the variance in the independent variable x_i

   That is explained by all the other independent variables $x_1, x_2, x_3 \ldots x_{j-1}, x_{i+1} \ldots x_k,$

If any two variables are correlated then they should not both be included in the same model. A logistic regression model with highly correlated independent variables will normally result in more standard errors for the estimated beta coefficients of these variables (Stoltzfus 2011). The solution is to remove at least one redundant variable. In cases of only one predictor, multicollinearity is not does not matter (Menard 2010).

6. Specification – i. all relevant predictors of the dependent variable are included in the analysis; ii. No irrelevant predictors of the dependent variable are included in the analysis; and iii. The form of the relationship is linear though allowing for transformations of dependent or independent variables (Menard 2010).

6.3 Development of the logistic analysis model

6.3.1 Cronbach's Alpha test

For reliability analysis of the instrument used to identify the critical success factors, a Cronbach's Alpha test was performed. The Cronbach's alpha value of 0.861 was produced. This proved that the internal consistency of the instrument was reliable (Table 6.2).
Out of the 43 variables reduced from 76 initially started with, they were further reduced to 36 with a final table of results as shown in Table 6.2. A Cronbach's Alpha value of 0.861 indicates that the remaining 36 variables were not highly correlated and the questionnaire was really a good instrument to use for analysis. The researcher finally used these 36 factors to identify the optimal CSFs.

Table 6. 2: Cronbach's Alpha reliability Test

Reliability statistics	
Cronbach's alpha	Number of items
0.861	36

6.3.2 Variables in the Model

The optimal number of variables used were obtained using the forward selection method. Out of the thirty-six variables used to get the optimal model, both forward and backward selection methods gave an optimal number of five variables shown in Table 6.3. This was reached after the fifth iteration. A summary of the optimal variables is shown in Table 6.3:

Table 6. 3: Optimal variables

Variables in the equation							
		B	**S.E**	**Wald**	**df**	**Sig.**	**Exp(B)**
	Strong support from senior management	11.435	7.078	2.61	1	0.106	92486.3
	Use of website for communication	-3.891	2.556	2.317	1	0.128	0.020
	Competent team	4.71	2.993	2.477	1	0.116	111.042
Step 5	Project manager communication skills	-3.891	2.556	2.317	1	0.128	0.020
	Projects with no multiple independent teams	-9.02	5.978	2.276	1	0.131	0.000
	Constant	-22.848	13.453	2.884	1	0.089	0.000
Variable(s) entered on step 1: strong support from senior management Variable(s) entered on step 2: Competent team Variable(s) entered on step 3: solid team Variable(s) entered on step 4: Use of website for communication Variable(s) entered on step 5: Project manager communication skills							

Table 6.3 shows the optimal variables included in the model. These were Strong support from senior management, competent team, solid team, use of website for communication and project manager communication skills.

6.3.3 Classification Table

To test the significance and optimality of the model, the same model was tested on the data and the classification table (Table 6.4) shows that a 97.8% correct classification was done with the model. This indicated that almost all data had been correctly classified by the developed model.

Table 6. 4: Classification Table

<table>
<tr><td colspan="7">Classification table</td></tr>
<tr><td colspan="7">Predicted</td></tr>
<tr><td rowspan="4">Step 4</td><td colspan="2"></td><td colspan="2">Probability of success</td><td colspan="2">Percentage correct</td></tr>
<tr><td colspan="2">Observed</td><td>Yes</td><td>No</td><td></td><td></td></tr>
<tr><td>Probability</td><td>Yes</td><td>171</td><td>1</td><td colspan="2">99.4</td></tr>
<tr><td>Success</td><td>No</td><td>3</td><td>5</td><td colspan="2">62.5</td></tr>
<tr><td colspan="3">Overall Percentage</td><td colspan="4">97.8</td></tr>
<tr><td colspan="3">Cut value</td><td colspan="4">0.5</td></tr>
</table>

6.3.4 Variance

A measure of the variance accounted for by the model is indicated by the Nagelkerke R-Squared value of 84%. This indicated that 84% of the variation in the dependent variable was accounted for by the model.

6.3.5 Bivariate correlations

A correlation matrix of the predicator variables shows that there was a very low correlation between the five variables. All the correlation coefficient values were far below 40% indicating that they were not correlated, hence can be used in the model. There was no multicollinearity between the variables.

Table 6. 5: Bivariate correlation coefficients

Bivariate correlation coefficients of variables in the model					
	Strong support from senior management	Competent team	Use of website for communication	Project manager communication skills	Solid team
Strong support from senior management	1	0.034	-0.083	0.047	-0.036
Competent team	0.034	1	0.042	0.079	0.042
Use of website for communication	-0.083	0.042	1	0.333	0.351
Project manager communication skills	0.047	0.079	0.0333	1	0.089
Projects with no multiple independent teams	-0.036	0.042	0.351	0.089	1
Correlation is significant at the 0.01 (two-tailed)					

6.3.6 Principal components analysis

A principal component analysis was done and Table 6.6 shows the results.

Table 6. 6: Component matrix

Component Matrix

	Component											
	1	2	3	4	5	6	7	8	9	10	11	12
Strong support from senior management	.032	-.010	-.282	.553	.250	-.197	.140	.351	.268	-.161	-.093	.111
Cooperative organizational culture	.459	-.474	.065	.156	.307	-.059	.227	.129	.086	-.224	-.194	.208
Oral culture placing value on face to face communication	.554	-.412	-.109	.120	.156	-.232	.201	.028	.082	-.036	-.106	.145
Oneness of the project team	.320	.180	-.291	.297	-.104	-.338	.077	.132	.350	.395	-.004	-.162
Support from stakeholders	.571	-.177	-.124	-.004	-.253	-.407	.272	-.108	-.034	.185	-.126	.037
Team members with high competence and expertise	.194	.257	-.195	.246	-.058	-.130	.226	-.496	-.096	.298	.116	-.045
Motivated team members	.306	.438	-.429	.137	.194	.060	.065	-.220	-.122	-.128	.194	-.060
Managers with light touch	.348	.272	-.399	.152	.231	.273	-.161	-.337	.095	-.224	.070	-.019
Good customer relationship	.643	-.240	-.159	-.111	.152	.213	-.105	-.193	.002	-.177	-.027	.127
Taking account of past experience and learning from it	.410	.395	-.371	.126	.103	.203	-.032	-.049	.036	-.057	.071	.036
Effective team building or motivation	.441	.396	-.253	.245	.007	.087	.104	-.001	-.030	-.057	-.060	-.105
Project goals awareness	.093	.098	.224	.351	.107	.469	.471	.215	-.262	-.086	-.029	-.189
Considering and appreciating multiple viewpoints	.313	-.318	.200	.247	.066	.391	.257	.192	-.274	.321	.008	.132
Use of website for communication	.449	-.458	-.027	.049	-.397	.234	.000	-.152	-.052	-.026	-.044	.160
Project manager technical background	.334	-.078	-.090	.260	-.519	.254	-.294	-.029	-.078	.037	-.186	.302
Project manager communication skills	.574	-.049	-.257	-.064	-.328	-.155	.022	.106	-.127	-.247	-.005	.146
Project team in different areas	.529	-.194	-.166	-.013	-.341	-.134	-.185	.333	-.104	-.226	.199	-.141
Honouring regular working schedule with no overtime	.374	-.120	-.018	.238	-.242	.090	-.227	.312	.080	-.028	.063	-.531

Strong customer commitment and presence	.646	-.289	.064	-.249	-.113	.013	.122	.038	-.006	-.140	.295	-.311
End user involvement and commitment	.633	-.106	.079	-.428	.100	.111	.328	-.132	.036	-.031	.073	-.147
Right amount of documentation	.635	-.136	-.127	-.403	-.010	.130	-.039	-.057	.136	.208	-.082	-.008
Appropriate technical training of them	.274	.543	-.074	-.172	-.172	.342	-.089	.233	.227	.300	-.178	.045
Realistic schedule	.187	.474	.066	-.233	-.013	.283	-.008	.199	.475	-.053	-.068	.165
End user client involvement and commitment	.503	.109	.316	-.279	.093	-.021	.264	-.036	.405	-.085	.042	-.042
Equipment support	.324	.505	.301	.027	-.245	-.071	.101	.079	-.112	-.184	-.100	.097
Competitor technologies	.298	.385	.527	.239	-.160	-.196	-.046	-.227	.063	-.104	-.012	-.051
Reliability of subcontractors	.390	.505	.397	.182	-.272	-.122	-.055	-.177	.009	-.103	.020	.065
Knowing client needs	.339	.449	.429	.047	.049	-.130	.108	-.038	-.079	-.096	-.099	.044
Economic standing of the organization in funding small project	.198	-.294	.396	.412	-.037	.164	-.098	-.083	.258	.119	.281	.021
Projects with no multiple independent teams	.409	-.471	.230	.233	.123	.120	-.221	-.230	.095	.183	.118	-.057
Projects upfront cost evaluation done	.525	-.242	.203	.102	.394	-.069	-.318	-.035	.109	.085	-.120	-.023
Projects with upfront risk analysis done	.412	.101	.193	.025	.387	-.091	-.445	-.005	-.165	-.078	-.322	-.170
Good performance by suppliers or contractors or consultants	.643	-.207	-.059	-.174	.010	-.154	-.089	.016	-.159	.100	-.154	.035
Effective management of risk	.502	.351	.038	-.086	.266	-.093	-.167	.182	-.352	.186	-.065	-.077
Having a clear project boundary	.491	.413	-.019	-.143	.177	-.045	.041	.210	-.236	.263	.120	.123
Identify project source	.259	.141	.116	-.026	.193	-.150	-.192	.251	-.048	.036	.661	.403

Extraction Method: Principal Component Analysis.
12 components extracted.

Table 6. 7: **Component transformation matrix**

Component Transformation Matrix

Component	1	2	3	4	5	6	7	8	9	10	11	12
1	.632	.289	.313	.315	.348	.157	.110	.178	.237	.193	.103	.163
2	-.297	.537	.424	-.246	.031	-.354	.409	-.230	-.090	.115	-.026	.122
3	.042	.604	-.556	-.180	.114	.379	.008	-.129	-.096	-.261	.201	.033
4	-.566	.185	.252	.130	-.059	.410	-.239	.402	.139	.241	.298	-.094
5	.045	-.246	.237	-.588	.483	.130	-.057	.306	-.349	-.183	.109	.149
6	.002	-.245	.273	.193	-.123	.241	.423	-.275	-.035	-.446	.519	-.174
7	.361	.101	-.029	-.243	-.516	-.274	-.095	.244	-.246	.237	.505	-.134
8	-.169	-.156	-.358	-.067	.102	-.304	.374	.348	.493	-.047	.294	.345
9	.102	-.030	-.033	-.228	-.320	.406	.572	.328	.021	.117	-.430	-.188
10	-.066	-.259	-.224	.005	.198	.212	.218	-.361	-.235	.707	.210	.129
11	.076	-.066	.183	-.235	-.425	.290	-.196	-.246	.221	-.036	-.029	.698
12	-.097	.043	-.072	.488	-.120	-.039	.140	.298	-.614	-.130	-.084	.470

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

6.3.7 Link function and the logistic model

A logistic regression model was developed that classifies any given computer networking project whether it is successful or not. It gives the probability of success which is compared when the value is greater or equal to 0.5 then the project is a success otherwise the project is a failure.

Results of the logistic regression (Table 6.2) show that the optimal variables were all significantly different from zero. This is justified by the Wald values (Column 4) that are all less than 5%. These values show the relationship between the variable and zero. The closer the values to zero the less relevant these variables are. In this case the Wald values are significantly different from zero indicating the validity of the variables obtained. In terms of the probability of each of the identified variables being important in predicting a computer networking project' success (Column 5).

The result indicates that all these variables are critical in the prediction of the success of a computer networking project. Taking our variables in the given order, the link function is:

$$\boldsymbol{g(x) = -512.243 + 235.908x_1 + 98.073x_2 + 55.293x_3 - 122.568x_4 - 171.586x_5}$$

Figure 6.3 depicts the processes represented by the link function equation and how that was used in conjunction with the developed model to predict the success of computer networking projects.

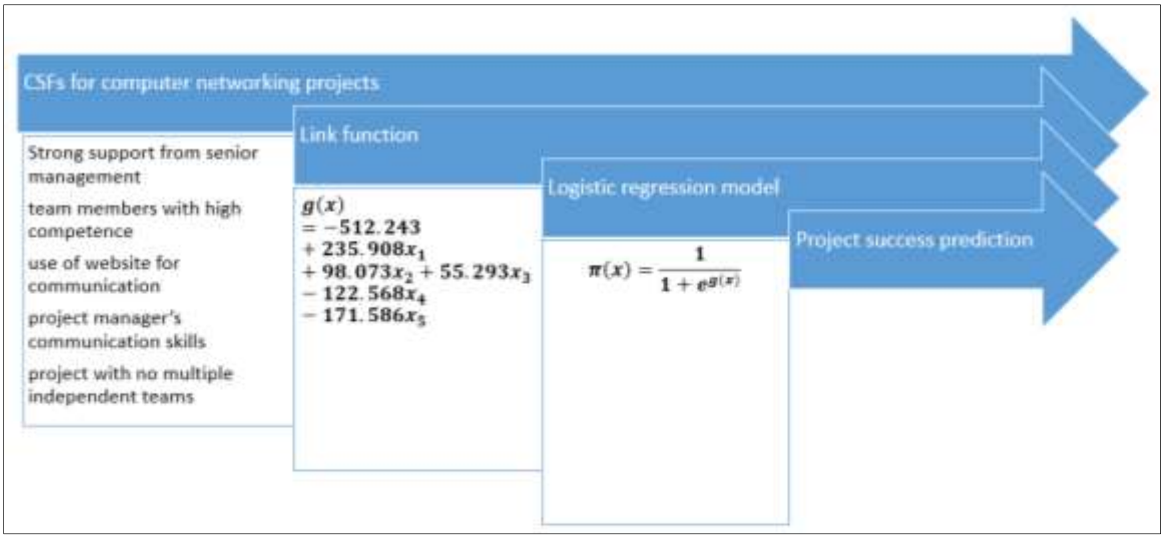


Figure 6. 3: Description of how the link function worked in the study

The link function is a mathematical function that connects the identified variables into one model that can be used in the prediction of the success of the model. From Table 6.2, the logistic model generated the five variables in the first column as significant. The second column indicates the weightings of the five variables.

The link function g(x) is given by:

$k + c_1x_1 + c_2x_2 + c_3x_3 + c_4x_4 + c_5x_5$

Where **k** is a constant

C_1 is the coefficient of variable 1 given as **x_1**

$C_2$is the coefficient of variable 2 given as **x_2** and so on.

The constant and the coefficients c_1, $c_2…c_n$ are given in column B in table 1. These values are fed into the link function to get g(x).

Meaning of the coefficients in the link function

The link function has coefficients C_1, $C_2…$ C_5 corresponding to the five CSFs for computer networking projects. Each factor has a different influence on the performance of a project. The effect differs in the direction and impact. Direction means either positive or negative and impact refers to the magnitude of the effect. A bigger negative coefficient means that the factor has a huge negative effect on the performance of the project. On the other hand a big positive value implies a huge positive effect. The signs help practitioners in knowing the direction their project would take if that factor was not carefully catered for. In the end the computed value is a function of the individual effects of these five factors.

The logistic model of determining the success or failure of a project is given by:

$$\boldsymbol{\pi(x) = \frac{1}{1 + e^{g(x)}}}$$

The value of g(x) obtained from the link function is fed into this logistic model. It is the resultant value that indicates the predicted success or failure of the project. If the resultant value of the computation is more or equal to 0.5, the project is expected to succeed. However, if the value obtained is less than 0.5, the project is likely to fail. More formerly this is shown as:

If $\pi(x) >= 0.5$ means project success

Else failure

The model above indicates that the optimal parametric model has five variables that define or classify a project's status.

The variables are Strong support from senior management, team members with high competence, use of website for communication, project manager's communication skills and project with no multiple independent teams.

Once these five critical factors are correctly rated for a specific computer networking project, the possible success or failure of the project can be predicted using the equation.

After the third stage which deals with the actual model development, simulations were run on the model and analysis and comparison of results was carried out (chapter seven).

The fourth stage is the derivations of mathematical inferences directed by the analysis and simulation of the model (chapter eight). The mathematical deductions were interpreted to make real world conclusions in this case the computation of values indicating the possible success or failure of a computer networking project. The last activity was the validation of the developed model. Validation aimed at determining the correctness and value of the model developed (chapter eight).

