Determining critical success factors for implementation of on-line registration systems

By

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Declaration

I, Robyn Cindy Thompson, declare that this dissertation is a representation of my own work, both in conception and execution. This work has not been submitted in any form for another degree at any university or institution of higher learning. All information cited from published or unpublished works have been acknowledged.

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Dedication

This dissertation is dedicated to my husband and best friend, Sean, who has given me years of marriage, unconditional love and two amazing children.

To our beautiful, talented children, Byron and Shenae, you are my reason for everything I do.

Contents

List of Acronyms

AS	Active Sum
CIA	Cross Impact Analysis
CIM	Cross Impact Matrix
CSFs	Critical Success Factors
DB	Database
DUT	Durban University of Technology
ERP	Enterprise Resource Planning
HEI	Higher Education Institution
IS	Information System
IT	Information Technology
ITS	Integrated Tertiary Software
PS	Passive Sum

Definitions

Anecdotally	Based on secondary data with no empirical evidence or scientific investigation.
Business Processes	A set of activities that takes one or more kind of input and creates output that is valuable to the user.
Critical	Absolutely essential for the success of something and, if neglected, has a high likelihood of failure.
Critical Factors	Those factors deemed to have an extremely high impact on the success or failure of a system.
Critical Success Factors	The limited essential areas that must be performed correctly to ensure a business achieves success, is competitive and flourishes.
Cross-sectional study	A survey method that collects data from the study population at a specific point in time, usually over a period of days or weeks.
Dichotomy	A division into two parts of a thinking, belief, philosophy or paradigm. In the context of research, it refers to the opposing approaches or paradigms in research.
Enterprise Resource Planning (ERP)	A configurable information system package implemented across various functional areas of an organisation, combining information and information-based processes.
Framework	A general overview of a group of interrelated components that support a particular approach to achieve an objective. A

	theoretical framework of a study supports the theory of the research work and is a basis for conducting research. A conceptual framework is the operationalization of the theory and expresses the researcher’s position on the problem and gives the study direction.
Longitudinal Study	Correlation research involving repeated observations of the same study over long periods of time.
Pairwise comparison	Comparing pairs of entities to find the most preferred of a quantitative property.
Paradigm	The underlying assumptions and intellectual structure on which a field of research and development is based.
Taxonomy	A classification or grouping principle.
Variable	A measurable attribute or characteristic that differs between subjects.

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Abstract

The assignment of identifying Critical Success Factors (CSFs) for the successful implementation of the Enterprise Resource Planning (ERP) systems has become an important problem in the information system (IS) research. The necessity to identify CSFs becomes perceptible because of the failure often associated with the ERP system implementation in corporate organisations. The investigation and identification of CSFs will help cut costs of implementing ERP systems in organisations by giving higher precedence to the most critical factors. Literature has indicated that some factors of ERP system implementation labelled as critical are, in most cases, not critical for achieving success in the ERP system implementation. It can be argued that the inherent prediction error in the identification of CSFs is associated with the method employed for identifying criticality. Certain researchers have asserted that many of the studies on CSFs have based their findings on the use of content analysis method to identify and classify implementation factors of ERP systems as critical or not, rather than empirical findings. This intrinsic drawback has led researchers to suggest the use of sound scientific methods such as the structural equation modelling technique to identify CSFs to help guide the implementation of ERP systems in organizations. However, because of the limitations of the existing findings, the expectation is still much higher in effectively resolving the problem of identifying CSFs, in general.

The overarching aim of this study was to determine those factors that are deemed critical for the successful implementation of the on-line registration system as an archetype of ERP system at HEIs. It was necessary to, firstly, identify common factors that have a significant impact on ERP system implementation and, secondly, to ascertain whether the identified factors are applicable in HEI settings, particularly to the on-line registration system. This study plans an in-depth exploration of the implementation of an on-line registration system with the identified factors forming the precursor to unearth those factors that are critical for the success of implementing on-line registration systems. The study has adopted a post-positivism mixed methods approach to identify and verify CSFs of the on-line registration system implementation, taking into consideration higher-order relationships between the factors. Data gathering took place using expert judgement with the involvement of role players in the implementation of on-line registration systems. The ADVIAN classification method provides the analytic tool for identifying factors that are deemed critical for successful implementation of on-line registration systems.

The results reveal the existence of various dimensions of criticality with organisational culture and ERP strategy and implementation methodology emerging as critical factors, while the driving factors for implementation include ERP vendor support and guidance, senior and top management support, project plan with agreed objectives and goals, project management to implement project plan and project leader. It is established that the driven factors that should be observed when intervention measures are implemented include change management, post-implementation evaluation, software testing and troubleshooting, user training and user involvement. It is hoped that the CSFs discovered in this study will contribute towards the under-researched area of ERP and pragmatically aid the improvement of a process area that is in desperate need of business process re-engineering at HEIs.

CHAPTER 1: Introduction

It is during the last 10-15 years that organisations, including Higher Education Institutions (HEIs), have realised the importance of upgrading or replacing their existing computer systems. This is due to the fact that the technology no longer meets the demands for various processing tasks and complex reporting that management requires. The technology that is required for multi-campus institutions and web-based learning is in high demands in the particular case of HEIs. It is, partly, for these reasons that HEIs choose to implement Enterprise Resource Planning Systems (ERP). The implementation of an ERP promises “a seamless integration of information flow through an organization by combining various sources of information into a single software application and a single database” (Nah 2001). An ERP system can be seen as a fully-integrated, configurable system that is implemented across all or some of the functional areas of the organisation (Kumar, Van Hillegersberg and Experiences 2000).

The HEIs in the 21st century rely heavily on computerised Information Systems (IS) for efficient functioning and planning using ERP, which is a popular integrated system that most institutions consider germane for the successful running of their day-to-day activities. The ERP systems have become a cornerstone for the successful operation of many organisations, including HEIs, and, if successfully implemented, they can have the potential to provide many benefits such as improvements in business productivity (Beatty and Williams 2006), improvement in business practices (Ram, Corkindale and Wu 2013), alignment to best practices (Pollock and Cornford 2004), increasing long-term cost savings (Beatty and Williams 2006) and improved access to services (Motiwalla and Thompson 2012). In addition, HEIs depend heavily on integrated information management software to enable and improve retention of current students as well as attracting new students (Murphy 2004). This is important in South Africa in the 21st century where many institutions in the same metropolitan area are attempting to attract the same cohort of students (Gibbs, Pashiardis and Ivy 2008) with a possible cause of this phenomenon being the dissolution of technikons that used to attract a different set of students, when compared to a university.

Typical ERPs implemented in HEIs consist of many integrated components with the on-line registration system being one of such components that has evolved from a *niche* to an integral part of an ERP system for HEIs. Registration is the process of selecting students to attend for that educational setting. It follows that the successful implementation of an on-line registration system may offer benefits such as convenience, off-site, anytime and timely access for the student to the registration procedure and to student registration data, elimination of human error and increased speed of the registration process due to automation of rule checking, streamlined processes, improved customer service and improvements in data consistency (Siau and Messersmith 2003; Olasina 2011). The successful implementation of an on-line registration system also enables students to complete their registration off site on a PC or smart device rendering the process both faster and more efficient. Many HEIs are embarking on a drive to become more student centred with the Durban University of Technology (DUT) declaring in the 2015-2019 strategic plan that "DUT has to be student-centred". The benefits realised by an ERP contribute towards the university's drive.

However, ERP implementation and subsequent upgrades or new integrations, for example, the on-line registration system, represent the challenge of significant expenditure in resources (Beatty and Williams 2006) with the successful implementation of an ERP system being a complex, resource-hungry endeavour requiring dedicated expertise (Beatty and Williams 2006). The literature points out the high failure rates of ERP implementation in organisations (Xu, Yu, Lim and Hock 2010; Kalema, Olugbara and Kekwaletswe 2014) with those ERPs that are implemented more likely to go over schedule and budget (Chang 2004). ERPs implemented in HEIs are not exempted from these identified challenges (Kvavik 2002; Abugabah and Sanzogni 2010). A key reason may be due to a typical on-line registration system having to integrate with other systems that constitute the ERP, a property that complicates the implementation process. It is the researcher's belief that the implementation of an on-line registration system will follow a similar implementation lifecycle as implementation of the initial ERP and will attract the same challenges. Based on the prior-mentioned complexity and the alignment of the implementation of an on-line registration system with the implementation of an ERP, it is a standpoint of this researcher that the on-line registration system can be perceived and explored as an ERP in its own right. Hence, the adopted definition of an on-line registration system is aligned with:

"An information technology solution that integrates and automates recruitment, admissions, financial aid, student records and most academic and administrative services" (Rico 2012).

HEIs, in developing nations such as South Africa, often face unique challenges when compared to their counterparts in developed countries. Increasing operational costs and simultaneous unreliable sources of income presents a major challenge. The recent #feesmustfall campaign is a sombre reaction by students to rising fees at HEIs. Meanwhile, the South African higher education sector attempts to provide quality tertiary education to an expanding number of impending students. With many universities in developed countries having implemented an on-line registration system decades ago, most South African universities have only recently explored this avenue. The case site for this study is the Durban University of Technology which started the implementation of on-line registration only in 2011. The on-line registration system is unique in that high demands are made of the system for a very short timeframe, that is, during registration cycles usually twice a year. This permits rigorous testing of customisations only at the time of the system going live. Further, on-line registration implementation requires specialist software engineering teams. Despite universities having academic departments focused on software development and integration, there isn't suitable capacity and availability of ERP development and implementation experts. Recently, some universities of South Africa underwent complex mergers. This presented another unique challenge of redundant ERP systems and administrative staff that utilise them. Resolutions to such problems arising during the merger resulted in instilled complex operating procedures and often mismatched systems. Given these challenges, it is apparent that the needs for implementation of an on-line registration system in the South African context may differ from those in developed countries.

Given the alarming reports of failure rates in HEIs compared to organisations (Abugabah and Sanzogni 2010), coupled with the high investment costs and low budget involved in ERP implementation along with the dependency that HEIs have on on-line registration and the additional challenges that HEIs in developing countries experience, it becomes increasingly important to better understand the challenges that are faced and identify factors that could lead to a successful implementation of an on-line registration system. This may then move closer to ensuring a successful implementation of a core component that is necessary for the efficient functioning of the university. Furthermore, there is an abundance of literature on the factors that are critical for ERP implementation, with the vast majority of reported findings focussing on organisations. However, despite this researcher's best efforts, little research has been uncovered specifically for HEI's on-line registration system. This view is supported by other researchers (Nielsen 2002; Rabaa'i 2009; Abugabah and Sanzogni 2010; Odero and Oloko 2013). Hence, this study posits a gap in the body of knowledge in this area which requires further research and contributions. Due to this being an undernourished research area, the researcher used current literature as the basis for the study. The researcher acknowledges that these CSFs formed the basis or a launch-pad. Results derived at the end of this study confirmed and added to this existing knowledge base.

1.1 Research Statement and Objectives

Successfully implemented ERPs can provide many intrinsic benefits for the HEIs (Shang and Seddon 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; King, Kvavik and Voloudakis 2002; Shang and Seddon 2002; Spathis and Ananiadis 2005; Xu and Quaddus 2013). It, therefore, follows that the successful implementation of an on-line registration system will also result in many benefits. However, it is evident in literature that many problems could arise from the project going over time and budget, the system not meeting the end user's needs, to the entire implementation failure, despite a considerable amount of time and resources having been invested in the project.