6.4 Chapter summary

This chapter covered the process used by the researcher to develop the logistic regression analysis model for the prediction of computer networking projects in Zimbabwe. The basis of the model was the set of CSFs derived from the survey which included the administration of an online questionnaire and the interviews carried out. The next chapter (chapter seven) presents the results of simulations done using the developed model. The model validation results shall be shown and discussed in chapter eight.

Chapter Seven: Simulation

7.1 Introduction

This chapter details the simulations which were run using the logistic regression analysis model developed in the previous chapter. A machine learning model was developed based on this logistic regression analysis model to simulate the prediction process. The machine learning model derived its input from a code that generated random integer numbers (Table 7.3) representing the weighting of each variable. The variables in this case represented the values obtainable from the item responses according to the rating of a project practitioner of the importance of each of the identified critical success factor.

The model developed and used for the simulation was based on the following link function developed:

$$\boldsymbol{g(x) = -512.243 + 235.908x_1 + 98.073x_2 + 55.293x_3 - 122.568x_4 - 171.586x_5}$$

The link function links the identified critical success factors for computer networking projects into one model to predict computer networking projects' success.

The logistic regression analysis model for predicting the success or failure of a project is given by:

$$\boldsymbol{\pi(x) = \frac{1}{1 + e^{g(x)}}}$$

The value of **g(x)** obtained from the link function was fed into this logistic regression analysis model to compute $\boldsymbol{\pi(x)}$. The resultant value indicated the predicted success or failure of the computer networking project. In the simulation, a resultant value of **1** indicated predicted success and a **0** indicated a predicted fail.

A machine learning model was developed to simulate the prediction of computer networking project success. The machine learning model was developed using Python programming language (Python version 3.6.8), Jupyter notebook platform and Tensorflow 2.0 beta 1 (machine learning major library). Python was chosen because it is a portable language that can run flawlessly on a variety of platforms such as Windows and Macintosh. Therefore, it is a portable language. It is also free and open source. Python has a large standard library. Thus, Python has powerful modules and functions useful for rapid application development.

Jupyter notebook is a tool for developing open source data science projects in different languages such as Python. It is an open source browser based software that permits code to run in a browser and it is interactive.

The following sections show the source code (Figure 7.1) used to run the simulation and the results obtained followed by a discussion of those results. The simulation was run fifty times and the results recorded in Tables 7.3 and 7.4. Table 7.3 shows the random numbers that were generated for the purposes of the simulation for 50 runs. The weighting of each critical success factor for computer networking project success was indicated as values to x1, x2, x3, x4 and x5. These values were fed into the link function as indicated in the source code (Figure 7.1). The result from the link function in each run was indicated under column g(x). The computer then computed the prediction value **($\pi(x)$).** A value of **1** indicated predicted success of the project and **0** indicated that the project was likely to fail.

```
result=[]
for i in range(50):
    result.append(table)
    #print(Array)
    #print(table)
    x_1=np.random.randint(1,6)
    x_2=np.random.randint(1,6)
    x_3=np.random.randint(1,6)
    x_4=np.random.randint(1,6)
    x_5=np.random.randint(1,6)
    cx_1 = 235.908*x_1
    cx_2 = 98.073*x_2
    cx_3 = 55.293*x_3
    cx_4 = 122.568*x_4
    cx_5 = 171.586*x_5
    g_x=-512.243+cx_1+cx_2+cx_3-cx_4-cx_5
    pi_x=1/(1+(np.exp(g_x)))
    Array=np.array([cx_1,cx_2,cx_3,cx_4,cx_5,g_x,int(pi_x)])
    table=[cx_1,cx_2,cx_3,cx_4,cx_5,g_x,int(pi_x)]
names=['x_1','x_2','x_3','x_4','x_5','g_x','pi_x']
data=pd.DataFrame(result,columns=names)
print(data)
```

Figure 7. 1: Source code for the machine learning input and output

7.2 Machine learning model description

A deep neural network binary classification model that predicts the project success or failure was developed (why and how was it chosen). The model worked in conjunction with the link function and the logistic regression analysis model. The random numbers generated by the code in Figure 7.1 were the initial input into the model. The machine learning model would then put the randomly generated weightings into the link function and the logistic regression analysis model. All these were done in the background to make the process invisible to the user. Generating random numbers eliminated the need to develop an instrument to collect computer networking project practitioners' perspectives on the CSFs for a specific project. In addition, the time to simulate was reduced to seconds.

A deep neural network has at least two hidden layers. An example of a deep neural network with an input layer in green, three hidden layers in red and an output layer in yellow is shown in Figure 7.2. Each and every neuron (node) in the preceding layer connects to each and every neuron in the proceeding layer. This is meant to exhaust all possible node permutations.

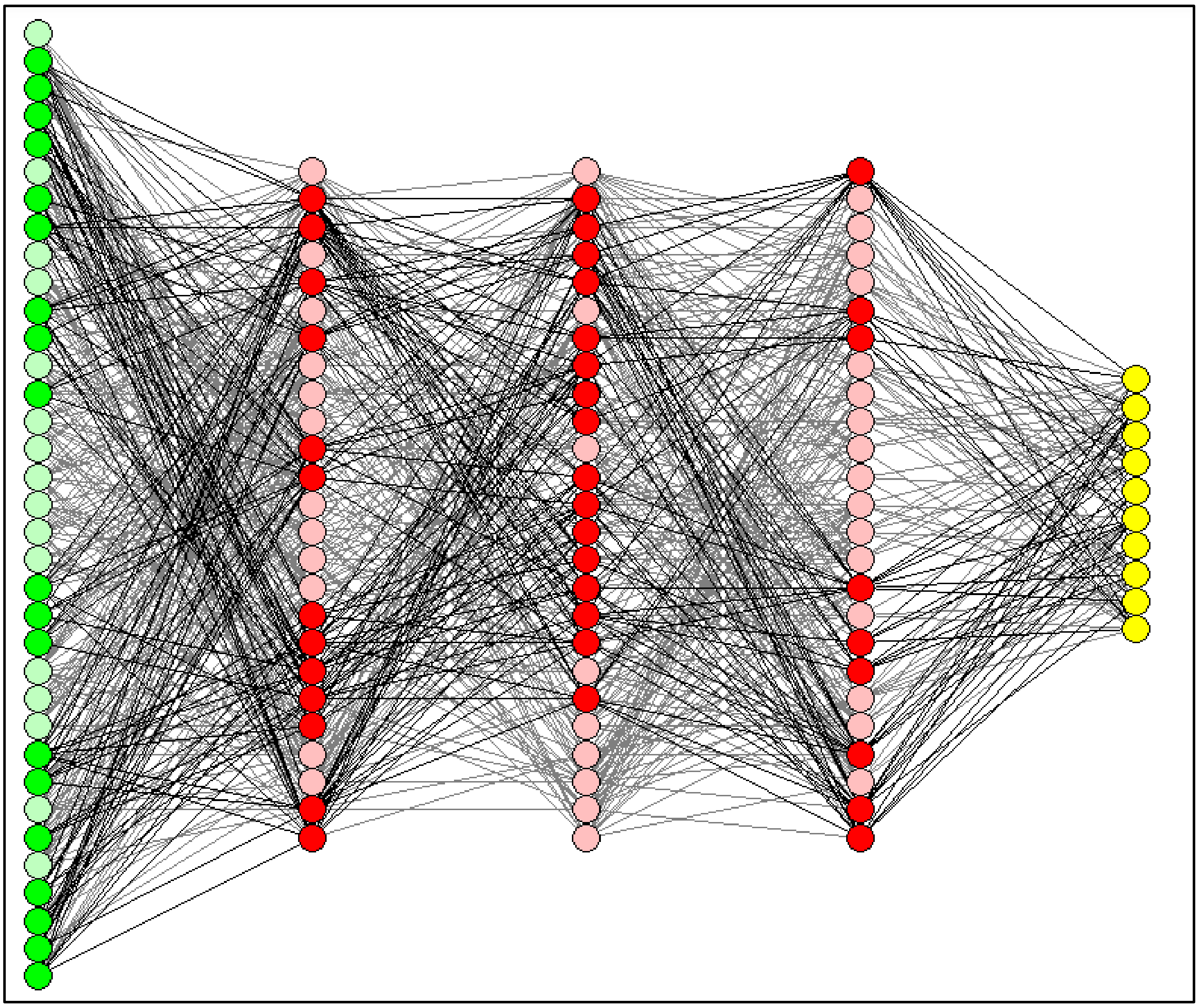


Figure 7. 2: Example of a deep neural network
(Source: Pearce (2014))

Figure 7.3 indicates the structure of a single node in a deep neural network.

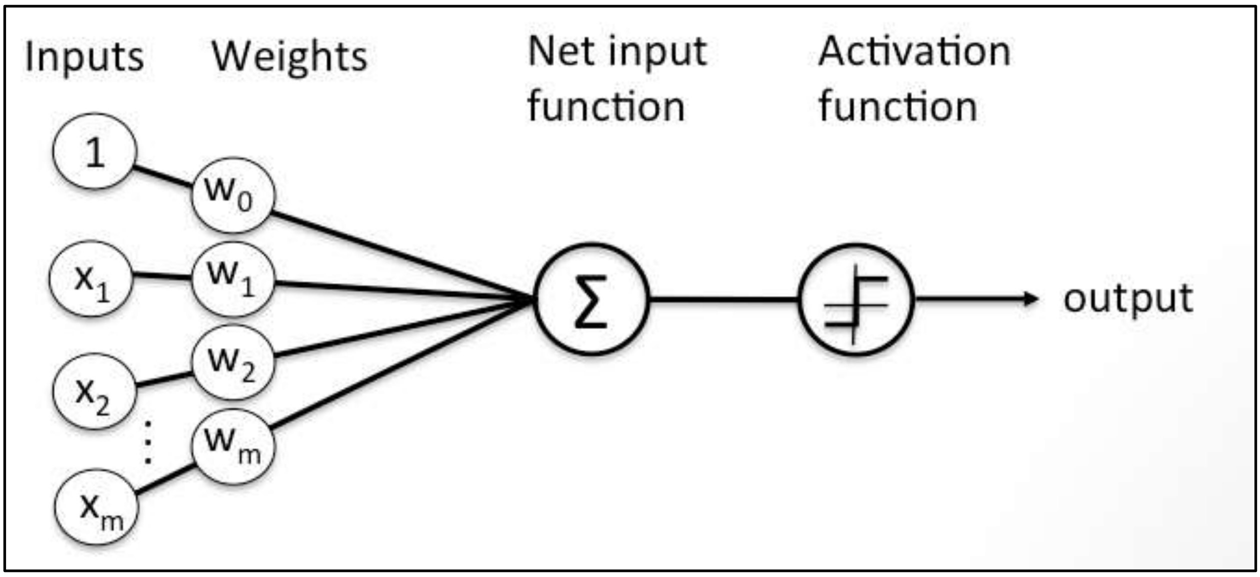


Figure 7. 3: Structure of a single neuron

The model equation is:

$Y = \sum W_iX_i + b_i$

Where:

1. Y is the Label, Output or Predicted variable
2. X_i are the Features, Inputs or Predictors (might be one or many)
3. W_i is the weight of each and every input in the model
4. b_i is the bias per each input

The model took x_1, x_2, x_3, x_4, x_5 and g(x) as inputs and produces $\boldsymbol{\pi(x)}$as the output.

The deep neural network binary classification model

The following section describes the construction of the deep neural network that was used to classify, hence predict the success or failure of a computer networking project. The layers were described, output shape and the accepted parameters. The model was sequential in nature. It accepted a total of 5837 parameters and all of them were trainable. The input layer had fifty five neurons with two hidden layers having fifty neurons each and an output layer with two neurons each taking one class that is **0** or **1**.

Building the model

```
model=Sequential()
model.add(Dense(55,input_dim=X.shape[1],activation='relu'))
model.add(Dense(50,activation='relu'))
model.add(Dense(50,activation='relu'))
model.add(Dense(2,activation='sigmoid'))
print(model.summary())
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 55)                385
_________________________________________________________________
dense_1 (Dense)              (None, 50)                2800
_________________________________________________________________
dense_2 (Dense)              (None, 50)                2550
_________________________________________________________________
dense_3 (Dense)              (None, 2)                 102
=================================================================
Total params: 5,837
Trainable params: 5,837
Non-trainable params: 0
_________________________________________________________________
None
```

7.3 Model accuracy

The model achieved an accuracy of 100% as proved below:

Model Evaluation

```
F_score=model.evaluate(X_test,y_test)
print("Model Accuracy:=","%s: %.2f%%" % (model.metrics_names[1], F_score[1]*100))
```

```
20/20 [==============================] - 0s 1ms/sample - loss: 0.0301 - accuracy: 1.0000
Model Accuracy:= accuracy: 100.00%
```

The confusion matrix of the Model (figure 7.4) also proved the accuracy of the model. It shows the number of items of the test data which were predicted correctly according to their respective classes. The matrix shows that all elements were correctly classified into their respective classes i.e. class **0** or **1.** No element from class **0** was wrongly classified into class **1**and no element from class **1** was classified as class **0**. This proves that the model has a 100% accuracy.

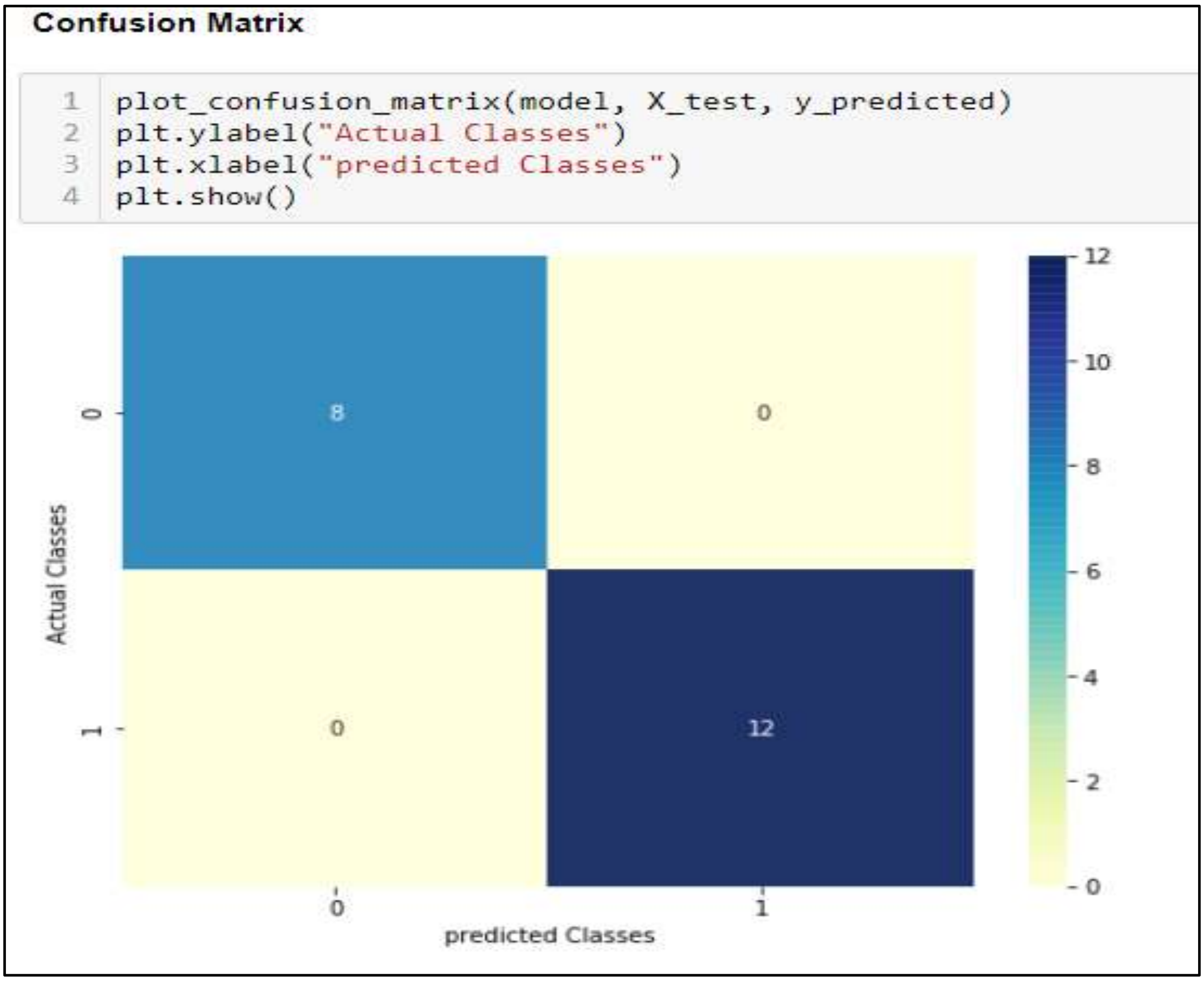


Figure 7. 4: Model confusion matrix

Out of the fifty simulation runs shown in Table 7.3, thirty one were predicted to succeed and nineteen predicted to fail. In this case, each run represents the aggregated project practitioners' responses to the questionnaire scaled items for the critical success factors for a single and specific computer networking project. Therefore, from this perspective, Table 7.3 represents prediction of the success on fifty different projects (0-49).