In an attempt to better understand and identify the critical areas that exist during the implementation of an ERP, some researchers have tried to identify the factors that lead to a successful ERP implementation (Holland, Light and Kawalek 1999; Holland and Light 1999; Shanks, Parr, Hu, Corbitt, Thanasankit and Seddon 2000; Verville, Bernadas and Halingten 2005; Supramaniam and Kuppusamy 2010). Other researchers have proposed taxonomies in an effort to summarise the research that has previously explored ERP implementation (Somers and Nelson 2004; Nah and Delgado 2006; Ngai, Law and Wat 2008; Shaul and Tauber 2013). However, some researchers stress that there exists a shortfall in focusing on HEIs and a lack of understanding of the elements that are necessary for a successful ERP implementation (Nielsen 2002; Rabaa'i 2009; Abugabah and Sanzogni 2010). This is especially evident for on-line registration systems where very little research has been done.

Given the gaps alluded to in the previous section, the question arising at this juncture is - what is needed for the successful implementation of an on-line registration system within an HEI? More specifically, what are those factors that affect the successful implementation of an on-line registration system? Hence, the main research question is enunciated as follows:

RQ: What are the critical factors for successful implementation of an efficient on-line registration system?

To answer the research question above, the following objectives exist:

Objective 1: To define *criticality* in the context of successful on-line registration implementation;

Objective 2: To establish, refine and categorise a set of factors that are deemed necessary for successful on-line registration implementation through literature for use in the fieldwork;

Objective 3: To uncover relationships that exist between factors and establish how each might impact on the on-line registration system implementation;

Objective 4: To identify the criticality, stability and integration of each factor; and

Objective 5: To determine which factors should be used for intervention strategies by identifying the following for each factor: precarious, driving and driven.

By achieving the objectives of this research, the requirements for successful implementation of an on-line registration system have been demystified. This research can serve as a springboard for other research into improved implementation of ERP systems in the context of HEIs.

1.2 Research Approach

For the research question to be adequately answered, a customised mixed methods study was adopted. In this approach, quantitative data were first collected in the form of critical success factors from the literature, followed by qualitative data. The quantitative data will be in the form of factor preference chains that are solicited from expert participants. Quantitative analysis tools were used to analyse the qualitative data collected. Using this approach, the researcher unearthed those key factors that impact on implementation of an on-line registration system, while simultaneously contributing to the extant body of knowledge of ERP system implementation as well as extending the literature into the tributary of higher education ERP systems and on-line registration systems.

The mixed methods approach gave the researcher the opportunity to use a combination of qualitative and quantitative approaches as needed for different areas of the study (Johnson and Onwuegbuzie 2004). The initial analysis of literature required quantitative methods to be employed such that a set of critical success factors could be taken further to the fieldwork, for which the researcher made use of content analysis. The identified factors were used in the next phase of data collection where expert participants identified preference chains or lists that they thought best described or identified how factors impact on each other. Due to the expert participants residing in a variety of cities, the researcher explored the option of using an on-line survey tool such as Qualtrics, Survey Monkey and Google forms to aid data collection. It was found that none of these tools provided an appropriate question type that enabled the data to be collected. The researcher, therefore, developed an on-line website, supported by a custom-designed database (DB) for the collection of data.

Due to the number of participants being small (10) as well as the experts being able to submit a variety of preference chains, according to their own knowledge and opinion, the data collection approach was qualitative in nature. This is in line with Henning, Van Rensburg and Smit (2004), who specify that a qualitative approach deals with in-depth qualities and understanding, where there is an investigation as to what interactions exist and what patterns emerge.

With the aim of the research being to identify those factors that are critical for a successful on-line registration implementation, it is the researcher's opinion that the study conducted falls within the post-positivist philosophy where the factors are being tested to ascertain into which category they fall. The researcher has very little interaction with the participants, which, once again, adheres to the positivistic philosophy (Ramanathan 2009).

The data collected from the participants were analysed using the ADVIAN classification tool developed by Linss and Fried (2009). The ADVIAN classification tool relies on a cross impact matrix (CIM) to aid factor analysis. Due to the limitations that exist with cross impact matrices, the researcher developed an algorithm to convert preference chains to a CIM, which was, thereafter, used as the input data for the ADVIAN classification tool.

1.3 Importance of the research

After assessing the available literature with regards to the success factors necessary for on-line registration system implementation at HEIs, it is evident that there is a lack of research and knowledge in various areas, namely, the areas of post-implementation, multi-user contribution and HEIs.

For the institution implementing the on-line registration system to enjoy the benefits of an effective, efficient registration system, it is essential that the on-line registration implementation is successful. Moreover, many personnel are involved in the registration process with the process impacting on many other administrative functions within the institution. It follows that a reliable, valid and efficient on-line registration system is essential to the university.

This system can be seen as a post-implementation addition to an existing ERP, with its implementation following the same processes as the implementation of the original ERP, but possibly with the added critical task of integration into the existing system. Most studies tend to focus on identifying the CSFs for successful ERP implementation (Bingi, Sharma and Godla 1999; Holland and Light 1999; Sumner 1999; Shanks *et al.* 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Al-Mudimigh, Zairi and Al-Mashari 2003; Nah, Zuckweiler and Lee-Shang Lau 2003; Somers and Nelson 2004; Fang and Patrecia 2005; Finney and Corbett 2007; Chetcuti 2008; El Sawah, Abd El Fattah Tharwat and Hassan Rasmy 2008; Ngai, Law and Wat 2008; Dezdar and Sulaiman 2009; Xu *et al.* 2010; Aldayel, Aldayel and Al-Mudimigh 2011; Dantes and Hasibuan 2011; Ram, Corkindale and Wu 2013; Shaul and Tauber 2013; Pavlovna, Aleksandrovich, Petrovich and Yuryevna 2015). However, only a few studies seem to focus on the identification of CSFs within the individual ERP implementation life cycle phases, a problem highlighted by Esteves and Pastor (2006). Yu (2005) supports the call for further examination of this area as there is a shift towards improvements or additions being performed on already implemented ERPs and the development of larger, broader ERP systems. Furthermore, Ram, Corkindale and Wu (2013) as well as Ngai, Law and Wat (2008) contend that a difference exists in the identified CSFs for pre-implementation as opposed to post-implementation of an ERP. These authors call for more research in other areas of ERP post- implementation and use, for example, an investigation into the CSFs relevant to the adoption and use phase of an implemented ERP. A comprehensive study by Shaul and Tauber (2013), when investigating 10 years of research on CSFs in ERP Planning, unveiled a general shortage of literature addressing post-implementation issues, strategies and methods.

Some opine that there is a dire need for empirical studies to apply the CSF approach to an organisation that has already implemented an ERP (Al-Mashari and Al-Mudimigh 2003). With much of the prior research on ERP implementation success being aimed at a wide variety of organisations, there appears to be little research specifically for the higher education sector (Nielsen 2002; Abugabah and Sanzogni 2010; Aldayel, Aldayel and Al-Mudimigh 2011). Literature also portrays a dismally high percentage of ERP system implementation failures in HEIs compared to organisations (Abugabah and Sanzogni 2010). Perhaps, the reason for such failures is the fact that HEIs appear to be unique in context as well as unique in their needs (Rabaa'i 2009). This reason further motivates the need for more in-depth studies to be conducted in an effort to minimise ERP failures in the institutions.

When looking at the study from a vendor perspective, Shaul and Tauber (2013) report that the majority of studies have centred around vendor specific ERPs such as SAP and Oracle and argue that very little research is based on other vendor products. The ERP system typically used by HEIs is not one that was developed by SAP nor by Oracle ERP. This study would, therefore, expand on the body of knowledge by identifying the CSFs of the on-line system where the vendor is not SAP nor Oracle.

In addition to the points made above, most of the research on critical factors has been done against the backdrop of developed countries, with no research, at present (to the best of this researcher's knowledge), focussing on these factors in developing SADAC nations like South Africa.

Kalema, Olugbara and Kekwaletswe (2014) also stress the need for more rigorous scientific research that identify CSFs for ERP implementation. The authors criticise the majority of existing research for their mainly theoretical literature-based analysis and identification of CSFs. They further adopt a strong standpoint and proclaim that not all the CSFs that had been identified in the literature were, in fact, critical.

It is believed that a study of this nature would prove useful to other tertiary institutions that are customising already implemented ERPs. This study would assist other HEIs identify and allocate extra resources to critical areas that could increase the success of post-implementation customisation. The researcher is of the opinion that the framework developed will provide practical guidelines as to which factors need to be addressed within the implementation life cycle to increase the success rate of an on-line registration system implementation.

This research posits a shortcoming and a significant gap in existing literature, given the complexity of the implementation process. It is the view of this researcher that knowledge of success factors uncovered for a single phase will add to a growing body of knowledge determined to improve ERP implementation in higher education institutes.

1.4 Structure of the dissertation

The dissertation is arranged into five chapters, with chapter one providing an introduction and overview of the study as a whole. Chapter two provides the reader with an overview and understanding of the literature that exists with regard to ERPs and CSFs, revealing insight into the challenges existing in these areas as well as their extreme importance in organisations and HEIs. Chapter three follows with a description of the methodology that is used in the study. This includes the research framework, underlying philosophy and the research approach used. This is followed by the tool for data collection and the data analysis tool, i.e., ADVIAN. The focus of chapter four presents the fieldwork, details of the data gathered and the data analysis results. Chapter five follows with an interpretation of the data analysis, followed by Chapter six which summarises the results and concludes with a summary of contributions, limitations of the study, and future research suggestions.

Chapter two follows with a discussion of the literature in context of the research.

CHAPTER 2: Literature Review

The literature review is divided into a number of areas, starting with ERP systems, the implementation thereof, as well as the benefits and challenges of these implementations with reference to organisations as well as HEIs. This is followed by an introduction into CSFs, their importance in organisations and HEIs and a list of all CSFs that have been identified by the literature, specifically for ERP implementation. Lastly, a discussion ensues about where research is focusses on on-line registration systems.

2.1 ERP systems in organisations

The idea and popularity of ERP systems began in the 1990's and has become one of the most widespread software applications in use (Holland, Light and Kawalek 1999; Robey, Ross and Boudreau 2002). It appears to be only since the 2000's that organisations began combining many independent ISs into single, fully integrated systems (Huang, Yen, Chou and Xu 2003), with most organisations beginning investment in vendor ERP suites between the years 2000 and 2010 (Huang *et al.* 2003). These implementations have resulted in noticeable improvements in organizational areas such as productivity, service quality, service costs as well as better decision making (Ngai, Law and Wat 2008). Added to this foray are improvements in customer relationships, better integration (Xu *et al.* 2010) and improved efficiency of systems (Ngai, Law and Wat 2008; Xu *et al.* 2010). It is also widely accepted that ERP systems have an important role to play when it comes to managing the business processes of an organisation (Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Supramaniam and Kuppusamy 2010; Aldayel, Aldayel and Al-Mudimigh 2011). Moreover, it is through the use of the ERPs and their central database (DB) that real time information can be shared and disseminated to various departments that may span across various cities and countries (Supramaniam and Kuppusamy 2010).

Kumar, Van Hillegersberg and Experiences (2000) define an ERP as a configurable IS package, implemented across various functional areas of an organisation, combining information and information-based processes. These ERPs integrate ISs that support various functions such as accounting, finance, management, marketing as well as production, allowing for current, real time data to flow between the functional areas (Motiwalla and Thompson 2012). Furthermore, these systems have become "web enabled', allowing employees, clients, partners and vendors anytime, anywhere access to the system (Motiwalla and Thompson 2012).

For the purpose of this research, the researcher will focus on those pre-written ERP software packages available from vendors as opposed to a custom-written ERP software solutions.

2.1.1 Higher Education Institution (HEI) context

HEIs consist of academic staff, administrative staff and students, each exhibiting different interests in the same organisation. For academic staff, the institution is a place for teaching, researching and assessment. Students view the institution as a place for learning, living and development as contributing members of society. The administrative staff at these institutions share many similarities with the corporate environment, including management structures, hours of work and human resource practices (Duderstadt, Atkins and Van Houweling 2002). According to Pollock and Cornford (2004: 36), higher education can be seen as "a band of scholars coming together in pursuit and dissemination of knowledge, governed by a more or less collegiate model of organisation, based around a complex structure of committees and with a high degree of individual and departmental autonomy".

It can be seen from the above that HEIs are "unique" and should be regarded as different from organisations in the corporate sector (Lockwood 1985; Balderston 1995; Pollock and Cornford 2004). Literature further suggests that HEIs are far more complex than corporate organisations, having unique characteristics such as: unique administrative needs; autonomy; independency from other institutions; limited measurability of outputs; complexity of purpose; internal fragmentation; and diffuse structure and authority (Lockwood 1985; Pollock and Cornford 2004; Abugabah and Sanzogni 2010). Mudaliar, Garde and Sharma (2009) contend that the uniqueness of HEIs is shown in the activities, starting with the student's admission, followed by course registration, curriculum design and placement of students. The decision-making processes in HEIs also vary greatly from organisations where a more formal, hierarchical communication structure exists (Duderstadt, Atkins and Van Houweling 2002). This is due to the organisation of HEIs rather being along the lines of academic disciplines, which are then organised into schools, faculties or colleges and then further divided into smaller departments (Duderstadt, Atkins and Van Houweling 2002).

This organisation has resulted in the need to improve the efficiency and performance of administrative tasks (Allen and Fifield 1999). In addition, it is noted that the rising expectations of students, added performance and quality requirements as well as more competitive research funding have encouraged HEIs to strive for excellence in administration processes and prompted institutions to provide students with the best opportunities for a competitive advantage (Allen and Kern 2001; Fisher 2006; Okunoye, Frolick and Crable 2012). It is not only the competitive environment that has influenced the administrative processes, but rapid advancements in technology have seen the emergence of virtual laboratories, digital libraries as well as on-line learning classrooms (Duderstadt, Atkins and Van Houweling 2002).

When considering the influence that information technology (IT) has in HEIs, it is not surprising that these institutions have implemented ERP systems for the development and reengineering of administrative systems as a means of improving performance (King 2002; Abugabah and Sanzogni 2010) as well as automating processes and services in an attempt to gain a competitive advantage (Kumar, Van Hillegersberg and Experiences 2000; Karande, Jain and Ghatule 2012). These ISs provide the support of several hundred functions to thousands of students, professors, lecturers and university staff (Kwon 2008). It is due to the previously-mentioned distinctive character differences of HEIs that results in system requirements generally not adhering to those of the traditional ERP. Traditional ERPs were designed rather for organisations, which generally include HR, finance, operations, logistics and sales and marketing applications (Pollock and Cornford 2004). However, HEIs often require additional systems that can facilitate and process student admission, recruitment, registration, financial administration and financial aid (Pollock and

Cornford 2004), as well as course administration, facilities requirements (like timetabling) and other applications specifically designed for the academic environment (Abugabah and Sanzogni 2010; Ghuman and Chaudhary 2012). According to Kwon (2006), the IS, or ERP used by the HEI, is critical for the competency of the institution.

An ERP in higher education refers to a software solution for the automation of both the academic and administrative functions of an institution (Rico 2012), with the main objective of an ERP in an HEI being "to integrate different administrative functions into a more systematic and cost effective approach to gain a strategic advantage" (Rabaa'i 2009: 3). Based on this definition, in context of this research, an ERP system for higher education can be defined as a configurable IT solution that integrates and automates recruitment, admission, registration, financial aid, student records, timetabling and most academic and administrative services, offering both on-site and off-site access.

Importantly, most ERP systems or system components at HEIs are now web enabled, enabling the student anytime access to the system, thereby promoting the effectiveness of the institution (Motiwalla and Thompson 2012). Along with the many benefits that an ERP and its implementation brings, there exist many more difficulties and implementation failures at HEIs when compared to business organisations (Madden 2002; Abugabah and Sanzogni 2010). Literature suggests that ERP implementation has challenges for both organisations in the private sector as well as the HEIs in the public sector. There appears to be an abundance of literature on these challenges for organisations, but very little research specific to HEIs (Rabaa'i 2009). The literature also suggests that challenges experienced by organisations are also experienced by HEIs and, due to the uniqueness of HEIs, additional challenges are often present (Abugabah and Sanzogni 2010). It follows that the characteristics relevant to ERP implementation in organisations can also be attributed to ERP implementations in HEIs.

Due to the additional complexities and difficulties experienced at HEIs, it can also be said that HEI implementations deserve additional specifically focussed research attention (Pollock and Cornford 2004).

2.1.2 Benefits of ERP in organisations

It has become increasingly common for organisations and HEIs to purchase generic, well established software packages like ERPs (Pollock and Cornford 2004). This trend started as far back as the 1990's with ERPs being chosen in place of custom written software packages (Brady, Tierney and Williams 1992). These ERPs seem to be establishing themselves as the backbone for many organisations (Shanks *et al.* 2000; Al-Mashari and Al-Mudimigh 2003; Parthasarathy, Anbazhagan and Ramachandran 2007; Motiwalla and Thompson 2012) with the primary purpose of an ERP being to gather the best business practices and then use these practices to improve or replace existing business practices (Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Myerson 2001; Ram, Corkindale and Wu 2013), resulting in the information becoming more valuable and useful. Having the flow of information occurring both dynamically and timely would help make the information more valuable and useful (Motiwalla and Thompson 2012).

The successful implementation of an ERP within an organisation should realise many benefits (Shang and Seddon 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; King, Kvavik and Voloudakis 2002; Shang and Seddon 2002; Pollock and Cornford 2004; Spathis and Ananiadis 2005; Ngai, Law and Wat 2008; Xu *et al.* 2010; Motiwalla and Thompson 2012; Xu and Quaddus 2013). Some of the benefits that have been alluded to by these researchers include:

- Improved reliability, consistency, integration and sharing of information in the organisation. This is across all functional areas of the organisation which directly improves internal workflow and increases the quality and accuracy of data;
- Efficient integration of data flows, business processes and best business practices;

- Improved customer services through anytime, anywhere access to systems;
- Improved decision making and planning for management through real time access to data and information;
- Improved access to information via mobile interface systems;
- Effective use and management of communication channels;
- Noticeable improvements in organizational areas such as productivity, service quality and reduced service costs;
- Improved efficiency with regard to the use of hardware components as well as a reduction in the number of required resources;
- Improved IT infrastructure capability and maintenance due to centralised IT staff, trained to support the user's needs;
- Long-term performance, cost reductions and profitability can be observed after 2 or 3 years; and
- Enhanced security of data and applications due to centralization of hardware, software, DBs, etc.

It can be seen that there are a number of advantages and areas of improvement from which an organisation will benefit through the successful implementation of an ERP system. It follows that HEIs would also experience these same benefits (Fisher 2006), with these existing at institutional, employee as well as student levels. Many of the benefits listed above have particular reference to HEIs, with some researchers identifying benefits specific to the HEI context, as shown in table 2.1 below:

Table 2.1: ERP Benefits for HEI

Benefit	Researcher
Improved access to information for planning and managing the institution	(King, Kvavik and Voloudakis 2002)
Standardised student data	(King, Kvavik and Voloudakis 2002)
Improved services offered to staff, students and faculty	(King, Kvavik and Voloudakis 2002)
Reduced business risk	(King, Kvavik and Voloudakis 2002)
Improved efficiency resulting in an increase in income and decrease in expenses	(King, Kvavik and Voloudakis 2002)
System modernisation including inclusion of web-based interfaces	(Oliver and Romm 2001)
Increased usability and flexibility	(Oliver and Romm 2001)
Better data and system integration	(Oliver and Romm 2001)
Reengineering of business processes	(Oliver and Romm 2001)
Reduction in maintenance	(Oliver and Romm 2001)
Risk avoidance	(Oliver and Romm 2001)
Reduction in data duplication	(Karande, Jain and Ghatule 2012)
Removal of human error	(Karande, Jain and Ghatule 2012)
Routine task automation	(Karande, Jain and Ghatule 2012)
Improved efficiency for generating attendance registers and examination sheets	(Karande, Jain and Ghatule 2012)
Improvements to timetable systems	(Karande, Jain and Ghatule 2012)
Efficiency of registration and enrolment of courses	(Karande, Jain and Ghatule 2012)
Higher degree of transparency	(Karande, Jain and Ghatule 2012)

With higher education sector becoming far more competitive, Qian, Schmidt and Scott (2015) also posit that the implementation of an ERP has the potential for realising a competitive advantage over other institutions.

2.2 Modular Design of an ERP

The HEIs, as well as organisations, have many functional areas, each requiring specialised IT-based systems. ERP software products are designed with this characteristic in mind and typically comprise a set of interrelated modules, each tuned to a specific business function. It has been found that many ERP vendors are changing their model and are moving towards separate modules for each of these functional areas (Sprott 2000; Dittrich, Vaucouleur and Giff 2009). Using this approach, the entire ERP is separated into modules which can be implemented separately by the organisation or HEI. This allows small- to medium-sized organisations the ability to slowly introduce components that will improve their operations (Sprott 2000) as their budget allows. This further caters for multiple configuration options (Dittrich, Vaucouleur and Giff 2009). The idea of this phased, flexible implementation approach is supported by McCarthy, David and Sommer (1996) and would be highly beneficial to all ERP users as a means of implementing components as the need, budget and resources allow, without compromising one of the most important aspects of the ERP, that being the integration of separate modules. The modules developed for organisational use are typically developed for the following areas: Supply Chain Management (SCM); Human Resource Management Systems (HRMS); Accounting and Financial Management; Customer Relationship Management (CRM); Plant Management; Material Management; Engineering and Maintenance Management; and so on with the naming of the modules being different among ERP vendors.

Not only does an ERP consist of many integrated system modules, but the system also consists of many components. For an ERP to deliver the benefits and goals that the organisation or institution desires, it is necessary that all components work together (Motiwalla and Thompson 2012). The key components in an ERP system (as well as any IS) are: hardware; software; DB, processes; and people. It has been found that many implementation failures are often caused by a lack of attention to the processes and people (Motiwalla and Thompson 2012). It will become apparent later, in section 2.3.2, that challenges exist in many of these component areas. The implementation of ERP systems for HEIs often starts with the basic functionality being implemented some time before the implementation of extra modules, such as an on-line registration or a timetabling system. Each of these additional modules integrate into the original ERP on implementation thereof. Due to the integration with existing modules, it is highly likely that additional challenges might be encountered in this implementation.

2.3 ERP Implementation

Even though organizations already had software systems that performed all the functions of an ERP, the ERP software environment, with its standardization and integration, provides a degree of interoperability that is not easily achieved with stand-alone, custom-built and legacy systems (Milford and Stewart 2000). Botta-Genoulaz and Millet (2006) summarized the motivations for adopting an ERP system from an operational aspect as follows: poor or not competitive business performance; cost structure too high; unsatisfactory response rate to customers and suppliers; complex, ineffective business processes; inability to support new business strategies; business becoming too global; and inconsistent business processes. With these motivations in mind, ERP implementation refers to the adoption of an ERP solution that suits the needs of the business, organisation or HEI.