Furthermore, the ROC curve (Figure 7.5) measures the specificity and sensitivity of the designed model. The area under the curve of the two outcomes of the dependent variable, project success is 99.6%. The closer the value is to 1 the good the developed model is. In Table 7.1, 99.6% shows that the developed model is classifying the data correctly indicating that we can use this to classify any given project as either a success or a failure.

Table 7. 1: Area under ROC Curve

Area Under the Curve		
		Area
Project success	yes	.996
	no	.996

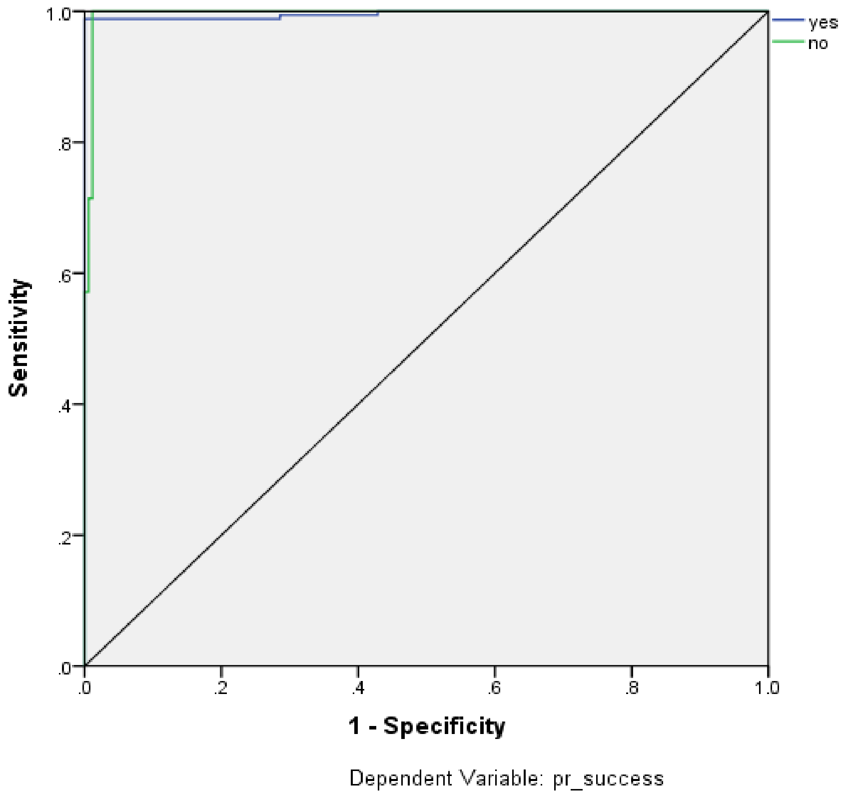


Figure 7. 5: ROC Curve

The Kolmogorov-Smirnov test (Table 7.2) was run and its results indicated that the variables chosen for the model were all significant as shown by the sig. values which are all less than 0.01.

Each method of ascertaining the correctness and validity of the regression model has its own weaknesses. The neural network method requires huge amounts of data to train. If the data is relatively small the method produces a higher value. It is also black box by nature implying that one cannot tell how the output was reached at. The ROC curve has a weakness that the actual thresholds are usually not displayed in the plot whereas the Kolmogorov-Smirnov test applies to continuous distributions and tends to be more sensitive near the centre of the distribution than at the tails. To strike a balance three different approaches were used here: the confusion matrix, ROC curve and the Kolmogorov-Smirnov test. The accuracy levels were 100% and 99.6%. It should be emphasised that the accuracy measures refer to the validity of the regression model in classifying success factors used in the prediction of project success.

Table 7. 2: One-Sample Kolmogorov-Smirnov test

		Committed management support	Clear objectives & goals	Effective communication	Effective project management skills	Team capacity/ competence
N		180	180	180	180	180
Normal parameters	Mean	320.410	3.414	169.122	17.551	0.624
	Std. dev	243.211	0.358	133.011	17.642	0.568
Most extreme differences	Absolute	0.164	0.079	0.204	0.172	0.066
	Positive	0.164	0.076	0.204	0.172	0.066
	Negative	-0.134	-0.078	-0.110	-0.167	-0.071
Kolmogorov-Smirnov		1.691	0.766	2.111	1.781	0.683
Sig. (2-tailed)		0.003	0.001	0.000	0.001	0.016

Input to the simulation

A computer code was developed that generates random numbers to represent the coefficients of the five factors critical to computer networking projects. The numbers will be used as input to the developed model via the neural network. Table 7.3 shows the various input variables (coefficients) as random numbers and the calculated values of g**(x)** and $\boldsymbol{\pi x}$. $\boldsymbol{\pi x}$ is the performance of a project of which 1 represents success and 0 failure. Each row represents a single run of the simulation. The values under columns X1 to X5 are the coefficients for each run. The simulation was run a total of fifty times as indicated in Table 7.3.

Table 7. 3: Random numbers used in the simulation

Number	X1	X2	X3	X4	X5	g(x)	$\pi(x)$
0	1179.54	490.365	276.465	367.704	343.172	723.251	0
1	943.632	490.365	55.293	245.136	514.758	217.153	0
2	235.908	490.365	276.465	490.272	686.344	-686.121	1
3	471.816	490.365	221.172	122.568	343.172	205.37	0
4	707.724	490.365	55.293	490.272	857.93	-607.063	1
5	1179.54	490.365	55.293	612.84	686.344	-86.229	1
6	1179.54	196.146	276.465	367.704	343.172	429.032	0
7	471.816	490.365	276.465	122.568	857.93	-254.095	1

8	471.816	490.365	55.293	490.272	171.586	-156.627	1
9	707.724	490.365	276.465	612.84	343.172	6.299	0
10	707.724	196.146	165.879	612.84	171.586	-226.92	1
11	1179.54	294.219	221.172	245.136	171.586	765.966	0
12	471.816	392.292	165.879	245.136	514.758	-242.15	1
13	471.816	98.073	55.293	490.272	686.344	-1063.68	1
14	1179.54	196.146	55.293	612.84	171.586	134.31	0
15	471.816	392.292	165.879	367.704	343.172	-193.132	1
16	471.816	392.292	276.465	245.136	343.172	40.022	0
17	235.908	294.219	276.465	367.704	857.93	-931.285	1
18	707.724	294.219	276.465	245.136	514.758	6.271	0
19	707.724	294.219	110.586	367.704	171.586	60.996	0
20	707.724	98.073	55.293	612.84	343.172	-607.165	1
21	235.908	294.219	110.586	612.84	514.758	-999.128	1
22	1179.54	196.146	165.879	490.272	343.172	195.878	0
23	471.816	392.292	276.465	367.704	514.758	-254.132	1
24	707.724	294.219	221.172	490.272	514.758	-294.158	1
25	943.632	98.073	165.879	122.568	343.172	229.601	0
26	235.908	392.292	55.293	245.136	171.586	-245.472	1
27	1179.54	490.365	276.465	122.568	857.93	453.629	0
28	235.908	196.146	55.293	122.568	514.758	-662.222	1
29	1179.54	392.292	110.586	367.704	514.758	287.713	0
30	235.908	98.073	276.465	490.272	686.344	-1078.41	1
31	707.724	196.146	221.172	245.136	171.586	196.077	0
32	471.816	98.073	110.586	245.136	857.93	-934.834	1
33	707.724	294.219	110.586	490.272	857.93	-747.916	1
34	471.816	392.292	165.879	367.704	857.93	-707.89	1
35	943.632	490.365	221.172	245.136	514.758	383.032	0
36	1179.54	196.146	110.586	490.272	343.172	140.585	0
37	707.724	294.219	165.879	490.272	343.172	-177.865	1
38	943.632	294.219	221.172	612.84	857.93	-523.99	1
39	707.724	392.292	110.586	122.568	686.344	-110.553	1
40	1179.54	196.146	110.586	490.272	857.93	-374.173	1
41	943.632	392.292	276.465	245.136	686.344	168.666	0
42	235.908	98.073	165.879	367.704	686.344	-1066.43	1
43	707.724	98.073	110.586	490.272	171.586	-257.718	1
44	707.724	98.073	165.879	367.704	686.344	-594.615	1
45	1179.54	98.073	110.586	122.568	857.93	-104.542	1
46	1179.54	392.292	55.293	122.568	343.172	649.142	0
47	707.724	294.219	55.293	612.84	343.172	-411.019	1
48	707.724	98.073	55.293	490.272	514.758	-656.183	1
49	235.908	196.146	221.172	367.704	857.93	-1084.65	1

Table 7.4 just like Table 7.3, indicates a set of fifty simulation runs of the logistic regression analysis model given random inputs corresponding to weights of the computer networking projects' CSFs. In the second set of simulation runs, thirty were predicted as successful and twenty as unsuccessful. The simulations were sufficient to prove that the developed model can predict the success of a computer networking project in its early stages. The smaller set of CSFs is the only one needed to predict the success of the project even though a lot more factors need to be considered during the project process.

Table 7. 4: Second set of fifty simulation runs

	x_1	x_2	x_3	x_4	x_5	G(x)	Pi(x)
1	471.816	294.219	110.586	245.136	343.172	-223.930	1
2	235.908	490.365	221.172	490.272	514.758	-569.828	1
3	471.816	490.365	276.465	122.568	686.344	-82.509	1
4	707.724	98.073	221.172	245.136	514.758	-245.168	1
5	707.724	490.365	55.293	612.840	514.758	-386.459	1
6	707.724	196.146	110.586	612.840	514.758	-625.385	1
7	943.632	490.365	276.465	245.136	686.344	266.739	0
8	471.816	294.219	165.879	245.136	686.344	-511.809	1
9	707.724	196.146	221.172	367.704	857.930	-612.835	1
10	943.632	294.219	55.293	245.136	686.344	-150.579	1
11	471.816	196.146	221.172	245.136	343.172	-211.417	1
12	235.908	490.365	221.172	612.840	343.172	-520.810	1
13	235.908	490.365	55.293	122.568	857.930	-711.175	1

	x_1	x_2	x_3	x_4	x_5	G(x)	Pi(x)
14	707.724	98.073	276.465	245.136	857.930	-533.047	1
15	943.632	196.146	110.586	612.840	171.586	-46.305	1
16	707.724	196.146	221.172	612.840	171.586	-171.627	1
17	471.816	392.292	221.172	612.840	343.172	-382.975	1
18	471.816	196.146	110.586	122.568	514.758	-371.021	1
19	943.632	392.292	276.465	245.136	171.586	683.424	0
20	943.632	98.073	276.465	245.136	514.758	46.033	0
21	1179.540	98.073	110.586	122.568	171.586	581.802	0
22	235.908	196.146	221.172	245.136	686.344	-790.497	1
23	1179.540	490.365	221.172	612.840	857.930	-91.936	1
24	471.816	294.219	110.586	122.568	857.930	-616.120	1
25	471.816	196.146	165.879	612.840	343.172	-634.414	1
26	943.632	98.073	110.586	612.840	686.344	-659.136	1
27	943.632	294.219	221.172	367.704	514.758	64.318	0
28	1179.540	294.219	55.293	245.136	171.586	600.087	0
29	235.908	392.292	55.293	490.272	857.930	-1176.952	1
30	943.632	490.365	165.879	490.272	514.758	82.603	0
31	1179.540	196.146	110.586	367.704	857.930	-251.605	1
32	943.632	98.073	221.172	122.568	514.758	113.308	0

	x_1	x_2	x_3	x_4	x_5	G(x)	Pi(x)
33	943.632	392.292	165.879	367.704	857.930	-236.074	1
34	235.908	294.219	276.465	490.272	857.930	-1053.853	1
35	1179.540	98.073	165.879	122.568	171.586	637.095	0
36	707.724	392.292	221.172	367.704	514.758	-73.517	1
37	943.632	392.292	276.465	122.568	686.344	291.234	0
38	943.632	392.292	276.465	245.136	343.172	511.838	0
39	943.632	196.146	165.879	490.272	686.344	-383.202	1
40	707.724	98.073	55.293	245.136	171.586	-67.875	1
41	1179.540	196.146	165.879	245.136	514.758	269.428	0
42	1179.540	490.365	110.586	122.568	857.930	287.750	0
43	471.816	98.073	276.465	612.840	514.758	-793.487	1
44	235.908	98.073	165.879	122.568	686.344	-821.295	1
45	943.632	98.073	110.586	612.840	857.930	-830.722	1
46	943.632	294.219	221.172	245.136	857.930	-156.286	1
47	235.908	294.219	55.293	612.840	343.172	-882.835	1
48	1179.540	98.073	165.879	612.840	686.344	-367.935	1
49	707.724	98.073	165.879	367.704	514.758	-423.029	1
50	707.724	490.365	110.586	612.840	343.172	-159.580	1

7.4 Application of the developed logistic regression analysis model to real life projects

The logistic regression analysis developed in this research was applied to sixteen real life computer networking projects in Zimbabwe. The projects were selected from renowned organisations. The idea was to put the developed model to test. The researcher asked project practitioners and managers working or who worked on a computer networking project to give their ratings on the five factors pertaining to the project in question (the factors corresponded to the computer networking projects' CSFs). The practitioners were given a questionnaire such as the one in Table 7.3 and were requested to complete it.

The organisations and respondents for the questionnaire administered to collect data that produced critical success factors for computer networking projects were different from those used in this section. The reason was to reduce bias. In the identified real life projects, an attempt was made to include as many stakeholders as were possible. The sixteen projects were all from the four selected organisations.

The stakeholders who gave the success ratings were the project managers, sponsors and the clients. These were selected to cater for different perspectives identified in this research. These pointed to project success depending on who is rating. Usually the project manager is interested in the process of developing an artefact, the sponsor looks at budgetary compliance whilst the client may be interested in the value generated by the artefact. Considering these stakeholders could balance the scale on the rating of success. All the projects considered were either completed or abandoned. The status of the projects were confirmed as success or failure from the stakeholders.

The model though based on four companies only can be used to predict the success of computer network project from other companies. This is because the selected companies were among the most contracted and established ones in the country. The organisations carryout networking projects for many private and public organisations locally. It is important to note that the model is based on CSFs for computer networking projects hence can only predict with confidence the success of that type of project. By design it was not meant to be generic.

The following was the short questionnaire given to the project stakeholders:

Rate each of the following factors as you see them in your networking project, indicate your response with a tick (√).

Table 7. 5: Short questionnaire for collecting model input

Code	Factor	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
x_1	strong support from senior management					
X_2	Competent team					
X_3	use of website for communication					
X_4	project manager's communication skills					
X_5	project with no multiple independent teams					

The five factors were coded X_1 to X_5 for ease of use in the model. When analysing the responses from the project practitioners, the researcher entered values as follows:
Strongly disagree = 1, disagree =2, not sure = 0, agree = 3, strongly agree = 4.

Data was collected from sixteen different computer networking projects. For the purposes of the research, these were simply referred to as project one, project two and so on. Responses from the different projects were coded using the criteria above. Table 7.6 shows the coded results for project one as an example. The responses for all the sixteen projects were coded in the same way. At this point the researcher dealt with real projects, therefore, the model was run as many times as the number of respondents from that project. As an example, project one had 19 responses whereas project two had eighteen. Responses from questionnaires were used in the model to produce the values of g(x) in the link function developed earlier and $\boldsymbol{\pi}(\boldsymbol{x})$from the logistic regression analysis model to predict the success of the project. Table 7.6 indicates how the data was coded before feeding it into the model for prediction. Figure 7.6 shows the computer code that uses the coded data to produce a prediction.