ERPs are not cast in stone, but need to be flexible and should evolve and change with the environment of the organisation or HEI in which it operates (Motiwalla and Thompson 2012). This is further supported by the modular design and nature of ERP systems previously discussed. The implementation of any system is usually time consuming, complex and resource intensive. The added size of an ERP further increases the complexity, resulting in the need for a plan and an understanding of the implementation life cycle before implementation commences (Motiwalla and Thompson 2012). A number of researchers have developed ERP life-cycle process models or frameworks as a way to better understand the process of adopting an ERP system. A number of these models will be discussed in the next section.

2.3.1 ERP Implementation Models

The life cycle of an ERP is significantly different (Dezdar and Sulaiman 2009) to that of traditional software. This is due to the ERP requiring configuration and customisation of the product to fit the organisation (Brehm and Markus 2000). The general life cycle of an IS is the development, implementation and maintenance, whereas the life cycle of an ERP includes many revisions and re-implementation after the initial implementation has taken place (Chang 2004).

ERP and system implementations are usually complex, time consuming, and resource intensive. With ERP systems continuously changing and evolving at a rapid pace, and having long implementation periods (Poston and Grabski 2001), researchers have developed differing models for ERP implementation (Shaul and Tauber 2013) to accommodate these changes. It, therefore, is important that the organisation understands the ERP implementation life cycle as a means of ensuring that planning takes place to maximise the realisation of the long-term investments (Motiwalla and Thompson 2012). It is also imperative that a proven methodology is used so that deadlines are met, costs are within budget and the client's requirements are realised (Motiwalla and Thompson 2012).

Implementing an ERP involves many activities starting with planning, moving through various project phases and then, once the ERP is operational, the need for a post-implementation review (Gelinas, Dull and Wheeler 2011), and later the stabilisation phase. It is widely cited in literature that ERP implementation consists of four main phases, namely: planning (or pre-implementation); implementation; stabilization into normal operation; and lastly enhancement - which encompasses continual upgrades and improvements (Shaul and Tauber 2010). Many researchers refine these phases further, sometimes adding sub-phases and some changing the name of the phase.

One of the first ERP life cycle structures, presented by Bancroft, Seip and Sprengel (1998), focussed specifically on the implementation of the SAP R/3 ERP. The model consists of five phases, focussing on the planning and acquisition activities at the start, through to the implementation of the ERP, which was the final phase. Importantly, this model does not include a phase that deals with maintenance, support or the addition of modules or the rollout of upgrades to the ERP. In the same year, a five-phase model was developed by Ross (1998) in which the distribution of activities across the phases differed. The first two phases dealt with the planning, design, acquisition and implementation of the ERP, with the last three phases focussing on maintenance, as well as the addition of new functionality and transformation. These last phases are vital as there is always a need for new upgrades to be implemented by the vendor as well as new functional requirements that may be needed by the organisation, often resulting in the final phases being most resource intensive.

Many other models have been presented by researchers (Esteves and Pastor 1999; Markus and Tanis 2000; Shanks 2000), with these models ranging from a 3-phase model with sub-phases developed by Shanks (2000), to the 6-phase model presented by Esteves and Pastor (1999). What is important in the context of this research is that each of these models has a phase dealing with the addition of a new module to the ERP, for example, the on-line registration system. The addition of the new modules fits into the "enhancements" phase in the well-cited Project Phase Model (PPM) of Shanks (2000), into the "onwards and upwards" phase of the model developed by Markus and Tanis (2000) and into the "infusion" phase of the framework of Somers and Nelson (2004).

A more recent model was developed and presented by Motiwalla and Thompson (2012) and supported by Shaul and Tauber (2010). This model is discussed and expanded upon in their text "Enterprise Systems for Management" (Motiwalla and Thompson 2012). The authors have been cited many times and have used this model as the basis for research regarding factors for successful implementation of ERPs (Shaul and Tauber 2010, 2012, 2013). The phases that are represented by this model include:

- Planning or Requirements Gathering and definition phase – requirements are gathered, the software and vendor are selected and the system is designed;

- Implementation or Build and go-live phase – the ERP is built, tested and implemented as well as user training performed;
- Stabilization phase – bugs are fixed, additional training is done; and
- Ongoing support phase is divided into 3 sub-phases:
  - Backlog phase – any user requirements that have not been met are addressed;
  - New Module phase – new modules are added as time progresses; and
  - Major Upgrade Phase – vendor upgrades and fixing of system bugs are performed.

No system is ever complete and it is for this reason that there is always a need for additional modules to be incorporated (Motiwalla and Thompson 2012) and, thus, the need for the "new module" phase. The on-line registration system, in this study, is an example of this need, with the ERP system having already been implemented and the on-line registration system implemented as a new, additional module. It is for this reason, in the context of this study and due to the site used in this study not having a formalised ERP implementation model, that this study advocates that the implementation of the on-line registration module be placed in the new module phase.

During the implementation of an ERP or a component of an ERP, many challenges are faced by the implementation team, the organisation or institution, as well as the users. This researcher is of the opinion that it is necessary to distil these challenges, as many of them are identified in the literature as factors that become critical for a successful implementation. Table 2.2 provides a summary of modules for ERP implementation.

Table 2.2: Summary of Models for ERP Implementation

Authors	Planning	Implementation	Stabilization	Ongoing
Bancroft, Seip and Sprengel (1998)	• Focus • As is • To be • Construction and testing	• Actual implementation		
Ross (1998)	• Design	• Implementation	• Stabilization	• Continuous improvement • Transformation
Esteves and Pastor (1999)	• Adoption • Decision • Acquisition	• Implementation	• Use and maintenance	• Evolution • Retirement
Markus and Tanis (2000)	• Chartering	• Project	• Shakedown	• Onward and upward
Shanks (2000)	• Planning	• Project		• Enhancements
Somers and Nelson (2004)	• Initiation • Adoption	• Adaption	• Acceptance • Routinization	• Infusion
Motiwalla and Thompson (2012)	• Planning	• Implementation	• Stabilization	• Backlog • New module • Major upgrade

2.3.2 Challenges of ERP Implementation

More often than not, organisations share a common goal with regards to the ERP implementation - that being a fast, seamless, error-free implementation with little disruption to normal operation and business processes (Doyle 2000). Despite this ultimate goal and the many benefits often associated with ERP implementation, it appears that a large number of ERP project implementations have not been successful (Soh, Kien and Tay-Yap 2000; Abugabah and Sanzogni 2010). Chang (2004) indicates that 90% of ERPs implemented are late or go over budget. Also, alarming, are reports that the failure rates of ERP implementations are in a range between 60% and 90% (Chang 2004; Xu *et al.* 2010; Al-Shamlan and Al-Mudimigh 2011), with further indications that over 40% of large-scale ERP projects fail and 60% – 80% of all ERP systems did not meet the outcomes that were expected (Mehlinger 2006). Furthermore, it has been found that many organisations have not used the implemented ERP to its full potential (Stein and Caldwell 1998; Markus, Axline, Petrie and Tanis 2000).

It is well known that the purchase and acquisition of an ERP requires dedicated resources in terms of cost, time and people. Group (2011) further stresses that a large number of organisations continue to suffer from ERP project overruns due to unrealistic expectations with regard to duration and resource allocations. Despite many organizations attempting to implement ERPs that address the business needs without going over budget or having unexpected delays, Kalema, Olugbara and Kekwaletswe (2014) report a significant number of terminated ERP implementation projects due to burgeoning complexities, having high-cost overruns and overall failure. ERP implementation failure due to the high degree of complexity is also supported by Scott and Vessey (2000); Helo, Anussornnitisarn and Phusavat (2008) and Maditinos, Chatzoudes and Tsairidis (2011). A concerning finding by Tanriverdi, Konana and Ge (2007) is that some organisations that have adopted an ERP system still have their own operational in-house systems which they continue to develop. These organisations do not move forward with the implementation due to the time it will take to move over to the new ERP and the possible risks that are involved in its replacement.

The problems listed above have led to much research and interest in the implementation of ERP systems and the identification of factors that contribute to the success or failure of a project (Bingi, Sharma and Godla 1999; Esteves and Pastor 2000; Soh, Kien and Tay-Yap 2000; Somers and Nelson 2001; Al-Mashari and Al-Mudimigh 2003). Somers, Nelson and Ragowsky (2000) indicate that, because of the high failure rate of ERP implementations, there exists a need for a better understanding of the processes, with Shaul and Tauber (2013) reporting that, despite it being difficult to predict the success and long-term survival of an ERP, many organisations eagerly commit to an implementation without investigating this fully.

Despite the researcher's best efforts, only a few sources have been found that focus specifically on the challenges of ERP implementation within the context of a higher education environment. Hence, the sources cited here mainly explore ERP challenges in organisations. It has already been established that HEIs experience similar challenges and benefits to those of organisations, so it follows that the challenges identified for organisations will also be relevant to HEIs (Pollock and Cornford 2004).

It is reported that, in the education sector, HEIs have made significant financial investments in ERP systems (Mehlinger 2006), spending in excess of $5 billion dollars in the few years prior to 2010 (Abugabah and Sanzogni 2010). It is also reported that 50% of ERP implementations in HEIs go over budget or exceed the planned timeframe (Kvavik 2002). These statistics concur with those reported for organisations. Moreover, Mehlinger (2006) reports that a staggering 60 to 80 percent of higher education ERP implementations failed to meet the outcomes that were expected and the result of the implementation was unsuccessful. A further concern reported by Abugabah and Sanzogni (2010) was that a number of ERP implementations for HEIs had not lived up to the expected levels of functionality.

A number of challenges specific to implementation of an ERP have been identified by researchers. The list below is by no means exhaustive, but includes all those challenges of interest to the study.

2.3.2.1 ERP Selection

In many cases, the ERP system does not fit the organisation. This is often due to the business practices of the ERP not fitting the business practices of the organisation. When this is the case, there is often an increased need for software customization, resulting in extra implementation cycles and an increase in the number of resources required and, ultimately, the project takes longer than expected. The organisation must, therefore, know its own business practices and have extensive specifications listed before choosing an ERP system (El Sawah, Abd El Fattah Tharwat and Hassan Rasmy 2008). The ERP selected should match these business processes and specifications as closely as possible The management must also be aware that ERP systems have a certain amount of inflexibility and must identify those possible inflexibilities.

2.3.2.2 Project Management

Many organizations are not aware of the size and complexity that exists throughout the life cycle of ERP implementation (Basu and Kumar 2002). A full time project team, including representatives from management levels, is needed to take ownership of the project, and must be empowered to do so. This team should have the knowledge of available funding, personnel, hardware, suppliers and so on that would be needed for successful ERP implementation (Shaul and Tauber 2013). Good project management skills are needed for successful project implementation which will prevent unnecessary costs and time overruns (Zhang, Lee, Huang, Zhang and Huang 2005).

2.3.2.3 Senior or Top Management

It is imperative that senior management remains committed to the entire process, so that the project is not jeopardised (Ngai, Law and Wat 2008). Without top management's display of support, commitment, and leadership, it is possible that there might be employee resistance to changes that are implemented (Aladwani 2001).

2.3.2.4 Data Management

Existing data that are inaccurate, incomplete, inconsistent or inaccessible, could negatively affect the implementation of the ERP. Correcting these data errors, after implementation, leads to increased costs and could also lead to implementation delays (Xu, Horn Nord, Brown and Daryl Nord 2002). Additional delays could be experienced if the data model of the software does not match or is not compatible with the organisation's data (Soh, Kien and Tay-Yap 2000).

2.3.2.5 Training

In order that the full functionality of the ERP system is used, all users need to be well trained on the business processes of the ERP as well as its use (Umble, Haft and Umble 2003; Shaul and Tauber 2013). Without this training, there is an increased risk of user dissatisfaction and resistance towards the system (Sumner 1999).