Table 7. 6: Coded responses from project one

Respondent	x_1	x_2	x_3	x_4	x_5
1	4	4	4	2	3
2	4	3	3	4	2
3	4	4	4	4	4
4	4	2	4	3	3
5	4	3	3	4	3
6	4	4	3	3	3
7	4	4	3	3	2
8	4	3	3	3	3
9	4	4	3	4	3
10	4	4	3	4	2
11	4	4	4	4	4
12	4	4	4	3	3
13	4	4	3	3	4
14	4	4	4	3	3
15	4	3	3	3	3
16	3	4	3	3	3
17	4	3	3	4	4
18	4	2	3	3	3
19	3	3	3	3	3

creating a function that creates a dataframe of cx_1,cx_2,cx_3,cx_4,cx_5,g_x and pi_x for each project's responses:

- g_x = -512.243+943.632x_1 + 392.292x_2 + 221.172x_3 - 245.136x_4 - 514.758x_5
- pi_x = 1/(1+(np.exp(g_x)))

```
In [5]: def create_dataframe(project_x_responses):
            data = pd.DataFrame()
            data["cx_1"] = project_x_responses.x_1 * 235.908
            data["cx_2"] = project_x_responses.x_2 * 98.073
            data["cx_3"] = project_x_responses.x_3 * 55.293
            data["cx_4"] = project_x_responses.x_4 * 122.568
            data["cx_5"] = project_x_responses.x_5 * 171.586
            data["g_x"] = -512.243+data.cx_1+data.cx_2+data.cx_3-data.cx_4-data.cx_5
            data["pi_x"] = 1/(1+(np.exp(data.g_x)))
            data.pi_x = data.pi_x.astype(int)

            return data
```

Figure 7. 6: Computer code

The model prediction results were aggregated into Table 7.7. After data for each project was fed into the model a percentage score for possible success was calculated. The individual projects were treated independently. The project number, number of responses per project and percentage prediction were consolidated into Table 7.7.

Table 7. 7: Model prediction of real life projects

Project	No. of respondents	% Predicted successful
1	19	47.6
2	18	55.6
3	16	87.5
4	20	50.0
5	19	31.5
6	18	38.9
7	20	20.0
8	20	45
9	18	61
10	20	65
11	19	15.8
12	20	40
13	19	52
14	18	50
15	18	38.9
16	20	50

Table 7. 8: Model prediction summary

Project number	**Actual status**	**Model prediction**
1	S	F
2	S	S
3	F	S
4	S	S
5	F	F
6	F	F
7	F	F
8	F	F
9	S	S
10	S	S
11	F	F
12	S	F
13	S	S
14	F	S
15	S	F
16	F	S
Correct prediction	62.5%	

The developed model successfully predicted 62.5% of the projects studied. The level of model accuracy is above average meaning that computer networking project practitioners can use the model to predict the possible success of computer networking project having considered the five CSFs. However, in four of the cases the model prediction was marginal. This was the case of 47.6%, 45% and 50% chances of success. Such projects should be treated with caution since any slight change in the conditions may shift the project performance either way. The project manager can study the coded responses to see which of the factors have unfavourable scores and try to address them. Once this is done genuinely the project performance can easily be improved. As an example, if the respondents indicated that communication is poor in the project, the manager may need to craft ways of improving communication among the team members. The final effect is ensuring that the project succeeds thereby putting the organisational resources to beneficial use.

However, successful average prediction of 62.5% means there are approximately 37% chances that the prediction may inaccurately predict the project outcome. The practitioners should use the model as a complementary tool in managing projects. The model is the only such attempt in predicting the success of computer networking projects in the country to the best knowledge of the researcher.

Discriminant analysis

The fact that the model correctly predicted an average of 62.5% of the projects motivated the researcher to apply discriminant analysis to further test the model strength. This was applied to real world project data to determine whether the binary value assumption for project success was meaningful. Results reported include the ‘Test for equality’, the ‘Box’s M test and the classification results table.

The test for equality Table 7.9 shows how significant the critical values in predicting the outcome. The column of note is the **sig.** whose values in this case were all less than 0.01 indicating that all the five variables are significant. Table 7.10 shows results of the Box’s M test which produced an overall **sig.** value for the five variables. The overall value was 0.000 indicating that they were all significant. In such case, the researcher proceeded with discriminant analysis.

Table 7. 9: Test for equality table

Variable name	Wilk's Lambda	Frequency	df1	df2	Sig.
Committed management support	0.622	14.01	1	32	0.000
Clear objectives and goals	0.761	7.523	1	32	0.001
Effective communication	0.811	1.614	1	32	0.002
Effective project management skills	0.724	1.722	1	32	0.001
Team capacity/competence	0.689	6.321	1	32	0.000

Table 7. 10: Box's M test results

Box's M	41.893
f approx.	2.110
df1	32.000
df2	847.134
Sig.	0.000

The sig. value of 0.000 is less than 0.001 indicating that the identified variables had unequal variances. In such as a case the researcher proceeded to perform the discriminant analysis. The results of the discriminant analysis were summarised in Table 7.11. Results show that when the identified variables were to be used in the prediction model, the model is capable of predicting approximately 88% of successful computer networking projects and 85% of failed projects. This result indicates that the factors identified have high influence to the success of a networking project and the model satisfactorily predicts the success of computer network projects.

Table 7. 11: Classification results

			Predicted project outcome			Total
				Fail (0.00)	Success(1.00)	
Original	Count	0.00		32	7	39
		1.00		10	150	160
	%	0.00		89.9	10.1	100.0
		1.00		7.8	92.2	100.0
Cross validated	Count	0.00		30	9	39
		1.00		14	146	160
	%	0.00		85.7	14.3	100
		1.00		11.9	88.1	100

7.5 Chapter summary

The logistic regression analysis model developed in this research was tested through computer simulations. The folder containing the source code, the system requirements and other important details can be accessed at:

https://www.dropbox.com/sh/4g4676nlmg0efg4/AABv1FC1nhQxT83zywUpWq0fa?dl=0

The reason behind simulating the model was to reduce time of testing the model. Instead of developing a data collection instrument, validating and using it, the researcher simply developed a computer program that generated values that could possibly be given by respondents. These values were fed into the developed logistic regression analysis model. A machine learning model was also developed for the simulation of the computer networking project success. In the final analysis, the model proved successful in predicting the success of a project given the practitioners' perspectives and knowledge about the factors critical to the success of computer networking project. The researcher went on to use only the five CSFs to gather project information on sixteen real projects. The responses were coded and fed into the model to predict the project success. The model correctly predicted 62.5% of the projects.

Chapter Eight: Evaluation of the research

8.0 Introduction

In this chapter the researcher critically evaluates the research and discusses in detail how the research achieved what it was meant to accomplish. The researcher evaluated the research study by providing an analysis of the achievement of the stated objectives. The researcher picked unique contributions of the study to knowledge, theory and practice in project management. In addition, the chapter provides an analysis of the way various research methodologies, philosophies and methods were uniquely combined in the study. Strengths and weaknesses of the developed model are also included in the chapter. Lastly the recommendations and future directions from the study were covered.

8.1 Research aim

The aim of the research was to construct a logistic regression analysis model to predict the success of computer networking projects in Zimbabwe. A logistic regression analysis model to predict the success of computer networking projects in Zimbabwe was successfully developed, tested, evaluated and applied.

8.2 Achievement of research objectives

Objective 1

To develop a framework for determining computer networking projects' CSFs in Zimbabwe. The objective was implemented in a unique three stage process of meta-synthesis analysis of literature, questionnaire administration and follow up interviews. The questionnaire responses were analysed using SPSS version 23.0 and the interviews by NVivo version 10.0.

This objective was successfully achieved through the application of the unique three stage process of meta-synthesis analysis, questionnaire and interview. This approach was unique in the sense that no single set of critical success factors was found in literature that was developed through that method. Meta-synthesis analysis of literature was used to determine CSFs for ICT projects in general. The questionnaire administration followed by the interviews produced data that was analysed to determine CSFs for ICT projects and computer networking projects in Zimbabwe.

CSFs for ICT projects in general obtained from the qualitative meta-synthesis analysis were:

1. Committed management support & sponsorship

2. Clear objectives & goals
3. Effective communication in the project
4. Effective project management skills/methods
5. Team capability or competence
6. User involvement.

CSFs for ICT projects in Zimbabwe obtained from the questionnaire and interviews were:

1. Committed management support and sponsorship.
2. Clear objectives and goals (project size complexity, project uniqueness and competitor technologies)
3. Effective communication in the project (direct communication)
4. Effective project management skills/methods (strong detailed planning, considering and appreciating multiple viewpoints, rigorous refactoring activities, projects with dynamic accelerated schedule, flexible approach to change, sound basis for project, realistic schedule, appreciating effect of human error, effective leadership conflict resolution and projects with upfront risk analysis done)
5. Team capability/competence (training provision and coherent self-organising team).

CSFs for computer networking projects in Zimbabwe identified through the interviews were:

1. Strong support from senior management
2. Committed sponsor
3. Adequate budget
4. Project goals awareness
5. Having a clear project boundary
6. Knowing client needs
7. Oneness of the project team
8. Competent team
9. Solid team.

The last two sets of CSFs were unique since no such research was ever done in Zimbabwe. Before this study was carried out, there was no literature on ICT projects' CSFs in Zimbabwe. Literature reports on CSFs for ICT projects in other countries with examples including South Africa, Egypt, Malaysia and other developed countries. As a result, this study is an important step in the study of ICT projects' CSFs in Zimbabwe.

Objective 2

Explore suitable designs and important mathematical modelling and simulation techniques useful in developing a logistic regression analysis model for the prediction of computer networking projects success in Zimbabwe. This objective was implemented through studying literature on mathematical modelling techniques and principles which included text books and journals.

The researcher discovered several alternatives for developing a mathematical model to predict computer networking projects' success. The alternatives included stochastic, deterministic, mechanistic, analytic, discrete, continuous, statistical modelling approaches. Each of these modelling techniques is applicable in a variety of situations in relation to the type of research through the nature of the research questions and objectives. Different alternative model development approaches have different benefits to the model under development.

In this study the researcher uniquely combined the stochastic, statistical, mechanistic and analytical approaches in developing the logistic regression analysis model to predict computer networking projects' success.

Objective 3

Develop a mathematical model to predict the success of computer networking projects in Zimbabwe. The objective was implemented using logistic regression analysis.

A unique logistic regression analysis model was successfully developed for the prediction of computer networking projects in Zimbabwe. The model was the main artefact of this research study. The model is the first of its kind in literature and in Zimbabwe in particular. No mathematical model was found in literature for the prediction of computer networking project success. The process used to develop the model was unique in its own right.
It was a unique three stage process of meta-synthesis analysis of literature, questionnaire and interview. The final product of that process was a set of CSFs for computer networking projects in Zimbabwe that correspond to the variables in the link function. Logistic regression analysis was used to develop both the link function and the corresponding model to predict the project success/failure from the identified CSFs. The modelling techniques applied were uniquely combined and comprised stochastic, statistical, mechanistic and analytical approaches.

The developed link function:

$$g(x) = -512.243 + 235.908x_1 + 98.073x_2 + 55.293x_3 - 122.568x_4 - 171.586x_5$$

The logistic regression model developed:

$$\pi(x) = \frac{1}{1 + e^{g(x)}}$$

Logistic regression had the benefit of it being binary outcome based. The result of a binary outcome statistical analysis is one of two possible outcomes. The outcome is always one of the two possible values. In this case the two outcomes were the success and the failure of the computer networking project.

To use the model to predict the success/failure of a computer networking project, the user needs to follow very few steps. The first step is to identify key participants and stakeholders in the project team. A short questionnaire whose questions are Likert scale items is administered to the selected stakeholders. Step two is the coding of the responses in the same way as with SPSS. Step three is to feed the coded values into the model through the link function. The link function feeds into the logistic regression analysis model. The values from the model indicate success by a one and failure by a zero. The prediction minimises the wastage of resources on projects that have a high probability of failure. The model can be run at any stage in the project process and as many times as one wishes. This great flexibility enables the project team to persistently check on the direction taken by a project through reviews. The developed model thus enhances project monitoring and review.

Objective 4

Test and evaluate the logistic regression analysis model developed to predict the success of computer networking projects. The objective was achieved through the application of a deep neural network model developed using Python programming language and Jupyter Notebook. The system was provided with data collected from live computer networking projects using a short questionnaire. The responses corresponded to variables in the link function equation and the logistic regression model used to predict the success of the project. The use of a deep neural network enabled the researcher to simulate and experiment with the developed model without the need to expend a lot of resources. Python had the benefit of being a portable and cross platform programming language. Jupyter Notebook had the advantage of it being web-based and it allows all developed files to be accessible via a website page.

The uniqueness in the testing and evaluation of the model was in the use of a deep neural network that is capable of being trained and then used to make predictions based on the training.

8.3 Methodological contribution evaluation

The aim of this research from a methodology perspective was to apply logistic regression analysis to develop a model to predict computer networking projects' success in Zimbabwe. This could only be possible after the researcher had captured the views and perceptions of networking project practitioners in Zimbabwe. Literature was consulted to provide a concrete foundation for determining these views and perceptions. The researcher accordingly decided on a unique three stage process of meta-synthesis analysis of literature, questionnaire and interview for this purpose. A meta-synthesis analysis of literature was carried out to identify ICT projects' CSFs in general. A questionnaire was developed and administered based on the CSFs from the analysis. Follow-up interviews were carried out to provide more insights on the CSFs from project practitioners in Zimbabwe. The product was a set of CSFs for ICT projects in Zimbabwe and a set of CSFs for Computer networking projects in Zimbabwe. Logistic regression analysis was applied onto the CSFs to develop the model to predict the success of computer networking projects. The model was tested and validated using a deep neural network. Python and Jupyter Notebook were used for this purpose.

8.3.1 Research Design

The overall design of the study was largely exploratory in nature. This type of design is suitable where the research problem has a few or no earlier studies to rely on to predict the outcome (De Vaus 2001). There was no literature on CSFs for ICT projects and computer networking projects in Zimbabwe. The researcher could minimally rely on the CSFs for ICT projects in general that were abound in literature. An exploratory design enabled the researcher to generate new ideas and assumptions about CSFs for ICT projects and computer networking projects in Zimbabwe (De Vaus 2011). In addition, the researcher developed a tentative theory in the form of a logistic regression analysis model to predict the success of computer networking projects.

Every research has to follow a certain paradigm which is a school of thought that provides the researcher's view of the world (Chilisa & Kawulich 2015). It is an abstract window through which the researcher views the methodological constructs to determine the research methods to be used in the study. In as much as each research paradigm has its own research methods, the researcher can adopt research methods that uses ideas from different research paradigms depending on the type of the research questions (Ignou 2005).

This research used two paradigms and a unique combination of research methods. The Critical theory and the interpretive paradigms were used. The methods used were qualitative meta-synthesis, questionnaire, interview and logistic regression analysis. These methods were applied in that order making it a unique three stage process of data collection. The critical theory paradigm normally shows the relationship between ideas and theoretical positions and their social environment. It attempts to contextualise/historicise ideas in terms of their origins within social processes.

In this study, the researcher followed the critical theory paradigm to get ideas on CSFs for ICT projects and computer networking projects from project practitioners in Zimbabwe. The CSFs for ICT projects obtained from literature through meta-synthesis analysis were considered theoretical positions in this study. As such, the study explored the relationship between those CSFs for ICT projects from literature and those obtained in Zimbabwe. Zimbabwe was the social environment in which these factors interplayed. Purposive sampling, open-ended interviews, open-ended questionnaire items used in this research are all supportive of the Critical theory paradigm.

The Interpretive paradigm is similar to the Critical theory paradigm. In the Interpretive paradigm the truth is based on the participants' perception of reality. Its aim is to gain insights into complex social relationships forming particular environments resulting in better appreciation of realities by those involved. Emphasis is placed on the individuals' understanding and meanings they assign to phenomena. For that reason, there is no predefinition of dependent and independent variables. Research thus precedes theory (Jha 2017) in the sense that it is from the researched data that theory is constructed.

In this study, data about CSFs for computer networking projects in Zimbabwe was first collected, analysed and later used to develop the logistic regression analysis model to predict project success. At the start of the research there were no CSFs for neither ICT projects nor computer networking projects in Zimbabwe. Data was collected through the unique three stage process (meta-synthesis analysis, questionnaire and interview). The data was analysed using SPSS version 23.0 and Nvivo version 10.0. The three stage process enabled the researcher to get data from as many primary and secondary sources as possible. The result of the analysis was CSFs for ICT projects and CSFs for computer networking projects in Zimbabwe. The CSFs for computer networking projects were used to develop the logistic regression analysis model to predict computer networking projects' success which was the main purpose of this study. This explains why the researcher chose to use the interpretive paradigm in conjunction with the critical theory.

The research employed both qualitative and quantitative research approaches since different stages of the research required a different method. Qualitative research approach (meta-synthesis) was used to explore and discover CSFs for ICT projects in Zimbabwe (Kumar 2011). The first stage of the three stage process (meta-synthesis), thus was qualitative whilst the second and third stages were quantitative. The responses from the questionnaire were quantitatively analysed using SPSS and those from the interviews were analysed quantitatively as well. In the third stage NVivo was used for the analysis. Corresponding research designs used were the Grounded theory and Phenomenology (Chilisa & Kawulich 2015). The Grounded theory focused on developing an understanding of the CSFs for ICT projects and computer networking projects for the researcher to develop a logistic regression analysis model from the CSFs determined. This was implemented through meta-synthesis analysis of literature, interviews and questionnaire administration. The model was used to predict the success of computer networking projects.

Phenomenology design enabled the researcher to study ICT project practitioners' experience in the management of CSFs for ICT and computer networking projects through the interview method. The researcher designed the interview and developed the interview question so that they suit the Phenomenology research design. The reason of doing so was to enable the computer networking project practitioners to expose their experiential knowledge. This knowledge was critical in the formulation and understanding of critical success factors for both ICT projects and computer networking projects in Zimbabwe.

The three stage procedure of data collection led to the unique combination of the Grounded theory and phenomenology research designs in one study. The combination produced comprehensive sets of CSFs, one for ICT projects in general and the other for computer networking projects in Zimbabwe.

8.3.2 Model development

There exist many different ways of constructing models. The researcher carefully chose and applied different constructs and dimensions in a unique and productive way. The logistic regression analysis model developed is a stochastic and analytic model that provides an understanding of the project process in terms of cause and effect of CSFs on the success of the project. The model was largely empirical or statistical in the sense that it did not take into account the mechanisms by which changes to the CSFs occurred but only quantitatively accounted for changes related to different conditions of the CSFs (Marion 2008; Bokil 2009).

Stochastic models focus on the probability that an individual makes the transition from one state to the other. In this case the model (stochastically) focused on how the project progressed from one stage to the next over time, thereby enhancing project monitoring and control. The probability of a project to succeed was the measure of interest.

The approach to the development of the model chosen was unique because of the way stochastic, analytic, mechanistic and empirical characteristics were infused into one model. Hence, the model was powerful since its impact was a function of these four.

8.3.3 Testing and evaluation of the model

Testing and evaluation of the developed model was not done using the usual simulation software such as Matlab or Arena. Rather, it was done through a machine learning model developed using Python programming language version 3.6.8 on the Jupyter Notebook platform. Python's major strength was its being a cross platform and portable language capable of running on many platforms e.g. Windows and Macintosh. Both Python and Jupiter Notebook are open source and flexible. In addition, Jupyter Notebook is a browser –based application that enables code to run in a browser interactively. The platforms chosen enhanced easier development of the testing environment and enabled the researcher to make the developed logistic regression analysis model and its test cases available to readers. Readers can access the tests and evaluations done on the model online. The machine learning model was a deep neural network binary classification one.

With a stochastic model, one can continuously simulate outcomes using generated random numbers and unite many simulations to estimate the dispersion of outcomes (Marion 2008). Part of the machine learning model generated random numbers representing user responses relating to CSFs for a computer networking project. The unique idea was to enable the researcher to run the simulation conveniently without the need for a lot of time and money. The number of instances the model simulation is run is determined by the user via the Python code. The generated random numbers were the weightings of the coefficients in the link function. The model accuracy was 100%. The simulation was run a hundred times in two batches of fifty each. In the first set of fifty runs thirty-one out of fifty were predicted successful and nineteen out of fifty unsuccessful. In the second set of fifty runs thirty were successful and twenty were unsuccessful. The model performance was impressive from the simulations made.

Once the model has been developed, it has to be tested against observations from the physical system it represents (Marion 2008). Against this background, on evaluation of the logistic regression analysis model, data was collected from computer networking project practitioners from sixteen different computer networking projects in Zimbabwe. The data was coded and fed into the deep neural network model. Correct predictions were 62.5%. Marginal predictions were obtained in only four cases out of sixteen projects studied. The project managers in such cases need to use their experience and local conditions to choose the direction of action for the project. A project whose possible success is predicted to be say fifty percent can go either way in the event of a slight change in the project conditions.

The evaluation thus proved that the logistic regression analysis model developed was unique and can be relied upon to predict the success of computer networking projects in Zimbabwe.

Strengths of the developed model

The model that was developed had the following strengths:

1. The model can predict the success of computer networking projects with a success rate of 62.5%.
2. The logistic regression analysis model is easy to use since an associated computer code with a read me file is given. The users simply install the relevant software and use the

given source code to run the model. The software needed is open source so it is cheap to run.

3. The model is comprehensive because it was developed from a variety of paradigms, designs approaches and methods. The model thus benefits from the strengths of each of the ingredient components.
4. By using Jupiter Notebook in the model development, users can access the model online through the Web interactively.

Threats to validity analysis

The research, though it was largely successful, had its own weaknesses. The following were a few weaknesses of the developed logistic regression analysis model developed:

1. Zimbabwe has a total of ten provinces of which the interviews were done only in three of the provinces: Harare, Mashonaland West and Mashonaland Central. Different results could be produced if all the ten provinces were considered.
2. The researcher assumed that all project practitioners and their management involved in the research had a common understanding of project success. Though due diligence was employed in a bid to get honest responses, it could not be ruled out that some respondents could be biased due to their respective roles in the project. In addition, the research focused only on critical factors for success leaving out failure factors.
3. The research was conducted in Zimbabwe, which is a developing country, so the results are not representative of the situation in all developing countries. It was carried out during the time the country was experiencing political and economic challenges. This could have impacted on the circumstances surrounding the organisations involved in computer networking projects and their client organisations. Inflation was high with many employed people having their salaries reduced to almost nothing. All items for human livelihood were expensive and beyond the reach for many people in the country. Some respondents were disgruntled and their responses could have been biased.
4. The developed logistic regression analysis model gave some predictions that were marginal. Such predictions leave decision makers with only one option of using their personal and professional judgements to map the way forward.

8.3.4 Contribution to the discourse on current matters

Literature is full of research findings on CSFs for ICT projects. All the researches were carried out in other countries but not in Zimbabwe. Despite the fact that no research on CSFs for ICT projects was done in Zimbabwe, no research was found in literature that focuses on computer networking projects. To improve on the success rates of the projects, there is need to foretell their potential success or failure. Therefore, this research provided the first CSF frameworks for ICT projects in Zimbabwe and computer networking projects in Zimbabwe. It also provides a model to predict the success of computer networking projects.

Zimbabwe is currently finalising its national digitalisation programme which thrives on hyper connectivity. This programme is predominantly anchored on computer networking projects. Thus, this research is both relevant and timeous.

8.3.5 Research's unique contribution to the body of knowledge

The major and unique contributions made by this research include:

1. The research produced a list of ICT projects' CSFs in general that was obtained through qualitative meta-synthesis analysis of literature. Though much research on ICT projects' CSFs has previously been carried out in other parts of the world, this research produced an ample list of CSFs through a unique method of meta-synthesis analysis of literature. The uniqueness was enhanced by the fact that literature analysed came from research across the globe.
2. A list of ICT projects' CSFs in Zimbabwe was developed from the analysis of questionnaire and interviews results. This was the first list of determined critical success factors for ICT projects to be produced for Zimbabwe.
3. A list of computer networking projects' CSFs in Zimbabwe that were identified through the analysis of questionnaire and interview results was produced. This list was unique in two ways: first it was the first time a research was conducted for computer networking projects in literature. Secondly, it was the first time that this type of research was done in the Zimbabwean context.
4. The major contribution of the study was the construction of a logistic regression analysis model to predict the success of computer networking projects in Zimbabwe. This model was the first of its kind in many ways. First, there were no models to predict the success of computer networking projects before. Second, the model was

developed from critical success factors determined from a unique three stage process (meta-synthesis analysis, questionnaire and interview) of data collection. Third, the research approach and design uniquely combined the critical theory and interpretive paradigms and different model design approaches (stochastic, analytical, mechanistic and statistical) to produce the prediction model.

8.3.6 Recommendations

In the light of the findings of this research study, the following recommendations were made:

Computer networking projects are different from other ICT projects hence project managers should not apply generic principles e.g. CSFs to all ICT projects. There is no one size fits all set of CSFs for ICT projects. Research into CSFs has to apply to specific types of ICT projects.

Computer networking project practitioners in Zimbabwe need to apply CSFs contextually. The CSFs for computer networking projects established in this research are a good starting point. CSFs for ICT projects should be used carefully, taking into consideration the context e.g. country. This research study produced a set of CSFs for ICT projects in Zimbabwe.

Predicting the success of a project is critical if resources are to be conserved by not committing and using them on projects that have very low potential of succeeding. The logistic regression analysis model developed in this research can be used to predict the potential success of computer networking projects.

More research needs to be carried out on other types of ICT projects in different environments. In Zimbabwe, particularly, more research needs to be done in the area of ICT project management CSFs.

8.3.7 Future research

The researcher recommends the following as possible avenues for future study:

Future studies could determine CSFs for other types of ICT projects. This study only focused on computer networking projects.

There is need to replicate studies on ICT projects CSFs in other provinces of Zimbabwe.

This study could be done once more when Zimbabwe regains political and economic stability to find out whether the same results can be obtained.

More research is necessary to improve on the developed model so that apart from predicting the potential success of a project, it can also provide pointers to the factors that need more attention.

Future research could consider project portfolio management to establish the influence of past projects on present and future projects.

8.3.8 Conclusion

This research established the CSFs for ICT projects in Zimbabwe and those factors critical to computer networking projects in the same country. The CSFs for ICT projects in Zimbabwe were: adequate budget, adequate funding, project size complexity, project uniqueness and competitor technologies, direct communication, strong detailed planning, considering and appreciating multiple viewpoints, rigorous refactoring activities, projects with dynamic accelerated schedule, flexible approach to change, sound basis for project, realistic schedule, appreciating effect of human error, effective leadership conflict resolution and projects with upfront risk analysis done, training provision and coherent self-organising team.

CSFs for computer networking projects in Zimbabwe identified were: strong support from senior management, committed sponsor, adequate funding, project goals awareness, having a clear project boundary, knowing client needs, oneness of the project team, competent team and effective team.

To improve on the success rate of ICT projects, research has to be done on specific types of ICT projects rather than putting them under one category (ICT projects). This research discovered that the management of ICT projects is not the same for all the types of projects. Therefore, acknowledging their differences and observing different CSFs can improve on the projects' success.

The research established only those factors considered critical for the projects, but that does not mean the rest of the factors should not be considered. The essence is that more attention should be put on the CSFs ahead of the rest of the factors.

A model was successfully developed that computer networking project managers can use to predict the potential success of their projects at any stage of the project process. The model was validated and tested. It managed to predict the success of projects by 62.5%.

In conclusion, all the objectives were achieved and the research questions answered. The results of the study can be used to promote the success of computer networking projects and pave way for future research in managing different types of ICT projects.

9.0 References

Abbasi, N, Wajid, I, Iqbal, Z and Zafar, F (2014). Project failure case studies and suggestions. International journal of computer applications. Vol. 86 (6) 0975-8887

Agbo, A (2010). Cronbach's Alpha: Review of limitations and associated recommendations. Journal of Psychology in Africa. Vol. 20(2) 233-239

Ahmad, M.M., & Cuenca, R.P. (2013). Critical success factors for ERP implementation in SMEs. Robotics and computer-integrated manufacturing, Vol.29, 104-111, February 2013.

Alkharusi, H (2012). Categorical variables in regression analysis: A comparison of dummy and effect coding. International journal of education. Vol. 4(2)

Alaskari, O., et al. (2012). Critical success factors (CSFs) for successful implementation of Lean tools and ERP systems. Proceedings of the world congress on engineering Vol.3, London, U.K. 2012.

Amponsah, R. (2012). Real project failure factors and the effect of culture on project management in Ghana. ICBE-RF Research report No.45/12 2012.

Anney, V. N (2014). Ensuring quality of the findings of qualitative research: looking at trustworthiness criteria. Journal of emerging trends in education and policy studies. Vol. 5(2) 272-281

Ata ul Musawir, Serra. C. E. M, Zwikael, O & Ali. I. (2017). Project governance, benefit management and project success, towards a framework for supporting organizational strategy implementation. International Journal of Project Management, Elsevier, 35(2017) 1658-1672.

Atsu, M. Antoh-Baidoo, F. K., Osatuyi, B & Amaoko-Gyampah. (2009). Examining the success factors of ICT projects in developing nations: A case of AB networks. Americas conference on information systems.

Alvi, M. (2016). A manual of selecting sampling techniques in research. Munich Personal RePEc Archive no. 70218.

Aronson, J. (1995). A pragmatic view of thematic analysis, the qualitative report. TQR, Vol. 2 (1), 1-3: retrieved from //nsuworks.nova.edu/tqr/vol2/iss1/3.

Avella, J. R. (2016). Delphi panels: research design, procedures, advantages and challenges. International journal of doctoral studies, 11, 305-321.

Ayash, M. M. (2015). Research methodologies in computer science and Information systems. Alquids Open University.

Ayinla, A. S and Adekunle, B. K (2015). An overview and application of discriminant analysis in data analysis. IOSR journal of mathematics Vol. 1(v) 12-15.

Bannerman, P. L. (2008). Defining project success; a multilevel framework. PMI research conference; defining the future of project management. Warsaw Poland, Newtown Square, PA: Project Management Institute.

Bartneck, C., Soucy. M., Fleuret. K & Sandoval. B. (2015). The Robot Engine - Making the Unity 3D Game Engine Work for HRI. Proceedings of the 24th IEEE International Symposium on Robot and Human Interactive Communication. Kobe, Japan, Aug 31 - Sept 4, 2015.

Bellomo, N, Angelis, E and Delitala, M (2008). Mathematical modelling in applied sciences, Computer science proceedings.

Bonett, D. G., & Wright, T. A. (2014). Cronbach's alpha reliability; internal estimation, hypothesis testing and sample size planning. Journal of organizational behaviour, Wiley online.

Bokil, V. A (2009). Introduction to mathematical modelling. Oregon State University.

Braun, V., & Clark, V. (2012). Thematic analysis. APA handbook of research methods in psychology Vol.2, American psychological association.
Braun, V., Clarke, V., & Rance, N. (2014). How to use thematic analysis with interview data. Research handbook, London: Sage, pp 183-197.
Brown, V. (2011). http://www.e-ir.info/2011/02/27/the-reflectivist-critique-of-positivist-ir-theory/ accessed 15/10/15.
Bursac, Z., Gauss. C. H., Williams D. K., & Hosmer. D. w (2008). Purposeful selection of variables in logistic regression, Source code for biology and medicine 3(17).
Cain, J. W (2014). Mathematical models in the sciences, molecular life sciences. Springer science + business media. New York.
Caliste, A. L. E. (2012). The project management project- challenges in the public sector. PMI Global Congress 2012- North America, Vancouver, British Columbia, Canada Newtown Square, PA: Project management institute.
Carey, S. W. (2011). Project management tools and techniques. AHIMA convention exhibit, Salt Lake City.
Carson, Y., & Maria, A. (1997). Simulation optimisation: methods and applications. Proceedings of the 1997 winter simulation conference, New York 1997.
Cerpa, N., Bardeen. M., Astudillo. C & Verner. J. (2016). Evaluating different families of prediction methods for estimating software project outcomes. Journal of Systems and Software, Vol 112(2016), 48-64.
Chen, H. L. (2015). Performance measurement and the prediction of capital project failure. International Journal of project management 33(2015) 1393-1404- Elsevier
Chiyangwa, T. B., & Mnkandla, E. (2017). Modelling the critical success factors of agile software development projects in South Africa. South African Journal of Information Management, 19(1), pp.1-8.
Cornel, L., & Mirela, L. (2008). Delphi-the highest qualitative forecast method. Seria stiinte Economice Vol. LX 1 (2008) 31-36.
Covarec, Y. (2012). Revisiting the definition of project success. PMI Global congress 2012- North America, Vancouver, British Columbia, Canada Newtown Square, P. A: Project management institute.
Chanail, R. J. et al. (2018). An introduction to qualitative meta-synthesis. TQR Conference 2018, Nova Southeastern University.
Chow, T., & Cao, D. B. (2007). A survey study of critical success factors in agile software projects. The journal of systems and software vol. 81(2008) 961-971.
Chilisa, B., & Kawulich, B. (2015). Selecting a research approach: paradigm, methodology and methods. New York: The Guilford Press.