2.3.2.6 Communication

This was further cited as a main challenge in studies conducted by Mahrer (1999) and Allen and Kern (2001) and is supported by Vevaina (2007), who found that managing human risk, such as cultural influences through effective communication, was crucial to the success of an implementation that took place at an Australian university.

2.3.2.7 Involvement and Commitment of Users

The implementation of an ERP affects a large part of the organisation with some employees being resistant to the change. It then becomes difficult to get commitment from these employees so that full use is made of the ERP (Davenport 2000; Gargeya and Brady 2005; Parthasarathy, Anbazhagan and Ramachandran 2007). Possible reasons for users being resistant to change could be due to the user being afraid of changes in: ease of use; job status; importance; job security; and responsibility (Shaul and Tauber 2013). Al-Shamlan and Al-Mudimigh (2011) as well as Jing and Qiu (2007) indicate that the main reason for failure of ERP systems is the users' resistance to change and the users' non-acceptance of new systems.

2.3.2.8 Organisational Culture

According to Tsichritzis (1999), HEIs view themselves as businesses, with students being the customers. With the implementation of an ERP system often encouraging the institution to take a more business-like approach, cultural changes are required (Allen, Kern and Havenhand 2002). These changes are often met with resistance, as not just technological changes are taking place, but organisational changes as well. In a study conducted by Allen and Kern (2001), in which four United Kingdom universities were studied, it was found that the culture of the organisation remains a challenge and had a marked effect on the successful implementation of ERPs in the institutions. Academics at the institution may also fear that the new system, with its increased transparency, could result in loss of control and administrative staff might worry about job security due to automation of processes (Pollock and Cornford 2005).

2.3.2.9 Customisation of the ERP

When the organisation requires changes and adaptations to an ERP that go beyond the adaptations envisioned by the vendor, the source code needs to be adapted. These sources-based customisations can range from simple report generations to more complex add-ons for a particular business or industry (Dittrich, Vaucouleur and Giff 2009). It is, therefore, important that a distinction is made as to what customisation entails. For this study, *customisation* refers to the software changes made to pre-packaged software so that the gap that exists between the business processes of the organisation and the business processes of the software is narrowed (Dittrich, Vaucouleur and Giff 2009). *Configuration* refers to setting the parameters of the ERP so that the organisation's features are best reflected (Brehm, Heinzl and Markus 2001).

Customisation is a recurring challenge that is observed in many studies focussing on organisations as well as HEIs and is generally not supported by vendors as it is often a cause of major difficulties (Gibson, Holland and Light 1999). Some of these difficulties experienced are specific to upgrades and maintenance of the system (Parthasarathy 2012). Some researchers posit that the ERP system must be changed or *customised* to fit the organisation (Dittrich, Vaucouleur and Giff 2009; Olson and Riordan 2012) whereas others feel that the organisation must change to fit the system (Chen, Law and Yang 2009), with Light (2001) reporting that, according to vendors, incompatibilities that exist between the system and the organisation can be overcome through *customisation*. Light (2001) also believes that many vendors are using the flexibility of the modular design of the ERPs that allows the organisation to choose from many 'business process templates', as a marketing strategy. It is for this reason that many vendors, therefore, try to accommodate an organisation's differences by adding modules that are specific to different sectors (Scott and Kaindl 2000).

An important observation, by researchers, shows that changes or modifications to the wrong parts of the system as well as over *customisation* to industry standards can lead to numerous system or implementation problems (Brady, Tierney and Williams 1992; Hanseth and Braa 1998). When too much *customisation* is done, the system ends up moving far from the industry standards which results in difficulty in the implementation of upgrades and new functionality (Light 2001). In addition, the *customisation* of an ERP is also costly and time consuming (Shehab, Sharp, Supramaniam and Spedding 2004).

In many cases, organisations are forced to compromise and accept the outcomes provided by the ERP purchased and mould the organisation to fit the system structure that has been provided by the vendor (Koch 1999; Markus *et al.* 2000; Wagner, Galliers and Scott 2004). This is due to there being a large number of technical and organisational differences that exist during *customisation* (Hanseth and Braa 1998; Ciborra 2000; Walsham 2001) as well as the time taken for these modifications (Koch 1999; Markus *et al.* 2000).

In line with the context of this study, Asemi and Jazi (2010) conducted a comparative study between developed and developing countries in which it was found that the importance of attention given to *customisation* was citied more often in developed countries than in developing countries. Additionally, in a South African study, Malie, Duffy and van Rensburg (2008) opine that the degree of *customisation* has a direct impact on the cost of the implementation with many participants being of the opinion that it is easier to change the product rather that change the current processes.

2.3.2.10 Centralised vs Decentralised Structures

Most ERP systems are designed for centralised structures and are not well suited to organisations that have decentralised structures and do not adhere to the norms. According to Fan, Stallaert and Whinston (2003), this is yet another reason for the failure of ERP system implementation.

The need for further investigation to identify the areas where challenges are most prevalent is supported by Abugabah and Sanzogni (2010), who indicated that, even though most HEIs have implemented ERP systems (Nielsen 2002), research regarding ERPs in higher education has been neglected, not just in specific countries, but across the globe. As far as the researcher can establish, there is also a lack of literature specific to the implementation of an additional module, specifically on-line registration and it is believed that this research will contribute to the body of knowledge that exists in the area of challenges encountered with the implementation of an additional module such as on-line registration.

It appears that the literature does not separate on-line registration implementation from typical ERP implementation, but this study proposes that on-line registration deserves closer and separate attention.

2.4 Critical Success Factors in General

In many cases, extensive resources are dedicated to the acquisition and implementation of new IT-based technologies, including ERP systems. It, therefore, follows that, for organisations and HEIs, it is critical that these projects are successful. In order for projects to be successful, it is important that the critical or essential areas are well represented and implemented. These essential areas or essential components can be referred to as Critical Success Factors (CSF). By identifying the CSFs for a project, everyone in the team will know what the most important aspects of the project are and will have common, clearly defined aims.

D. Ronald Daniel, first presented CSFs in the 1960's (Rockart 1979). His work was then extended in the 70's by John F. Rockart (Rockart 1979), who became one of the first people to study CSFs in the context of an IT implementation. According to Rockart (1979), the CSFs for any business are the limited, essential areas that must be performed correctly to ensure a business achieves successful competitiveness and flourishes.

The CSFs have been extended and implemented in many different environments within business as well as in the implementation of software. ERP software solutions is one such area that has had considerable research done into the various CSFs that exist for its successful implementation. Early researchers that focussed on CSFs for ERPs include Bingi, Sharma and Godla (1999); Fui-Hoon Nah, Lee-Shang Lau and Kuang (2001) and Holland and Light (1999). Holland and Light (1999) define CSFs for ERP implementation as the factors that are essential for an ERP project to be successful. To expand on this definition, CSFs for successful ERP implementation are defined as:

> "A set of activities that need special considerations continual attention for planning for and implementing of an ERP system" (Rabaa'i 2009).

In addition, Verville, Bernadas and Halingten (2005) note that a CSF, on its own, is not sufficient to ensure the success of an implementation, but several critical success factors are needed to ensure success.

2.4.1 Defining success and criticality

The definition or clarification of success becomes necessary, but it is difficult to evaluate and define because it is multidimensional and relative to both time and the objectives that might have been set. Literature on ERP implementation success suggests that success is defined in terms of achievement of predetermined goals regarding cost overrun, schedule overrun, system performance deficit and failure to achieve the expected benefits of the system (Hong and Kim 2002). A successful ERP implementation is further defined as a project that, over time, results in financial benefits for the company through more accurate market forecasting, increased production efficiency, improvements in customer service and more (Umble, Haft and Umble 2003). However, there seems to be no clear definition for "success" in the academic realm as well as in practice (Markus and Tanis 2000; Zhang *et al.* 2005). In terms of project success, this can be measured by the extent to which the project result is achieved, in terms of budget and schedule or by the extent to which the business goals are met (Markus and Tanis 2000). It, therefore, follows that success can be measured differently when examined from different viewpoints and it is important that success is rather measured from the perspective of the organisation or institution's management and the measurement tool be based on a set of success metrics that look at the different dimensions that exist, for example, technical, organisational and personnel (Markus and Tanis 2000).

When it comes to criticality of factors, according to Kalema, Olugbara and Kekwaletswe (2014), not all elements are critical. They define critical factors as those factors that have a high influence on the system and have a high influence on other factors. The measure of criticality will be further elaborated on in chapter 3, section 3.3.3.3. In the context of this study, the criticality of a factor is defined as:

“Factors that have a high influence on other factors, are highly influenced by other factors and therefore influence the success of the on-line registration implementation”. This achieves the first objective of the study, which is to define *the criticality* in the context of successful on-line registration implementation.

In the context of this study, the researcher believes that critical success factors are defined as those factors that are extremely influential in the system as well as on other factors, are essential for achieving the predetermined goals and objectives of the system being implemented and are necessary to produce a high quality system that is delivered on time, within a budget and with a high level of acceptance by the users.

2.4.2 Importance of identifying Critical Success Factors

ERP systems are designed using best business practices with the majority of ERPs’ implementations in HEIs being designed by prominent software houses such as SAP, Oracle, PeopleSoft, Microsoft, Siemens AG and Sungard (Abugabah and Sanzogni 2010). Despite this design and the large amount of resources invested in these systems, literature shows that the implementation of many ERP systems still fails. It is, therefore, essential that the CSFs for implementation of ERP systems are identified. Ram, Corkindale and Wu (2013) provide a summary of the problems and/or failures that were recently experienced in ERP system implementation. Within the findings, ten projects, in 2011, were identified, with eight being listed as major corporate companies in the USA, one from Australia and one from the UK. The cost of these project failures amounted to billions of pounds and billions of dollars. The reasons for the project failures included, among others, cost overruns, drop in net income, implementation issues, lawsuits due to implementation failure, non-delivery of expected results and the system not meeting the customer’s expectations. These reasons further highlight the need and importance of further research being conducted to help reduce failure levels. It becomes vital in the South African context, with the immense pressure being placed on the budgets of HEIs, with the recent uprisings such as the #feesmustfall national campaign, that there is a dire need for ERP implementations to be completed within a budget and within the allocated time constraints.

By careful management of the identified CSFs, HEIs should improve the success of ERP implementation (Kalema, Olugbara and Kekwaletswe 2014). These authors also propose that, by applying good management skills to other success factors that were not identified as critical, the success of ERP implementation would be further improved. Careful management of the CSFs identified in the on-line registration system as well as good management skills of those factors identified as critical could improve the success rate of an on-line registration implementation.

2.4.3 Critical Success Factors for ERP implementation

Literature portrays an abundance of CSFs for ERP implementation, with publications presenting a different set of CSFs as well as different names being used for the same CSF, dependent on the way the data were classified. Many of the CSFs identified by researchers have been based on literature reviewed and not on empirical data methods, with very few frameworks or models having been developed for the identification of CSFs for implementation of ERP systems (Shaul and Tauber 2013).

An on-line registration system is a module that is added to an existing ERP system. It, therefore, fits into the post-implementation phase of ERP implementation and attracts critical success factors from this phase (Shanks *et al.* 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Somers and Nelson 2001; Al-Mashari and Al-Mudimigh 2003; Esteves and Pastor 2006; Shaul and Tauber 2010). As postulated by previous researchers, the phase in which the addition of a new module takes place differs extensively. Although all the phases, that are named and cited, exist in the post-implementation category, different names or descriptions have been used by different authors and researchers. Esteves and Pastor (1999) use the phase name evolution, whereas Ross (1998) refer to this phase as the continuous enhancement phase. The same phase is referred to as onward and upward by Markus and Tanis (2000) and Nah and Delgado (2006), infusion by Somers and Nelson (2004), enhancements by Shanks (2000) and merely post-implementation by Ijaz, Malik, Lodhi, Habiba and Irfan (2014). Shaul and Tauber (2013) and Motiwalla and Thompson (2012) both refer to the post-implementation phase as the ongoing support phase, which then gets divided into three sub-phases, one of which is the new module phase.