Cusworth, J. W., & Franks, T. R. (2013). Managing projects in developing countries. Routledge, Taylor and Francis Group, London and New York.
Dalkey, N. C and Helmer, O (1963). An experimental application of the Delphi method to the use of experts. Management science. Vol. (9) 458-467
Damoah, I. S., Akwei, C., & Mouzughi, Y. (2015). Causes of government project failure in developing countries- Focus on Ghana. British academy of management conference, Portsmouth University. Available at: https://www.researchgate.net/publication/299537426_Causes_of_government_project_failure_in_developing_countries_-_Focus_on_Ghana: accessed Oct 25 2018.
Davis, K. (2016). A method to measure success dimensions relating to individual stakeholder groups. International Journal of project management, Elsevier, 34(2016) 480-493.
Davis, K. (2017). An empirical investigation into different stakeholder groups perception of project success. International Journal of Project Management, Elsevier, 35(2017).

De Hoyos, M., & Barnes, S. A. (2014). Analysing interview data. Warwich Institute for employment research.
Demeyer, S. (2011). Research methods in computer science. ICSM p 600.
De Vaus, D. A. (2001). Research design in social research, London: SAGE.
Devault G (2019). Establishing trustworthiness in qualitative research. Market research techniques.
Dimitras, A. I., Zanakis, S. H., & Zopounidis, (1996) A survey of business failures with an emphasis on prediction methods and industrial applications, European Journal of operations research, Elsevier 90(1996) 487-513.
Ding, Y., Jing, J., & Zhu, X. (2014). The importance of computer network technology in the coal quality inspection. 2014 IEEE workshop on advanced research and technology in industry applications (WARTIA).
Dizaji, Z. A., & Gharehchopogh, F. S. (2015). A Hybrid of Ant Colony Optimization and Chaos Optimization Algorithms Approach for Software Cost Estimation. Indian Journal of Science and Technology, Vol 8(2), 128–133.
Dolezal, R., Horning, O, Sobeslav, V & Korabecny J. (2015). HPC Cloud Technologies for Virtual Screening in Drug Discovery. Springer International Publishing Switzerland ACIIDS 2015, Part II, LNAI 9012, pp. 440–449, 2015.
Donohoe, H., stellefson, M., & Tennant, B. (2012). Advantages and limitations of the e-Delphi technique. American journal of health education, Vol. 43(1).
Dufresne, K. (2017). The Delphi Technique, Tutorials and Fundamentals. Available at https://www.students4bestevidence.net/the-delphi-technique/ accessed 14/12/2014.
Ebad, S. A (2016). Influencing factors for IT software project failures in developing countries: A critical literature survey. Journal of software Vol. 10 (6) 1145-1153
Ebad, E (2018). An exploration study of ICT projects failure in emerging markets. Journal of global information technology management. Routledge Vol. 21 (12) 139-160
Erbas, A. k., Kertil. M., Cetinkaya. B., Cakiroglu. E., Alacaci. C & Bas. S. (2014). Mathematical modelling in mathematics education: Basic concepts and approaches. Educational sciences: Theories and practice Vol. 14(4) 1621-1627.
Erwin, E., Brotherson, M. J., & Summers. J. A. (2011). Understanding qualitative meta-synthesis, issues and opportunities in early childhood intervention research. Journal of early intervention, Vol. 33(3), SAGE publications, 186-200.
Evans, C. (2017). Analysing semi-structured interviews using thematic analysis: exploring voluntary civic participation among adults. Sage research methods data sets.
Evans, D. L, Drew, J. H and Leemis, L. M (2008). The distribution of the Kolmogorov-Smirnov, Cramer-von Mises and Anderson-Darling test statistics for exponential populations with estimated parameters. A white paper.
Fernandez, L. (2018). Qualitative interview analysis: the use of systematic functional linguistics or reveal functional meanings. Qualitative social research, Vol. 19(2) Article 6.
Forero, R, Nahidi. S, De Costa. J, Mohsin. M, Fitsgerald. G, Blackman. D, McCarthy. S & Aboagye. P. (2018). Application of four-dimension criteria to assess rigour of qualitative research in emergency medicine. BMC health services research. (2018) 18:120.
Flick, U. (2009). An introduction to qualitative research. 4th edition, Sage Publications.
Floyd, F. J., & Widaman A. (1995). Factor analysis in the development and refinement of clinical assessment instruments. Psychological assessment Vol 7(3).
Frejd, P. (2014). Modes of mathematical modelling: An analysis of how modelling is used and interpreted in and outside of school settings. Linkoping Studies in behavioural sciences No. 181.

Freitas, R. (2009). Scientific research methods and computer science. MAP-1 Seminars workshop.
Garel, G. (2012). A history of project management models: From pre-models to the standard models. International journal of project management Vol. 31. 663-669.
Geus, T. (1981). The idea of a critical theory, Cambridge University Press, Cambridge.
Hall, N.J. (2012). Project management: Recent developments and research opportunities. Systems Engineering Society of China and Springer-Verlag Berlin Heidelberg Vol. 2(21) 129- 143.
Hairul, M., Nasir, M. H. N. M., & Sahibuddin, S. (2011). Critical success factors for software projects: A comparative study. Scientific research and essays 6: 2174-2186.
Hassani, H. (2017). Research methods in computer science. 2nd Edition.
How, A. (2003). Critical theory, traditions in social theory. Palgrave Macmillan, UK.
Hossain, L. N., Fernandez-Llimos. F. Luckett. T., Moullin. J. C., Durks. D., Franco-Trigo. L, Benrimoj. S. I. & Sabater-Hernandez. D. (2017). Qualitative meta-synthesis of barriers and facilitators that influence the implementation of community pharmacy services: perspectives of patients, nurses and general medical practitioners. BMJ open 2017:7.
Hu, Y., Feng. B, Mo. X, Zhang X, Ngai. E. W. T, Fan. M, & Liu. M. (2015). Cost-sensitive and ensemble-based prediction model for outsourced software project risk prediction. Decision support systems, Elsevier, 72(2015) 11-23.
Huang, G, Kurnia, S and Linden, T (2018). A study of critical success factors for enterprise systems implementation by SMEs. 22nd Pacific Asia Conference on Information systems. Japan.
Hung, L., Chang, Hung, Yen & Chou. (2016). Key success factors of vendor-managed inventory implementation in Taiwan's manufacturing industry. Journal of global information management, Vol. 24(1), 37-60.
Hussein, B. A., Ahmad, S. B. S., & Zidane, Y. J. T. (2015). Problems associated with defining project success. Procedia Computer Science, Elsevier, 64(2015)940-947.
Hyeou-Ae (2013). An introduction to logistic regression: from basic concepts to interpretation with particular attention to nursing domain. Journal of Korean academy of nursing, Vol. 43(2).
Ignou, N. K. D. available at: http://www.celt.mmu.ac.uk/researchmethods/Modules/Selection_of_methodology/ accessed 12/10/2015
Imboden, D. M., & Pfenninger, J. (2013). Introduction to systems analysis. DOI, Springer-verlag, Berlin Heidelberg.
Imtiaz. A., Al-Mundary. A. S., Mirhashemi. T & Ibrahim. R (2013). Critical success factors of information technology projects. International Journal of computer and systems engineering. Vol. 7(12) 2013.
Jafari, M., Rezaeenour. J., Mazdeh. M. M & Hooshmandi. A. (2011). Development and evaluation of a knowledge risk management model for project-based organizations: A multi-stage study, Vol. (49) 3.
Jain, A. & Reddy, B. V. R. (2013). Node centrality in wireless sensor networks: importance, applications and advances. 3rd IEEE International advance computing conference (IACC).
Jardin, P. (2015). Bankruptcy prediction using terminal failure process. European Journal of operations research, Elsevier, Vol. 242(2015) 286-303.
Jiang, Y., & Hu, A. (2010). A link importance evaluation method based on the characteristics of network communication. Second international conference on networks security, wireless communications and trusted computing.

Jha, G. (2017). 6 sampling techniques: how to choose a representative subset of the population. Socialcops, academy editors' picks resources.

Joslin, R., & Muller, R. (2016). The relationship between project governance and project success. International journal of project management, Elsevier, 34 (2016) 613 – 626.

Jugder, N. (2016). The thematic analysis of interview data: an approach used to examine the influence of the market on curricular provision in Mongolian higher education institutions. Hillary place papers, 3rd edition, University of Leeds.

Karunaratne, T., Peiris, C., & Hansson, H. (2018). Implementing small scale ICT projects in Developing countries- how challenging is it? International journal of education and development using information and communication technology, Vol. 14 (1) 118- 140.

Kashiwagi, I (2014). A global study on ICT projects performance. Journal for the advancement of performance information and value, Netherlands Vol. 10(1)

Kellner, D. Critical Theory and the crisis of social theory; available at

https://pages.gseis.ucla.edu/faculty/kellner/essays/criticaltheorycrisisofsocialtheory.pdf, Accessed 22/02/2018.

Kenton, W. (2018). Delphi Method, Investopedia Investing Financial analysis available at https://www.investopedia.com/terms/d/delphi-method.asp accessed 14/12/2018

Kim, J. O., & Mueller, C. W. (2011). Introduction to factor analysis: what is it and how to do it. Issue 13.

Kivunja, C., & Kuyini, A. B. (2017). Understanding and applying research paradigms in educational contexts. International journal of higher education, Vol. 6(5) 2017.

Klastorin, T. D. (2004). Project management: tools and trade-offs. 1st edition. Wiley, Hoboken, N.J.

Komai, S, Saidi, H, and Nakanishi, H (2007). Study on the critical success factors in IT system implementation. Penerbit UTM Press. Vol. 9(2017)31-38

Komolafe, O. O, Ehikhuenmen and Abiodun (2018). Mathematical modelling techniques of two independent variable civil engineering data using coefficient equations approach. 13th UNILAG annual research conference and fair.

Kothari, C. R. (2004). Research methodology; methods and techniques. Second revised edition, New age international publishers, New Delhi, India.

Korstjens, I and Moser A (2018). A practical guide to qualitative research. Part 4: Trustworthiness and publishing. European journal of general practice. Vol. 24(1)120-124

Kukushkin, A., & Zykov, S. (2013). The dynamic modelling of the project management. Process Procedia Technology, Vol. 9, 893-899.

Kumar, R. (2011). Research methodology, a step by step guide for beginners. 3rd Edition, SAGE, Los Angeles/London/New Delhi/Singapore/Washington DC.

Lachal, J., Reva-Levy. A., Orri. M. & Moro. M. R. (2017). Meta-synthesis: an original method to synthesise qualitative literature in psychiatry, methods, frontiers in psychiatry.

Lavrakas, P. J. (2008). Cronbach's alpha. Encyclopaedia of survey research methods.

Lever, J., Kryzywinski M., & Altman, T. (2010). Points of significance: Principal component analysis.

Lehtinen, T. O. A., Mantyla, M. V., Vanhanen, J, Ltkonen, J & Lassenius, C. (2014). Perceived causes of software project failures- an analysis of their relationships. Information and software technology, Elsevier.

Leigh, J., & Bryant, D. (2015). Monte Carlo strategies for selecting parameter values in simulation experiments. Systems biology, Oxford University Press 64(5)741-751.

Leydesdorff, E., & Wijsman, T. (2007). Netherlands Court of Audit; why government ICT projects run into problems?

Lin, Y., & Chang, P. C. (2012). Maintenance reliability of a computer network with node failure in the cloud computing environment. International journal of innovative computing, information and control, Vol. 8(6) 4045-4058.
Lopes, P. H. C, Reid, I and Hodson, P. R (2007). Two dimensional Kolmogorov-Smirnov Test. XI International workshop on advanced computing and analysis techniques in physics research.
Lummas, M. (2012). Types of factor analysis: available at infor.paiwhq.com/3-types-of-factor-analysis-analysis/ accessed20/02/2017.
Macapagal, M. (2010). ICT project management in theory and practices. United Nations Asian and Pacific Training Centre for Information and communication technology for development (APCICT).
Maguire, M., & Delahunt, B. (2017). Doing a thematic analysis: a practical, step-by-step guide for learning and teaching scholars. All Ireland journal of teaching and learning in higher education (AISHE-J), Vol.8 (3), autumn 2017.
Malhotra, N. K. (2007). Marketing research: an applied orientation. 4th edition, Pearson Education, India.
Mapepeta, B. (2016). Background study to the study of "the impact of project failure on the socio-economic development in Zimbabwe: A case of Masvingo province". PM World Journal vol. v (viii).
March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology. Decision support systems 15(1995) 251-266.
Marion, G (2008). An introduction to mathematical modelling. Bioinformatics ans statistics, Scotland.
Marques, J., Vrajao. J, Sousa. J. & Peres, E. (2013). Project management success I-C-E model-a work in progress. Procedia Technology, Vol. 9. 910-914.
Matthew, U., Shahadat, U., & Crawford, L. (2016). Predicting the future of project management research. Procedia- Social and behavioural sciences, Elsevier 226(2016) 27-34.
Mbindi, H. T. (2016). Why project management training and certification is necessary? The Sunday News (Zimbabwe), 27 November 2016.
Milis, K. (2002). Success factors for ICT projects; empirical research, utilising qualitative and quantitative approaches. Doctoral Thesis, Limburgs Universitair, Centrum.
Milosevic, D., & Lewwongcharoen, B. (2004). Project management tools and techniques: the contingency use and their impacts on project success. PMI research conference: Innovations, London, England New Square, P A: Project management institute 11- 14 July2004.
Minging, Z., & WuXuguang, Y. (2011). Evaluating node importance in complex networks based on factor analysis. International conference on computer science and network technology – 2011.
Mishra, B. K., & Singh, A. K. (2012). SIjRS E-Epidemic model with multiple groups of infection in computer network. International Journal of nonlinear science, Vol. 13(3) 357-362.
Mohagheghi, P., & Jorgensen, M. (2017). What contributes to the success of IT projects? Success factors, challenges and lessons learnt from an empirical study of software projects in the Norwegian public sector. IEEE/ACM 39th IEEE international conference on software engineering companion.
Mohajan, H. (2017). Research methodology. Munich Personal RePEc Archive (MPRA): available at mpra.ub.uni-muenchen.de/83457/.
Montequin, V. R., Cousillas. S., Ortega, F& Villanueva J. (2016). Analysis of the success factors and failure causes in projects: comparison of the Spanish information and

communication technology (ICT) sector. International journal of information technology project management, vol. 7(1), 18-31.
Montequin, V. R., Cousillas, S., Ortega. F. & Villanueva J (2014). Analysis of the success factors and failure causes in information and communication technology (ICT) projects in Spain. Procedia Technology 16(2014)992-999, Oviedo, Spain.
Moon, K. Brewer. T. D, Januchowski-Hartley. S. R, & Adams. V. M. (2016). A guide to improve qualitative social science publishing in ecology and conservation journals. Ecology and society. Vol. 21(3): 17.
Mount, E., Gaultney. D., Vrijsen. G., Adams. M., So-Young Baek, Maunz. P., & Kim. J. (2015). Scalable Digital Hardware for a Trapped Ion Quantum Computer. Electrical and Computer Engineering Department, Duke University, Durham, N.C. 27708, USA.
Musiyandaka, D., Ranga, G., & Kiwa J. F. (2013). An analysis of factors influencing success of ICT4D projects: A case study of the Schools Computerisation Programme in Mashonaland West Province, Zimbabwe. The Journal of community informatics, Vol.9 (4) Special Issue.
Nakamoto, H., Nishikubo, D., & Kobayashi, F. (2018). Food texture evaluation using logistic regression model and magnetic food texture sensor. Journal of food engineering, Elsevier 222(2018) 20-28.
Nawi, H. S. A., Rahman, A., & Ibrahim, O. (2013). Government ICT project failure factors: project stakeholders' views. Journal of research and innovation information systems, Malaysia.
Nencini, L. (2015). DYNAMAP monitoring network hardware development. The 22nd International Conference on Sound and Vibration, Italy 12-16 July 2015.
Nethathe, J. M., Van Waveren., & Chan, K. Y. (2011). Extended critical success factor model for management of multiple projects: An empirical view from Transnet in South Africa. South African Journal of Industrial Engineering, Vol. 22(2) 189-203.
Neophyton M, Stavrou K, Vassilion V and Pitsillides A (2014). The importance of adaptive applications in mobile wireless networks.
Neverauskas, M., Bakinaite, J., and Meiliena, C. (2013). Contemporary approach to the possibility of project's success increase. Journal of economics and management, Vol.8 (4) 2013.
Okereke, O. C (2017) Causes of failure and abandonment of projects and project deliverables in Africa. PM World Journal Vol. VI (2)
O'Sheedy, D.G. (2012). A study of agile project management methods used for IT Implementation projects in small and medium sized enterprises. DBA Thesis, Southern Cross University, Lismore, NSW.
Olejnick, R. (2011). Computer network design based on AHP method. Information systems in management XI, databases, distance learning and web solution technologies, WULS Press, Warsaw.
Oyediran, O. B. (2016). Mathematical modelling and simulation and applications. Workshop on COMSOL software, NMC Abuja (31st July-6th August 2016).
Pade, C., Mallinson, B., & Sewry, D. (2004). An elaboration of critical success factors for rural ICT project sustainability in developing countries: exploring the DWESA case. Journal of information technology case and application research, Vol.10 (4) 32-55.
Pankratz, O., & Basten, D. (2018). Opening the black box: Managers' perceptions of IS project success mechanisms. Information and Management 55(2018) 381-395.
Paterson, B. L., Dubouloz. C. J., Chevrier. J., Ashe. B., King. J & Moldoveanu. M. (2009). Conducting qualitative meta-synthesis research: insights from a meta-synthesis project. International Journal of qualitative methods.