A few researchers have looked at CSFs for ERP implementation, in context of the various implementation life cycle phases (Shanks *et al.* 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Somers and Nelson 2001; Al-Mashari and Al-Mudimigh 2003; Esteves and Pastor 2006; Shaul and Tauber 2010). Some studies find that CSFs should be identified and analysed at each phase of implementation (Esteves and Pastor 2006) with some factors only being significant to certain phases (Somers and Nelson 2001).

As stated in an earlier section, the implementation of an on-line registration system is positioned within the New Module phase of the model developed by Motiwalla and Thompson (2012) and, once again, there seems to be a lack of literature that is specific to CSFs for successful ERP implementation in the various phases of the implementation life-cycle. However, according to Nah and Delgado (2006), implementing a new module to an existing ERP follows the same phases as a new, full ERP implementation, with the CSFs identified for new modules matching those for ERP implementation. The researcher, therefore, believes that the same CSFs identified for the entire lifecycle can be applied to the implementation of a new module, like the on-line registration system. In addition, there are a limited number of studies that have been conducted at HEIs, and, therefore, a limited set of CSFs specific to institutions exists with all of the CSFs identified for HEIs included in the set of CSFs generated from literature for organisations. Therefore, based on the researcher previously establishing that HEIs are similar to organisations and can be treated as such, as well as the view that an on-line registration system can be treated as an ERP, the CSFs identified from literature for organisations, across the entire ERP implementation lifecycle and presented below in table 2.3 will be used in the fieldwork for this study. It must be noted that some researchers have indicated that different sets of success factors exist for different phases of the implementation life-cycle (Ram, Corkindale and Wu 2013) with a call for more research in this area. The researcher acknowledges that this might be a limitation of the study.

To identify the CSFs for ERP implementation success from previous literature, the researcher used a content analysis technique, which follows a set of systematic review steps (Khan, Kunz, Kleijnen and Antes 2003). Search engines were used to retrieve relevant research papers from journals, conference proceedings and other academic DBs. The literature search included various combinations of the following words and phrases: “ERP”, “enterprise resource planning”, “CSF”, “critical success”, “critical factor” and “implementation”. The documents returned were analysed for success factors. A total of 38 documents were analysed, which gave rise to a number of different factors with the most relevant 20 different factors being presented in the table 2.3.

Table 2.3 represents a summary of the identified factors for the entire ERP implementation lifecycle. These include studies based on organisations as well as studies done at HEIs and CSFs identified for the “New Module” phase of the ERP implementation life-cycle. The identified CSFs have been placed in 4 different categories: ERP Environment, ERP Implementation project, ERP User and Organisation, while other researchers have based their classifications on different factors (Markus and Tanis 2000; Al-Mudimigh, Zairi and Al-Mashari 2003; Zhang, Lee, Zhang and Banerjee 2003). The frequency column indicates the number of documents that reference that factor. It must also be noted, at this point, that some of the documents reviewed only looked at specific categories of factors, for example, only strategic factors, and not all areas of ERP implementation. The author of the article did not negate the existence of other categories, but merely chose to focus on one category in particular for that study. It is the researcher’s opinion that this could result in a slightly skewed frequency value which could be a limitation of the study.

Due to many researchers using varying names for the same factor, the factor name that was used more frequently in the literature as well as the name that best explains the factor have been used in this study. In some cases, literature portray an abundance of factors, with Shaul and Tauber (2013) identifying a list of 84 CSFs. This is due to the author unpacking each factor into multiple sub-factors. The researcher has chosen to follow other researchers who have rather chosen not to focus on sub-factors, but rather on logical groupings (Finney and Corbett 2007; Dezdar and Sulaiman 2009). From table 2.3 below, it can be seen that the researcher has only selected those factors with a frequency of 5 or more to take forward to the fieldwork. The researcher acknowledges that each vendor may have his/her own implementation approach and organisations could have different goals for the system being implemented. Therefore, theoretically, that there could be a number of combinations that could affect the success of an implementation.

Table 2.3, presented below, satisfies objective 2 of the study: To **establish, refine and categorise a set of factors that are deemed necessary for successful on-line registration implementation through literature for use in the fieldwork.** It is these factors that will be taken through to the fieldwork and presented in the questionnaire.

Table 2.3: Summary of CSFs for the ERP implementation lifecycle

CSF	Discussion / Definition	References for organisational studies	HEI Studies	New Module Phase Studies	Freq-uency
		ERP ENVIRONMENT			
ERP Vendor Support and Guidance	Vendors provide guidance, support, technical expertise and training to the organisation throughout the implementation process and, therefore, it is of utmost importance to the success of the project that the vendor is reliable, financially stable and provides the highest level of support (Bingi, Sharma and Godla 1999; Verville and Halingten 2002; Al-Mashari and Al-Mudimigh 2003; Somers and Nelson 2004). When looking at the system the vendor is supplying, Davenport (1998) specifies that many organisations do not look at whether the system fits the business processes, which ultimately reduces the amount of customisation required. It follows that, to reduce the amount of customisation necessary, the selected system must match the organisation's business processes as closely as possible (Somers and Nelson 2001; Verville, Bernadas and Halingten 2005; Shaul and Tauber 2013).	(Bingi, Sharma and Godla 1999; Verville and Halingten 2002; Somers and Nelson 2004; Ngai, Law and Wat 2008; Upadhyay and Dan 2008; Dezdar and Sulaiman 2009; Shaul and Tauber 2010; Supramaniam and Kuppusamy 2010)	(Aldayel, Aldayel and Al-Mudimigh 2011; Karande, Jain and Ghatule 2012)	(Shaul and Tauber 2012)	11
Expert ERP Consultant	The need to employ an external ERP consultant has been widely supported by many researchers (Bingi, Sharma and Godla 1999; Al-Mudimigh, Zairi and Al-Mashari 2001; Al-Mashari and Al-Mudimigh 2003; Shaul and Tauber 2013) with Ifinedo (2008) proposing that the external ERP consultant is more critical than top management support as well as the project plan and vision. It is further proposed that the consultant is able to compensate for a lack of internal expertise and inadequate top management support. The consultant would be responsible for analysing the business needs, selecting a vendor and package and managing the implementation (Wagner and Monk 2008). It follows that the following skills would be needed: technical knowledge, functional knowledge, interpersonal skills, industry knowledge and possible specialisation for particular modules of an ERP (Bingi, Sharma and Godla 1999; Sumner 1999). Lastly, it is imperative that the knowledge of the consultant gets passed on to the organisation (Al-Mashari and Al-Mudimigh 2003) so that the organisation becomes less dependent on the consultant.	(Sumner 1999; Esteves and Pastor 2000; Shanks *et al.* 2000; Somers and Nelson 2004; Finney and Corbett 2007; Ifinedo 2008; Upadhyay and Dan 2008; Dezdar and Sulaiman 2009; Shaul and Tauber 2010; Supramaniam and Kuppusamy 2010)	(Aldayel, Aldayel and Al-Mudimigh 2011; Karande, Jain and Ghatule 2012)	(Somers and Nelson 2004)	13
Software integration	During the implementation process, for all the benefits of an ERP to be recognised, the system needs to be integrated into the entire organisation (Bingi, Sharma and Godla 1999). During integration and implementation, it, sometimes, becomes necessary for an extra code to be developed so that the legacy system (existing system) and ERP software integrate fully (Holland and Light 1999).	(Bingi, Sharma and Godla 1999; Holland and Light 1999; Esteves and Pastor 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Al-Mudimigh, Zairi and Al-Mashari 2003; Ngai, Law and Wat 2008; Dezdar and Sulaiman 2009; Shaul and Tauber 2010; Wickramasinghe and Gunawardena 2010; Aldayel, Aldayel and Al-Mudimigh 2011; Shaul and Tauber 2013)	(Karande, Jain and Ghatule 2012)	(Shaul and Tauber 2012)	13

Software testing and troubleshooting	While implementing the system, testing and troubleshooting are needed to ensure that the software is functioning correctly (Holland and Light 1999). This is done by performing testing and simulation runs prior to the system "going live" (Kumar, Van Hillegersberg and Experiences 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Al-Mashari and Al-Mudimigh 2003). To improve the chance of implementation success, a testing and troubleshooting architecture should be developed (Shaul and Tauber 2013), which should include a plan for testing the interface with any existing system (Shaul and Tauber 2013)	(Bingi, Sharma and Godla 1999; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Al-Mudimigh, Zairi and Al-Mashari 2003; Finney and Corbett 2007; Shaul and Tauber 2010; Wickramasinghe and Gunawardena 2010; Aldayel, Aldayel and Al-Mudimigh 2011; Shaul and Tauber 2013)	(Karande, Jain and Ghatule 2012)	(Shaul and Tauber 2012)	10
		ERP USER			
User Training	User training is essential so that a solid understanding of the system is achieved and the system can be used to its full potential (Umble, Haft and Umble 2003). This training could also reduce the degree of user resistance to the new ERP system (Sumner 1999), thereby increasing user satisfaction and maximising ERP benefits. It has been found that efforts put into user training have resulted in higher paybacks and a more successful ERP implementations (Sumner 1999)	(Sumner 1999; Esteves and Pastor 2000; Shanks *et al.* 2000; Al-Mudimigh, Zairi and Al-Mashari 2003; Umble, Haft and Umble 2003; Somers and Nelson 2004; Finney and Corbett 2007; Upadhyay and Dan 2008; Dezdar and Sulaiman 2009; Shaul and Tauber 2010; Supramaniam and Kuppusamy 2010; Wickramasinghe and Gunawardena 2010)	(Watson and Schneider 1999; Davis and Huang 2007; Aldayel, Aldayel and Al-Mudimigh 2011; Karande, Jain and Ghatule 2012)	(Shaul and Tauber 2012)	17
User Involvement	Clear, effective communication and user participation during the implementation of an ERP across all levels of an organisation are extremely important (Nah, Zuckweiler and Lee-Shang Lau 2003; Shaul and Tauber 2013) and are said to be an essential success factor (Rabaa'i 2009). Users should also participate in defining new processes that are being implemented (Shaul and Tauber 2013). This participation and communication with users should occur from the onset of the project such that the user is educated and understands the concept and benefits of the ERP from the beginning (Yu 2005). This user involvement increases the chance of the ERP being accepted by employees and, therewith, increases the chances of a successful implementation (Amoako-Gyampah and Salam 2004).	(Esteves and Pastor 2000; Nah, Zuckweiler and Lee-Shang Lau 2003; Somers and Nelson 2004; Verville, Bernadas and Halingten 2005; Yu 2005; Finney and Corbett 2007; Ngai, Law and Wat 2008; Dezdar and Sulaiman 2009; Shaul and Tauber 2010; Wickramasinghe and Gunawardena 2010; Shaul and Tauber 2013)	(Aldayel, Aldayel and Al-Mudimigh 2011)	(Shaul and Tauber 2012)	13
		ORGANISATION			
Senior and Top Management Support	Top management support was found by many authors to be one of the top critical factors in a successful ERP implementation, with it being empirically proven, by Sarker and Lee (2003), that to achieve ERP implementation success, it is essential that, at top management level, strong committed leadership exists. It has also been established that to secure employee acceptance of the project and the changes to be implemented as well as ensure the success of the project, top management need to demonstrate support, commitment, authority and leadership (Aladwani 2001). Implementing an ERP is not merely changing to a new software solution. It involves transforming the current business practices and repositioning the organisation (Myerson 2001). It is, therefore, important that top management's support and approval continue	(Holland and Light 1999; Esteves and Pastor 2000; Shanks *et al.* 2000; Aladwani 2001; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Al-Mudimigh, Zairi and Al-Mashari 2003; Nah, Zuckweiler and Lee-Shang Lau 2003; Sarker and Lee 2003; Somers and Nelson 2004; Verville, Bernadas and Halingten 2005; Nah and Delgado 2006; Finney and Corbett 2007; Ngai, Law and	(Aldayel, Aldayel and Al-Mudimigh 2011; Karande, Jain and Ghatule 2012)	(Shanks 2000; Somers and Nelson 2004; Nah and Delgado 2006; Shaul	24

	through all phases of the implementation process, not just in the initiation phases (Al-Mudimigh, Zairi and Al-Mashari 2003). It has further been established that top management involvement expands to: approval and support of the ERP project (Ngai, Law and Wat 2008), allocation of resources (Holland and Light 1999; Nah, Zuckweiler and Lee-Shang Lau 2003; Shaul and Tauber 2013) as well as resolving conflicts that may arise in an organisation (Davenport 1998).	Wat 2008; Dezdar and Sulaiman 2009; Noudoostbeni, Yasin and Jenatabadi 2009; Shaul and Tauber 2010; Supramaniam and Kuppusamy 2010; Wickramasinghe and Gunawardena 2010)		and Tauber 2012)	
Project Plan with clear agreed upon objectives and goals	According to literature, there are 3 areas included in a project plan and vision for an ERP: - **Organisational operation plan** in which key employees of the organisation create a clear vision specifying operational rules, stakeholders' requirements are met and project goals are identified. - **Aligning ERP strategy with the organisation's goals** – measurable targets are set to enhance the level of implementation success (Finney and Corbett 2007; Ifinedo 2008) - **An ERP Implementation plan** is important and changes depending on the organisational requirements as well as the complexity of an existing ERP or existing legacy system (Holland and Light 1999) It is through the project plan that clear objectives and goals are set, the project is justified in terms of time and financial investment and the risks and expected benefits of the ERP are highlighted (Holland and Light 1999; Al-Mudimigh, Zairi and Al-Mashari 2001; Nah, Zuckweiler and Lee-Shang Lau 2003; Zhang *et al.* 2003; Ngai, Law and Wat 2008; Rabaa'i 2009). A clear project plan has been cited by many researchers as being a factor that affects the success of an ERP implementation.	(Holland and Light 1999; Esteves and Pastor 2000; Shanks *et al.* 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Al-Mudimigh, Zairi and Al-Mashari 2003; Somers and Nelson 2004; Verville, Bernadas and Halingten 2005; Nah and Delgado 2006; Finney and Corbett 2007; Ngai, Law and Wat 2008; Upadhyay and Dan 2008; Dezdar and Sulaiman 2009; Supramaniam and Kuppusamy 2010; Wickramasinghe and Gunawardena 2010; Xu *et al.* 2010)	(Davis and Huang 2007)	(Shanks *et al.* 2000; Somers and Nelson 2004; Nah and Delgado 2006)	19
Effective, organisation-wide communication	Effective communication for ERP implementation includes: - **interdepartmental communication** (Al-Mashari and Al-Mudimigh 2003) - involves a close working relationship between departments so that technical and organisational issues can be resolved - **open communication between the various implementation parties** (Sumner 1999) such that all stakeholders are aware of the project scope, meaning, schedule and benefits, as well as the active involvement and updating of all stakeholders (Shaul and Tauber 2013) Communication can be used as a useful strategy to reduce user resistance towards the new system and improve user acceptance (Chen 2014). It, therefore, becomes important that a communication plan is developed to ensure open communication within the organisation, at all levels (Yusuf, Gunasekaran and Abthorpe 2004).	(Holland and Light 1999; Esteves and Pastor 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Al-Mudimigh, Zairi and Al-Mashari 2003; Somers and Nelson 2004; Nah and Delgado 2006; Finney and Corbett 2007; Ngai, Law and Wat 2008; Dezdar and Sulaiman 2009; Noudoostbeni, Yasin and Jenatabadi 2009; Shaul and Tauber 2010; Supramaniam and Kuppusamy 2010; Wickramasinghe and Gunawardena 2010; Xu *et al.* 2010)	(Davis and Huang 2007; Aldayel, Aldayel and Al-Mudimigh 2011; Karande, Jain and Ghatule 2012)	(Nah and Delgado 2006)	18
Organisational Culture	If all the members of the organisation have a common goal and vision or have an "open to change" culture, the success of the ERP implementation would be greatly increased (Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001). Since national culture is embedded in the culture of the organisation, it follows that national culture is a factor affecting the successful implementation of an ERP (Zhang *et al.* 2003). It is said that the values and beliefs that exist in different countries will affect the culture of the organisation and will, therefore, affect professional activities including the implementation of an ERP (Krumbholz and Maiden 2001). Most studies conducted on CSFs for ERP implementation have been within USA (Huang and Palvia 2001), with limited research having been conducted in Brazil, India and China (Ngai, Law and Wat	(Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Huang and Palvia 2001; Krumbholz and Maiden 2001; Al-Mudimigh, Zairi and Al-Mashari 2003; Nah, Zuckweiler and Lee-Shang Lau 2003; Zhang *et al.* 2003; Finney and Corbett 2007; Ngai, Law and Wat 2008; Dezdar and Sulaiman 2009; Xu *et al.* 2010)			9

	2008). Ngai, Law and Wat (2008) believe that organisations operating in different countries will have different, country specific requirements. These could be due to legal and government requirements or differences in business practices or culture.				
Legacy System and business processes	Legacy system refers to the identification of existing systems that may be in place, with particular reference to business processes, organisational structure, culture and existing IT infrastructure (Holland and Light 1999). It is necessary to understand the existing system so that possible problems can be identified and a change plan can be developed (Holland and Light 1999; Finney and Corbett 2007). It must be noted that the more complex the legacy system is, the higher the number of technological and organisational changes that are required (Holland and Light 1999; Nah, Zuckweiler and Lee-Shang Lau 2003).	(Holland and Light 1999; Esteves and Pastor 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Al-Mudimigh, Zairi and Al-Mashari 2003; Nah, Zuckweiler and Lee-Shang Lau 2003; Finney and Corbett 2007; Ngai, Law and Wat 2008; Dezdar and Sulaiman 2009; Shaul and Tauber 2010; Wickramasinghe and Gunawardena 2010)	(Karande, Jain and Ghatule 2012)		11
	ERP IMPLEMENTATION PROJECT				
Project Management to implement project plan	Implementing an ERP, which encompasses software and hardware as well as organisational problems, is an extremely complex process which can last years. It is for this reason that effective management is needed to prevent cost and time overruns as well as ensuring control (Zhang *et al.* 2005). It is only through efficient project management that the activities relating to ERP implementation can be planned, coordinated and monitored through the different stages of the project (Somers and Nelson 2004). Project management is an ongoing task that runs through the full life-cycle of implementation (Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001). Effective project management entails developing a formal implementation plan, creating a realistic time schedule, having periodic meetings, appointing a capable, responsible project champion and having stakeholders involved in the project team (Zhang *et al.* 2005). In support of this view, Bingi, Sharma and Godla (1999) identified the main reasons for a project failing were due to a lack of understanding of the project needs and not being able to provide proper leadership and guidance to a project. It is then not surprising that many researchers have identified effective project management as a critical success factor for ERP implementation success.	(Bingi, Sharma and Godla 1999; Holland and Light 1999; Esteves and Pastor 2000; Shanks *et al.* 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Al-Mudimigh, Zairi and Al-Mashari 2003; Nah, Zuckweiler and Lee-Shang Lau 2003; Somers and Nelson 2004; Verville, Bernadas and Halingten 2005; Zhang *et al.* 2005; Nah and Delgado 2006; Finney and Corbett 2007; Ngai, Law and Wat 2008; Dezdar and Sulaiman 2009; Noudoostbeni, Yasin and Jenatabadi 2009; Shaul and Tauber 2010; Supramaniam and Kuppusamy 2010; Wickramasinghe and Gunawardena 2010)	(Aldayel, Aldayel and Al-Mudimigh 2011)	(Nah and Delgado 2006; Shaul and Tauber 2012)	21
ERP Strategy & Implementation methodology	There are a number of different approaches to ERP implementation (Ngai, Law and Wat 2008) with many researchers identifying the importance of having an implementation strategy and specifically using a phased approach (Cliffe 1999; Scott and Vessey 2000; Mandal and Gunasekaran 2003). Holland and Light (1999) indicate that the importance of the ERP strategy is often overlooked. Holland and Light (1999) also discuss the skeleton and single-module strategy for ERP system implementation with a basic system being implemented initially and extra functionality being added through modules, once the initial system is operational. They also contend that top management need to ascertain whether the business is going to change business processes to fit the system or modify the system to fit the existing processes. This task has been cited as one of the most important aspects to implementation success (Ngai, Law and Wat 2008).	(Holland and Light 1999; Esteves and Pastor 2000; Al-Mudimigh, Zairi and Al-Mashari 2003; Somers and Nelson 2004; Finney and Corbett 2007; Ngai, Law and Wat 2008; Noudoostbeni, Yasin and Jenatabadi 2009; Shaul and Tauber 2010)	(Aldayel, Aldayel and Al-Mudimigh 2011)	(Nah and Delgado 2006; Shaul and Tauber 2012)	11
Business Process Re-engineering (BPR) and Customisation	During the implementation of an ERP, the reengineering of current business processes is often considered critical so that the business processes match those of the ERP and full functionality of the software can be fully realised (Sumner 1999; Shanks *et al.* 2000; Light 2001). It is due to some business processes of the organisation being different or	(Bingi, Sharma and Godla 1999; Holland and Light 1999; Sumner 1999; Esteves and Pastor 2000; Shanks *et al.* 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang	(Aldayel, Aldayel and Al-Mudimigh		16