Pearce, M. (2014). Dropout neural network gif. Statistics and Machine Learning Reading Group. University of Warwick Centre for Complexity Science. https://warwick.ac.uk/fac/cross_fac/complexity/people/students/dtc/students2013/eyre/statsreadinggroup/

Peng, J., Lee, k. L., & Ingersoll, G. M. (2014). An introduction to logistic regression analysis and reporting. The journal of education research.

Pinto, I. K., & Slevin, D. P. (1988). Project success: definitions and measurement techniques. Project management journal, 19(1) 67-72.

Quarteroni, A. (2009). Mathematical models in Science and Engineering. Notice of the AMS Vol 56(1).

Radujkovic, M., & Sjekavica, M. (2017). Project management success factors. Creative construction conference 2017, Croatia, Procedia Engineering 196(2017) 607-615.

Ram, J., & Corkindale, D. (2014). How "critical" are the critical success factors? Examining the role of CSF for ERP. Business process management journal, Vol.20 (1) 151-174, 2014.

Ram, J, Corkindale, D., & Wu Mong-Lu. (2013). Implementation of CSFs for ERP: Do they contribute to implementation success and post-implementation performance? International Journal of production economics.

Rausch, M., & Leitner, Z. (2017). Should metacognition be measured by logistic regression?

Rausch, M., & Zehetleitner, M. (2017). Should metacognition be measured by logistic regression? Consciousness and cognition, Elsevier. 49(2017)2 91-342.

Reich, B. H., Gemino, A., & Sauer, C. (2012). Knowledge management and project-based knowledge in IT projects: A model and preliminary empirical results. International Journal of project management, Vol. 30. 663-764.

Roche, J.M. (2011). Factor analysis uses for index design and subjective scale validation. HDCA Summer School on capability and multidimensional poverty, Netherlands.

Rummel, R, J. (2011) Understanding factor analysis available at www.hawaii.edu/powerskills/UFA.HTM: accessed 15 November 2017.

Salamah, H., & Alnaji, L. (2014). Challenges leading to projects struggle in IT project management office. WSEAS Transactions on Business and Economics, Vol 11 (2104).

Salija, N., Bilandzic, A., & Stanic, M. (2017). Logistic regression modelling: procedures and pitfalls in developing and interpreting prediction models. Croatian operational Research review CRORR 8(2017) 631-652.

Santra, A. K and Christy, J (2012). Genetic algorithm and confusion matrix for document clustering. International journal of computer science issues Vol. 9(2)

Santos, C., Santos V., Tavares. A & Varajao J. (2014). Project management success in health, the need for additional research in public health projects. Procedia technology, Elsevier, vol. 16 (2014) 1080-1085.

Saxena, G. (2017). Multidimensional competency construct for social entrepreneurs: A logistic regression approach. Kasetsart Journal of Social Sciences (2017) 1-5.

Saravanakumar, S., Mohanaprakash. T. A., Dharani. R & Kumar. C. J. (2012). Analysis of ANN-based Echo state network intrusion detection in computer networks. International Journal of computer science and telecommunications, Vol. 3 (4).

Sebestyen, Z. (2017). Further considerations in project success, Procedia Engineering, Elsevier Vol. 196(2017) 571-577.

Serrador, P., & Turner, J. R. (2014). The relationship between project success and project efficiency. Procedia-social and behavioural sciences, 27^{th} IPMA World Congress, Elsevier 119(2014)75-84.

Setzer, A. (2015). Research methods in computer science. White paper.

Shah, S. R., & Al-Bargi. (2013). Research paradigms: researcher's worldviews, theoretical frameworks and study designs. Arab world English journal, Vol. 4 (4) 252-264.

Shah, M. H, Braganza, A and Morabito, V (2007). A survey of critical success factors in e-Banking: an organisational perspective. European journal of information systems. Vol. 16(2007)

Shenton A. K (2004). Strategies for ensuring trustworthiness in qualitative research projects. Education for information Vol. 22(2004) 63-75

Sherhar, A., & Dvir, D. (2004). Project management evolution: past history and future research directions. PMI Research Conference Innovations, London, England. Newton Square, P.A: Project management institute, Proceedings of the PMI Research Conference 11-14 July 2004- London UK.

Shukla, D., Verma, K., & Gangele, S. (2012). Least square curve fitting applications under rest state environment in internet traffic sharing in computer network. International Journal of computer science and telecommunications, Vol. 3(5).

Siddaway, A, Wood, A. M and Hedges, L. V (2019). How to do a systematic literature review: a best practice guide for conducting and reporting narrative reviews, meta-analysis, and meta-synthesis. Annual review of Psychology.

Sijtsma, K. (2009). On the use, the misuse and the very limited usefulness of Cronbach's alpha. Psychometrika, Vol. 74(1) 107-120.

Somers, T. M., & Nelson, K. (2011). The impact of critical success factors across the stages of enterprise resource planning implementations. Proceedings of the 34th Hawaii International conference on systems sciences.

Sperandei, P (2013). Understanding logistic regression analysis. Federal University of Rio de Janeiro, Brazil.

Squires, H., & Tappenden, P. (2011). Mathematical modelling and its application to social care. Methods review 7, School of social care research.

Stankovic, D. (2013). A survey study of critical success factors in agile software projects in former Yugoslavia IT companies. The Journal of systems and software, February 2013.

Steyerberg, E. W., Harrel Jr. F. E, Borsboom. G. J. J. M., Eijkemans. M. J. C, Vergouwe. Y & Habbema. J. D. F. (2001). Internal validation of predictive models: Efficiency of some procedures for logistic regression analysis. Journal of clinical epidemiology 54 (2001)774-781.

Steyerberg, E., et al. (2001). In search of a sensible strategy in small data sets. Medical decision making 2001(21) 45-56.

Stoltzfus, J. C. (2011). Logistic regression analysis: a brief primer-research methods and statistics. Academy emergency medicine (official journal of the society for academic emergency medicine) 18:1099-1104.

Taherdoost, H. (2016). Sampling methods in research methodology; how to choose a sampling technique for research. International Journal of academic research in management, Vol.5 (2), 2016 18-27 ISBN 2296-1747.

Taruwona, R. (2011). Grappling with constraints of project management, the Herald 21 March 2011.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. International Journal of medical education, 2011(2) 53-55.

Taylor, P. (2015). The importance of information and communication technologies (ICTs): An integration of the extant literature on ICT adoption in small and medium enterprises. International journal of economics, commerce and management, Vol. (3)5, UK.

The Standish Group's Chaos Report: http://image.slidesharecdn.com/at14hannanfinal-150615185904-lva1-app6891/95/breakthrough-portfolio-performance-managing-a-mix-of-agile-and-nonagile-projects-5-638.jpg?cb=1434394775: accessed on 11/09/2015.

Tichapondwa, S. M., & Tichapondwa, S.P. (2009). Successful project management: Insights from distance education practices, CC-BY-SA-NC.
Tsaroucha, A., Boath. E., Porteous. E & Write. A. (2015). Using a modified Delphi method to develop a new advanced accreditation award (Tripple A) in money advice practice. Innovative practice in higher education, Vol. 2(2) April 2015.
Ugwu, O. (2007). Critical success factors for construction ICT projects- some empirical evidence and lessons for emerging economies. Electronic journal of information technology in construction industry.
USC Libraries available at http://libguides.usc.edu/writingguide/researchdesigns: Accessed 12/10/2015 Available at;
http://www.analytictech.com/mb313/elements.htm: accessed 13/10/2015.
Velten, K. (2009). Mathematical modelling and simulation: Introduction for scientists and engineers. Wiley-VCH Verlang GmbH and Co. KGaA, Weinheim ISBN: 978-3-527-40758-8.
Verburg, R., Bosch-Sijtsema., & Vartiainen, M. (2013). Getting it done: critical success factors for project managers in dispersed work settings. International Journal of project management, Vol.31 (1), 67-79.
Verner, J. M., Sampson, J., & Cerpa, N. (2008). What factors lead to software project failure? ResearchGate, IEEE Xplore.
Volden, G. H. (2018). Public projects success as seen in a broad perspective, lessons from a meta-evaluation of 20 infrastructure projects in Norway. Evaluation and programme planning 69(2018) 109-117, Elsevier.
William, N. (2011). Research methods; the basics. Routledge, London & New York.
Williams, T. (2016). Identifying success factors in construction projects: a case study. Project management journal, Vol 47(1) 97-112.
Williams, L, J., & Abdi, H. (2010). Principal component analysis. Wiley interdisciplinary reviews: computational statistics 2.
Wu, W. W. (2010). Beyond business failure prediction. Expert Systems with applications 37(2010) 2371-2376) – Elsevier.
Yeoh, W., & Koronios, A. (2010). Critical success factors for business intelligence systems. Journal of computer information, Vol.50 (3) 23-32.
Yong, A. G., & Pearce, S. (2013). A beginner's guide to factor analysis: focusing on exploratory factor analysis. Tutorials in quantitative methods for psychology, Vol. 9(2) 79-94.
Zhang, Z. (2016). Model building strategy for logistic regression: purposeful selection. Annals of translational medicine, Vol. 4 (6) 111 doi: 10.21037/atm.2016.02.15.
Zhang, J., Kornov, L., & Chritensen, P. (2013). Critical factors for EIA implementation: literature review and research options. Journal of environmental management, Vol.114. 148-157.
Zhou, C., Wang. L. Zhang. Q & Wei X. (2014). Face recognition based on PCA and logistic regression analysis. Optik- International Journal for light and electron optics, Vol. 125 (20) 5916- 5919.
Zhu, Z., Lin. C., Zhang. X, Wang. K., Xie. J & Wei. S. (2018). Evaluation of geological risk and hydrocarbon favourability using logistic regression model with case study, Marine and petroleum geology, Elsevier 92(2018)65-77.
Ziemba, E., & Oblak, I. (2013). Critical success factors for ERP systems implementation in public administration. Interdisciplinary journal of information, knowledge and management vol.8.
Zinyama, T., & Nhema, A. G. (2016). E-Government and Development in Zimbabwe: An appraisal. Public Policy and Administration Research, Vol.6 (2).

Zimbabwe's National Project Management Association (PMIZ): Available at http://pmiz.org.zw/ accessed 15/11/2018.

Zucker, A. (2015). What we really know about successful projects.

Appendices

Appendix A: UNISA Ethical clearance certificate

UNISA university of south africa

UNISA COLLEGE OF SCIENCE, ENGINEERING AND TECHNOLOGY'S (CSET) RESEARCH AND ETHICS COMMITTEE

03 April 2018

Ref #: 007/TM/2018/CSET_SOC
Name: Mr Tavengwa Masamha
Student #: 46687041
Staff #:

Dear Mr Tavengwa Masamha

Decision: Ethics Approval for 5 years (Humans involved)

Researchers: Mr Tavengwa Masamha
Chinhoyi University of Technology, Off Chirundu Road, P. Bag 7724, Chinhoyi, Zimbabwe
46687041@mylife.unisa.ac.za, 263 672 2203/5, 263 775 289 445,

Project Leader(s): Prof E Mnkandla, mnkane@unisa.ac.za, +27 11 670 9059

Working title of Research: Development of a mathematical model to predict the success of a computer networking project using logistic analysis

Qualification: PhD in Computer Science

Thank you for the application for research ethics clearance by the Unisa College of Science, Engineering and Technology's (CSET) Research and Ethics Committee for the above mentioned research. Ethics approval is granted for a period of five years, from 03 April 2018 to 03 April 2023.

1. The researcher will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the Unisa College of Science, Engineering and Technology's (CSET) Research and Ethics Committee. An amended application could

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www.unisa.ac.za

be requested if there are substantial changes from the existing proposal, especially if those changes affect any of the study-related risks for the research participants.

3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
7. No field work activities may continue after the expiry date (26 March 2023). Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.
8. Field work activities may only commence from the date on this ethics certificate.

Note:

The reference number 007/TM/2018/CSET_SOC should be clearly indicated on all forms of communication with the intended research participants, as well as with the Unisa College of Science, Engineering and Technology's (CSET) Research and Ethics Committee.

Yours sincerely

Dr. B Chimbo

Chair: Ethics Sub-Committee SoC, College of Science, Engineering and Technology (CSET)

Prof I. Osunmakinde

Director: School of Computing, CSET

Prof B Mamba

Executive Dean: CSET

Approved - decision template – updated Aug 2016

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Appendix B: Participant information sheet

Ethics clearance reference number:

Research permission reference number (if applicable):

15 January 2018

Title: **A Logistic Regression Analysis Model for Predicting the Success of Computer Networking Projects in Zimbabwe**

Dear Prospective Participant

My name is Tavengwa Masamha and I am doing research with Professor Ernest Mnkandla, an Associate Professor, in the School of Computing towards a PhD at the University of South Africa. We do not have any funding for this research. As a student I am using my own sources of income to fund any necessary phases in this research. We are inviting you to participate in a study entitled Development of a mathematical model to predict the success of a computer networking project using logistic analysis.

WHAT IS THE PURPOSE OF THE STUDY?

This study is expected to collect important information that could help computer networking project practitioners to predict the possible success of computer networking projects so that resources are not committed to and used in projects that will fail. The important information to be collected include the factors critical to the management of computer networking projects in particular and ICT in general. These factors will be fed into a logistic model that will calculate a value to be used for the prediction of the success or failure of either a project at any stage of the project process.

WHY AM I BEING INVITED TO PARTICIPATE?

This research deals with computer networking projects in particular. I observed that in many organisations that I came across, people directly involved in computer networking projects are relatively small and on average do not exceed 20 people. Due to financial and time constraints I can only conduct this research in three organisations including yours. Therefore I am considering involving every member of the computer networking teams. This is why I invited you to participate in this research since you are part of the computer networking team.

I got your conduct details from your management after successfully seeking permission to conduct the research in your organization.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

The study involves *questionnaires and semi-structured interviews*. The questionnaire will have two main parts, the demographic data part where you indicate such details as gender and time spent in the current organization and the success factors part in which case a Likert scale will be used for the questions. All you need to do is to put an (x) in the box corresponding to your response (see the attached part of the questionnaire). The questionnaire takes 10 – 15 minutes to complete. If you are chosen to participate in the interview phase, you shall be given a set of questions to be answered a week before the interview date for you to familiarize with them and to prepare the appropriate answers. Interviews shall be conducted in small groups of 5 people and can take 20 minutes for each group.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw from this research only before you are issued with the relevant research instruments. The instruments do not have any section where you put your identity details so your privacy and confidentiality is guaranteed. You may not withdraw at any later date because there will be no time for the researcher to replace you hence the reduced numbers will negatively affect the findings.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

Your participation unfortunately does not have any financial benefits but rather it has professional benefits. The results will add to the principles and processes of managing computer networking projects which will definitely help project practitioners to produce better projects. Better projects means betterment of livelihoods.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

This study does not have any potential risk or discomfort to the participants. You fill in the questionnaire at your convenience and the interviews are carried out at your usual work facilities. So if any risks exist they will not emanate from the study itself.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

Your name will not appear anywhere in the research material. Your management agreed that your department members freely participate in this research so no one will victimize you for participating. All your responses will use researcher defined codes that cannot be linked to your identity. So no one will be able to connect you to your answers. This code is the one to be used in the data, conferences or publication if need be.

Your anonymous data may be used in writing publications, thesis or report. This data will never link to the originator since researcher defined codes will be used.

However, you may be asked to be part of a focus group to discuss certain issues that arise from questionnaires or literature. In this case w*hile every effort will be made by the researcher to ensure that you will not be connected to the information that you share during the focus group, I cannot guarantee that other participants in the focus group will treat information confidentially. I shall, however, encourage all participants to do so. For this reason I advise you not to disclose personally sensitive information in the focus group.*

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a minimum period of five years in a locked cupboard/filing cabinet at my Chinhoyi University of Technology office for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. H*ard copies will be shredded using an appropriate shredder and electronic copies will be permanently deleted from the hard drive of the computer through the use of a relevant software programme.*

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

No payment shall be made for your participation, however, the researcher will try to minimise your costs by providing the resources needed e.g. hard copies where necessary and avoids your movement from your work place.

HAS THE STUDY RECEIVED ETHICS APPROVAL

This study has received written approval from the Research Ethics Review Committee of the School of Computing, UNISA. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Tavengwa Masamha on +263 773 418 535/ +236 775289445 or tavtaf@gmail.com. The findings are accessible for at most 5 years from now. Should you require any further information or clarity contact me on the provided contact details.

Should you have concerns about the way in which the research has been conducted, you may contact Professor Ernest Mnkandla on mnkane@unisa.ac.za, +2773 219 6927/063 070 8446.

Thank you for taking time to read this information sheet and for participating in this study.

Thank you.

Tavengwa Masamha

Appendix C: Research permission letter

Request for permission to conduct research at name of organisation

Development of a mathematical model to predict the success of a computer networking project using logistic analysis.

Date………………………………10 January 2018..…………….

Contact person's name…………Tavengwa Masamha...………….

Office no…………………………Engineering Block office E7…….

Department………………………ICT & Electronics……………….

Telephone number………………+263 773418535…

Email address……………tavtaf@gmail.com or 46687041@mylife.unisa.ac.za

Dear *contact person's title and name*,

I, Tavengwa Masamha am doing research with Ernest Mnkandla, a Professor in the School of Computing towards a PhD at the University of South Africa. We are inviting you to participate in a study entitled Development of a mathematical model to predict the success of a computer networking project using logistic analysis. The aim of the study was to identify critical success factors for computer networking projects, develop a logistic model and use the two to predict the success of any given computer networking project so as to minimise the wastage of resources.

Your company has been selected because it has a vibrant networking team that is appropriate for the determination of critical success factors for computer networking projects and validation of the logistic model as required in this study. The study will entail the completion of a questionnaire and eventually some interview sessions.

The benefits of this study are that your organisation is free to have access to the final results of this study which will help your networking practitioners to enrich their work. Also, the study provides new insights into the literature on the proper management of computer networking projects.

There are no foreseen risks associated with your participation in this study.

Feedback procedure will entail direct communication between myself as the researcher and your organization contact person. If need be the contact person may contact my supervisor.

Yours sincerely

Tavengwa Masamha (Lecturer and researcher)

Appendix D: Organisation-A

CHINHOYI UNIVERSITY OF TECHNOLOGY

✉: P. Bag 7724, Chinhoyi ☎: 263-67-22203-5 : 263-67- 27214 E-mail : vicechancellor@cut.ac.zw

Vice-Chancellor's Office: Prof. D. J. Simbi - PhD, BSc, MIM, CEng, FZ'welE, FICorr, FZAS, Hons FZ'welE

HUMAN RESOURCES DEPARTMENT

22 January 2018

Mr Tavengwa Masamha
c/o Chinhoyi University of Technology
P. Bag 7724
CHINHOYI

Dear Mr Masamha

RE: REQUEST TO CARRY OUT A RESEARCH PROJECT AT CHINHOYI UNIVERSITY OF TECHNOLOGY

We acknowledge receipt of your application letter dated 18 January 2018 seeking permission to undertake a research study under a title that reads: ***The development of a mathematical model to predict the success of a computer networking project using logistic analysis.***

You are kindly advised that permission to undertake your study is hereby granted. However, you are reminded to observe the University Official Secrecy Oath.

The University would also expect results of your research upon completion.

Thank you.

T.A. Kaseke (Mr)
DEPUTY REGISTRAR, HUMAN RESOURCES

Appendix E: Organisation-B

More

Norman Ncube

to me

Dear Tavengwa

You are free to come to our institution for any ICT related research issues where you feel we can be of some help.

Regards

Mr Norman Ncube
BSc Hons (NUST), MBA (NUST), MSc(MSU)
ICT Manager
Zimbabwe Council for Higher Education
21 JM Nkomo Rd
Hatfield
Harare
Zimbabwe

+263772898829
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nmncube@zimche.ac.zw
nmncube@gmail.com

ZIMCHE
Quality Assurance in Higher Education

Appendix F: Organisation-C

More 13 of 6,006

Permission to carry out study with ZEGU IT Staff

Brian Maodza bmaodza@zegu.ac.zw via zegu.onmicrosoft.com Jan 16 (2 days ago)

to me

Dear Sir

Reference is made to your communication regarding your request to carryout your study with our IT staff members. It is with great pleasure to notify you that permission has been granted. For any assistance contact the under signed.

Regards

Maodza Brian BSc. IT, CCNA, CCNSP

Click here to Reply or Forward

Appendix G: Organisation-D

Click here to enable desktop notifications for Gmail

More

Request to carryout study Inbox x

Tav M Dear Sir I am Tavengwa Masamha, a lecturer at Chinhoyi University of Technolo...

Tarisai Mhungu

to me

Dear Mr Masamha,,

You may gladly come through. Just advise when you wish to.

Regards,

Tarisai Mhungu

Appendix H: Organisation-E

Tav M <taviaf@gmail.com> Jan 18 (4 days ago)

to Munyaradzi

I am looking at factors critical to the success of computer networking projects which I will use to develop a mathematical model to predict the success of any given computer networking project

Munyaradzi Takayindisa Jan 18 (4 days ago)

to me

no problem you can come through

Appendix I: cover letter to an online anonymous web-based survey

Ethical clearance #: 007/TM/2018/CSET_SOC
Research permission #:

Dear Prospective participant,

You are invited to participate in a survey conducted by Tavengwa Masamha under the supervision of Ernest Mnkandla, an associate professor in the School of Computing towards a PhD at the University of South Africa.

The survey you have received has been designed to identify factors critical to the success of computer networking projects. The identified factors will then be fed into the mathematical model to be developed. The calculated value shall then indicate the possible success or failure of the project. You were selected to participate in this survey because it was observed that you have the appropriate qualification, skill and experience for the provision of required data. You are not eligible to complete the questionnaire if you have less than 12 months in computer networking experience. By completing this survey, you agree that the information you provide may be used for research purposes, including dissemination through peer-reviewed publications and conference proceedings.

It is anticipated that the information we gain from this survey will help us to determine the factors critical to the success of computer networking projects. You are, however, under no obligation to complete the survey and you can withdraw from the study prior to submitting the survey. The survey is developed to be anonymous, meaning that we will have no way of connecting the information that you provide to you. Consequently, you will not be able to withdraw from the study once you have clicked the send button based on the anonymous nature of the survey. If you choose to participate in this survey it will take up no more than 15 minutes of your time. You will not benefit from your participation as an individual, however, it is envisioned that the findings of this study will add to the available literature on the management of computer networking projects. We do not foresee that you will experience any negative consequences by completing the survey. The researcher(s) undertake to keep any information provided herein confidential, not to let it out of our possession and to report on the findings from the perspective of the participating group and not from the perspective of an individual.

The records will be kept for five years for audit purposes where after it will be permanently destroyed, electronic versions will be permanently deleted from the hard drive of the computer. You will not be reimbursed or receive any incentives for your participation in the survey.

The research was reviewed and approved by the UNISA School of Computing Ethics Review Committee. The primary researcher, Tavengwa Masamha, can be contacted during office hours at +263 773 418 535 or +263 775 289 445. The study leader, Professor Mnkandla can be contacted during office hours at +27732196927. Should you have any questions regarding the ethical aspects of the study, you can contact the chairperson of the School of Computing Ethics Research Committee. Alternatively, you can report any serious unethical behaviour at the University's Toll Free Hotline 0800 86 96 93.

You are making a decision whether or not to participate by continuing to the next page. You are free to withdraw from the study at any time prior to clicking the send button.

Tavengwa Masamha (Researcher)

Appendix J: Questionnaire for computer networking practitioners

KEY UNDERSTANDING:

Computer network project

Computer network installation

Critical success factor

Tavengwa Masamha

PHD candidate

Hse num 10256 Brundish

Chinhoyi

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1. This research is conducted as part of a doctorate program at University of South Africa. The research seeks to identify factors that influence the success of ICT projects particularly computer networking projects. The identified factors shall be further analysed to reduce them to a smaller set of factors known as the critical success factors (CSFs). The responses provided in this questionnaire will assist in identifying those factors which are critical to the success of a computer networking project.
2. The research seeks to contribute to the existing body of knowledge for future scholars and project managers that are interested in making computer networking projects succeed. The results of the research shall also enrich the project management literature mainly on the management of computer networking projects.
3. Your participation in this questionnaire is voluntary. If you agree to participate, you are assured that your involvement will not impact on any of your school or work performance in any way.
4. Your response will be confidential and anonymous. Please answer truthfully.
5. If you are not sure of the meaning of the question, kindly seek clarity from the researcher using contacts provided above.
6. I thank you for participating in the survey.

Respond to the questions below by Indicating with **an (x)** in the appropriate box.

Gender

Male ☐ Female ☐

Highest qualification

Diploma ☐ Undergraduate degree ☐ Masters' degree ☐ PhD ☐

Employment category

Senior management ☐ Middle management ☐ Low level ☐ Technician ☐

Time in the organization (Years)

1 – 4 ☐ 5 - 10 ☐ Above 10 ☐

Time in ICT project management

1 – 4 ☐ 5 - 10 ☐ Above 10 ☐

All the factors listed in the table below were found to influence the success of ICT projects. You are required to indicate, with **an (x)** in the appropriate box, how you rate the extent to which each of the factors positively influence the success of a computer networking project.

Project team factors

Success factor	Rating					Project successful? Y/N
	Strongly agree	Agree	Not sure	Disagree	Strongly disagree	
Oneness of the project team						
Team members with high competence and expertise						
Motivated team members						
Coherent and self-organising team work						
Project goals awareness						
Having access to innovative/ talented/ skilled/suitably qualified/sufficient people						
Skills transfer to new teams/members						
Pursuing simple design						
Rigorous refactoring activities						
Project team in one place						
Appropriate technical training of the team						
Projects with small team						
Projects with no multiple independent teams						
Clear and realistic goals or objectives						
Knowing client needs						
Project size/level of complexity/number of people involved/duration						
Project team in different areas						
Team selection						

Owner Organisation factors

Success factor	Rating					Project successful Y/N
	Strongly agree	Agree	Not sure	Disagree	Strongly disagree	
Cooperative organizational culture instead of hierarchical						

Oral culture placing high value on face-to-face communication						
Organisational adaptation/culture/structure						
Good customer relationship						
Honouring regular working schedule with no overtime						
Strong customer commitment and presence						
Customer having full authority						
Flexible approach to change and effective change management						
Adequate budget						
End-user/client involvement and commitment						
Clear communication channel/feedback						
Equipment support						
Economic standing of the organization in funding small projects						
Sound basis for project						
Outsourcing the project						
Economic standing of the organization in funding large projects						
Adequate resources						
Strong support from senior management						
Committed sponsor						

Project management factors

Success factor	**Rating**					**Project successful Y/N**
	Strongly agree	Agree	Not sure	Disagree	Strongly disagree	
Committed manager						
Managers who have light touch or adaptive management style						

Taking account of past experience and learning from it						
Effective team building/motivation						
Training provision						
Appreciating the effect of human error						
Considering and appreciating multiple viewpoints						
Effective leadership/conflict resolution						
Effective monitoring/feedback/control						
Strong/detailed planning and control systems						
Correct choice/past experience of project management methodology/tools						
Monthly project reviews						
Use of website for communication						
Realistic schedule						
Project nature being non-life-critical						
Project type being of variable scope with emergent requirements						
Project manager technical background						
Right amount of documentation						
Delivery of most important features first						
Project manager communication skills						
Strong communication focus with face-to-face meetings						
Projects with dynamic, accelerated schedule						
Projects with upfront cost evaluation done						
Having a clear project boundary						
Competent project manager						
Projects with upfront risk analysis done						
Effective management of risks						
Identify project source						
Size and duration of the project						
Project uniqueness						

Design review with project stakeholders						
Design review with project team and top management						

External factors

Success factor	Rating					Project successful Y/N
	Strongly agree	Agree	Not sure	Disagree	Strongly disagree	
Support from stake holders/champions/project sponsors						
Political stability and social involvement						
Environmental influences						
Proven/familiar technology						
Competitor technologies						
Reliability of subcontractors						
Good performance by suppliers/contractors/consultants						

In the spaces provided **below**, **list** any other factors you think can positively influence the success of computer networking projects.

Factor	Rating					Project success Y/N
	Strongly agree	agree	Not sure	disagree	Strongly disagree	

THANK YOU

Appendix K: interview topics

1. This research is conducted as part of a doctorate program at University of South Africa. The research seeks to identify factors that influence the success of ICT projects particularly computer networking projects. The identified factors shall be further analysed to reduce them to a smaller set of factors known as the critical success factors (CSFs). A logistic model will be developed that can be used to predict the success of a computer networking project. The responses provided in this questionnaire will assist in identifying those factors which are critical to the success of a computer networking project.
2. The research seeks to contribute to the existing body of knowledge for future scholars and project managers that are interested in making computer networking projects succeed. The results of the research shall also enrich the project management literature mainly on the management of computer networking projects.
3. Your participation in this interview is voluntary. If you agree to participate, you are assured that your involvement will not impact on any of your school or work performance in any way.
4. Your responses will be treated as strictly confidential and anonymous. Please answer truthfully.
5. If you are not sure of anything pertaining to this interview, kindly seek clarity from the researcher using contacts provided above.
6. I thank you for participating in the survey.

The following questions are the main and guiding ones only. The researcher may ask follow up questions depending on the flow of the interview. You are expected to go through the questions before the interview so as to gather any relevant supporting material that may be needed during the interview. If possible you may document the main points for reference during and after the interview.

A. The meaning of computer networking project

1. What do you understand by the term computer networking project?
2. How is a computer networking project distinct from a general ICT project?
3. Literature on the management of ICT projects mainly focus on ICT projects in general rather than focusing on specific types of ICT projects. What do you think is the implication of this to the practice of project management?
4. Why is it important to research on ICT project management instead of applying the existing body of knowledge?

B. The meaning of critical success factor.

1. What do you understand by the term critical success factor?
2. Is the concept of critical success factors important in the study and management of ICT projects specifically computer networking projects?

3. Which factors do you find to be critical to the management of computer networking projects specifically?
4. Rank/ prioritise the success factors you have suggested.
5. Literature is full of lists of these critical success factors. To what extent do you find those lists useful to the management of ICT projects?
6. Can you suggest other means of enhancing the research on the use of these critical success factors?

C. Success of computer networking project

1. What do you consider for you to conclude that a computer networking project is successful?
2. How do you determine that that project has been successful (criteria)?
3. Are there any methods or tools in place that you use to predict the success or failure of a computer networking project?
4. If any methods are available, to what extent do you find them useful?
5. Suggest any improvements or new methods/tools that can be developed to predict the success of computer networking projects.

D. The role of computer networking projects

1. Explain the role of computer networking projects in today's business environment.
2. Give any information not covered in the questions that you find important to this study and computer networking project management.

Appendix L: Trustworthiness and transferability

The researcher shall ensure that the research study findings are credible, transferable, confirmable and dependable. The following shall be ensured:

For Credibility, I shall use triangulation of methods. Here I shall use the questionnaire and the interview approaches. The results should be consistent for the results to be credible.

For Transferability I will ensure that my research findings apply to other situations, contexts and circumstances. This will be done through using an online questionnaire which means that respondents come from very different setups. Each situation or circumstance is covered by using an online approach as opposed to issuing questionnaires to people in the same environment.

Also for confirmability the researcher will remove researcher bias by keeping an audit trail highlighting every step of the data analysis process in order to provide a rationale for all the decisions made from the results. This will show that findings accurately show the participants' responses. Lastly for dependability I will establish the extent to which the study can be repeated by other researchers thereby producing consistent results. This shall be achieved through documenting all methods and procedures keeping a trail of the research study. Also, people outside the research will be asked to review and examine the study process and data analysis to ensure consistency of findings and that the research can be repeated.

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Appendix M: Turnitin Similarity Check Summary

Thesis Revision 3

ORIGINALITY REPORT

10%	5%	4%	9%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Higher Education Commission Pakistan Student Paper	1%