	incompatible to those of the ERP that it becomes necessary for a certain amount of BPR to take place (Nah, Zuckweiler and Lee-Shang Lau 2003; Somers and Nelson 2004). Sumner (1999) contends that modifying the ERP, through customisation, to meet the current business practices often results in ERP implementation failures, cost increases as well as an increase in the possibility of errors (Davenport 1998). Moreover, additional customisation could lead to increases in the project time as well as new software releases and upgrades from the vendor becoming more difficult to implement (Shehab *et al.* 2004). Bingi, Sharma and Godla (1999), Akkermans and van Helden (2002), Finney and Corbett (2007) and Holland and Light (1999) all support the idea of minimising customisation, also referred to as "vanilla ERP". Another train of thought, supported by both Davenport (1998) and Ngai, Law and Wat (2008), is that when an organisation selects an ERP system, it should be selected to match the business processes and practices of the organisation (Chen 2001; Law and Ngai 2007). Ngai, Law and Wat (2008) also suggest the need for a gap analysis to ascertain the differences that exist between the organisation's requirements and features that the ERP provide. It follows to say that the ERP software that presents the smallest gap and best fit should reduce the amount of business process re-engineering, thereby reducing the time and risk as well as the amount of customisation that would be needed later.	2001; Somers and Nelson 2004; Finney and Corbett 2007; Ngai, Law and Wat 2008; Dezdar and Sulaiman 2009; Shaul and Tauber 2010; Supramaniam and Kuppusamy 2010; Wickramasinghe and Gunawardena 2010; Xu *et al.* 2010)	2011; Karande, Jain and Ghatule 2012)		
Change Management	During ERP implementation, various functional departments will be affected, with a variety of changes being inevitable (Umble, Haft and Umble 2003). The organisation needs to be ready for the changes (Sumner 1999) so that there is less resistance at implementation (Umble, Haft and Umble 2003). Fui-Hoon Nah, Lee-Shang Lau and Kuang (2001) refer to change management as a program that is formally prepared to deal with the implications of the ERP implementation. It involves the control and management of those elements which may be agreeable to the changes as well as those forces resistant to change (Stebel 1992). The plan needs strategies that will lead to an effective ERP implementation as well as a thorough understanding of the organisational culture (Ngai, Law and Wat 2008). One of the major tasks is to develop a positive employee attitude and obtain user acceptance of the project (Holland and Light 1999; Shanks 2000). To accomplish this, it is necessary that the training and education, that are provided to the users, help them to understand the system and increases the possibility of their acceptance and use of the ERP (Ngai, Law and Wat 2008). This will also help users understand the benefits and need for the system (Somers and Nelson 2001; Mandal and Gunasekaran 2003). Importantly, change management is one of the most widely cited CSFs (Finney and Corbett 2007).	(Esteves and Pastor 2000; Shanks 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Nah, Zuckweiler and Lee-Shang Lau 2003; Somers and Nelson 2004; Nah and Delgado 2006; Finney and Corbett 2007; Ngai, Law and Wat 2008; Upadhyay and Dan 2008; Dezdar and Sulaiman 2009; Shaul and Tauber 2010; Wickramasinghe and Gunawardena 2010; Xu *et al.* 2010)	(Al-Nafjan and Al-Mudimigh 2011; Al-Shamlan and Al-Mudimigh 2011; Karande, Jain and Ghatule 2012)	(Shanks 2000; Nah and Delgado 2006; Shaul and Tauber 2012)	18
Data Management	ERPs consist of a number of integrated modules requiring careful management of data in order for accurate, consistent and reliable information to be available (Ngai, Law and Wat 2008). The availability and timeliness of this data are essential for an effective system, without which, implementation delays are inevitable (Somers and Nelson 2001). When an ERP is adopted, there are 2 major data management processes that need to be considered: 1 – the organisation must check that the data model for the software is compatible with the organisation's data (Soh, Kien and Tay-Yap 2000), 2 – part of the	(Bingi, Sharma and Godla 1999; Shanks *et al.* 2000; Somers and Nelson 2004; Verville, Bernadas and Halingten 2005; Finney and Corbett 2007; Ngai, Law and Wat 2008; Shaul and Tauber 2010)	(Nielsen 2002)	(Shaul and Tauber 2012)	9

	ERP plan should include the task of mapping and converting the data (Ahituv, Neumann and Zviran 2002; Shaul and Tauber 2013). It is, therefore, necessary that plans for data conversion, accuracy, analysis as well as a migration be developed (Shaul and Tauber 2013). Prior research has established that the degree of data accuracy positively impacts on the success of an ERP implementation (Bingi, Sharma and Godla 1999; Somers and Nelson 2001; Zhang *et al.* 2003).				
Project Leader	A project champion is usually a high powered member of top management who is responsible for handling organisational change as well as having an important role in the implementation of an ERP (Sumner 1999) and should be able to provide the project with a leader that can lead from a business perspective and result in a more successful implementation (Sumner 1999). The leader will need to lead, motivate and support the team members during times of stress which come with extended working hours (Bingi, Sharma and Godla 1999; Nah, Zuckweiler and Lee-Shang Lau 2003) as well as communicating the importance and significance of the project to the rest of the organisation (Sumner 1999).	(Esteves and Pastor 2000; Shanks *et al.* 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Nah, Zuckweiler and Lee-Shang Lau 2003; Somers and Nelson 2004; Finney and Corbett 2007; Ngai, Law and Wat 2008; Dezdar and Sulaiman 2009; Shaul and Tauber 2010; Supramaniam and Kuppusamy 2010; Wickramasinghe and Gunawardena 2010)	(Karande, Jain and Ghatule 2012)	(Shanks 2000; Somers and Nelson 2004; Nah and Delgado 2006)	15
Skilled Project Team	The ERP implementation team must consist of the best IT, technical and business personnel, as well as members from across the organisation that are available on a full-time basis (Bingi, Sharma and Godla 1999; Al-Sehali 2000; Shanks 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Mandal and Gunasekaran 2003; Somers and Nelson 2004; Finney and Corbett 2007). This composition should lead to a team that has both a deep understanding of the project from an IT perspective as well as from the organisation's business process perspective (Sumner 1999; Shanks *et al.* 2000). Ngai, Law and Wat (2008) also acknowledged the importance of the inclusion of external consultants within the project team. It is this project team that is responsible for managing the project through all phases of implementation, with the management encompassing both human-resource related items (user training) and material items (schedules and budgets) (Umble, Haft and Umble 2003).	(Holland and Light 1999; Al-Sehali 2000; Esteves and Pastor 2000; Shanks *et al.* 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Nah, Zuckweiler and Lee-Shang Lau 2003; Somers and Nelson 2004; Verville, Bernadas and Halingten 2005; Nah and Delgado 2006; Finney and Corbett 2007; Ngai, Law and Wat 2008; Upadhyay and Dan 2008; Dezdar and Sulaiman 2009; Shaul and Tauber 2010; Supramaniam and Kuppusamy 2010; Wickramasinghe and Gunawardena 2010)	(Aldayel, Aldayel and Al-Mudimigh 2011; Karande, Jain and Ghatule 2012)	(Shanks 2000; Somers and Nelson 2004)	20
Autonomous Project Team	Within this team, there needs to be a team member that has the authority to make decisions quickly and effectively (Shanks 2000). There must also exist a high level of trust between the various stakeholders in the team in order for the project to succeed (Karande, Jain and Ghatule 2012)	(Shanks *et al.* 2000; Kraemmerand, Møller and Boer 2003; Nah, Zuckweiler and Lee-Shang Lau 2003; Ngai, Law and Wat 2008; Dezdar and Sulaiman 2009; Shaul and Tauber 2012; Ram, Corkindale and Wu 2013)	(Karande, Jain and Ghatule 2012)	(Shaul and Tauber 2013)	9
Post Implementation Evaluation	Once implementation has taken place, the outcome or benefits of the system need to be assessed so that the success of the project can be determined (Holland and Light 1999; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Al-Mashari and Al-Mudimigh 2003). The success of the project is often difficult to assess (Umble, Haft and Umble 2003), but Skok and Legge (2002) are of the opinion that different groups that were involved in the project implementation should be able to contribute towards determining whether the project was successful. These groups include management, users, developers and consultants.	(Holland and Light 1999, Holland, Light and Kawalek 1999; Finney and Corbett 2007; Dezdar and Sulaiman 2009; Wickramasinghe and Gunawardena 2010)		(Shaul and Tauber 2012)	5

2.5 On-line student registration ERP system

For an HEI, the administration sector is key to the successful running of the institution. Okewu and Daramola (2014) report that an on-line administration system improves business workflow, enhances efficiency, reduces the need for paper, improves controls, automates email alerts, supports user-friendly web-based interfaces, makes use of best practices, streamlines processes and integrates into existing systems. The literature also suggests that an on-line registration system is designed to manage the student body with easy transfer of information (Odero and Oloko 2013), and, according to Olasina (2011), provides a cost effective, secure registration process that also gives students on-line access to their files. Additionally, the system allows institutions to focus more on the educational needs of students and less on paperwork.

The on-line registration functional area starts foremost with the application, acceptance and registration of the student, with many of these activities being web-based or offered on-line. Oliver and Romm (2001) identified one of the main reasons for ERP implementation in HEIs as being the adoption of web-based (or on-line) interfaces, with on-line registration being one such example. In support, Motiwalla and Thompson (2012) mention that the primary reason organisations might choose to implement an ERP is that access to services is increased - on-line access would provide this increase. This is particularly relevant to the on-line registration system at an HEI where it is essential for customer-service levels for the student to be able to register off-site, using a web service. According to Daradimos, Kaitsa, Stavrakas, Triantis and Stavrinos (2015), the benefits experienced by users of the on-line registration system designed by them were convenience as well as off-site, anytime, timely access to the registration procedure for the student. Staff of the department also realised the benefits of timely access to registration data, elimination of human error and increased speed of the registration process, due to automation of rule checking. These benefits are further supported by Olasina (2011) with the mention of providing information in a real-time, electronic format; students being able to find and add additional courses as the need arises; the registration process being simplified through the on-line, user-friendly wizard. In addition to these benefits, Wang (2002) found a number of advantages for students and staff who used the on-line registration system designed by himself. Another benefit, mentioned by Wang (2002), is the reduction in the use of paper and ink, which benefits both the HEI as well as the environment.

The registration system deals with large amounts of data and documentation, but having an efficient, cost-efficient, secure registration process that uses an on-line system, allows institutions to focus less on the paperwork and more on meeting the educational needs of the students. It has been established in prior sections that the on-line registration system, which is a component or module of an HEI ERP, will also experience the same benefits that organisations experience. In summary, it follows that the on-line registration system should afford the following prospective benefits:

- Improvements to reliability, consistency, integration and sharing of information. This is across all functional areas, directly improving internal workflow and increasing the quality and accuracy of data;
- Efficient integration of data flows, business processes and best business practices;
- Improvements to customer services through convenient, anytime, anywhere, timely access to systems via mobile interfaces;
- Improvements in decision making and planning for management through real time access to data and information;
- Effective use and management of communication channels;
- Improved efficiency with regard to the use of hardware components as well as a reduction in the number of required resources;
- Improved IT infrastructure capability and maintenance due to centralised IT staff who are trained to support the user’s needs;
- Long-term performance, cost reductions and profitability can be observed after 2 or 3 years;
- Enhanced security of data and applications due to centralization of hardware, software, DBs and so on;
- Improved access to information for planning and managing the institution;

- Standardised, accurate student data;
- Improved services offered to staff, students and faculty;
- Reduced business risk; and
- Improved efficiency resulting in an increase in income and a decrease in expenses.

A popular ERP that is implemented at many HEIs is the integrated tertiary software (ITS) ERP system, which provides functionality for all academic office operations and also provides self-service functions to both staff and students. The organisation is able to choose and customise only those components which are required. There are generally five major components that are essential to the institution, namely: student management system; financial management system; human resource system; and a payroll management system.

The student management system is of most interest for this study and is responsible for the management of the academic programmes, qualifications, subjects, courses and modules that exist in a curriculum. Within this system, there exist ten components, one of which is the Student Administration component responsible for maintaining the records for both students and academics. Each of the components have modules. It is the on-line registration module that exists in the Student Administration component of the student management system that is the focus of this study.

2.5.1 Current Literature for On-line Registration System

Odero and Oloko (2013) report on the lack of literature specific to on-line registration systems. This being said, some of the previous research efforts related to on-line registration systems and HEIs are presented below:

Okewu and Daramola (2014) report on the use of the component-based software engineering (CBSE) paradigm for development of an administrative ERP for an HEI in Nigeria, referred to as an e-Administration system. The researchers postulate that, through concrete empirical data, it is confirmed that the usable ERP developed using the CBSE paradigm is superior to that developed using traditional software development tool.

In another study, with specific focus on an on-line registration system, the researcher uses the waterfall development model to develop a system to enrol candidates for a General Associate Degree examination (Ala'a 2010). The focus of the study is the development of the software as a means of reducing errors that were encountered by the manual system, improving communication and accuracy of statistical data, ensuring completeness of the application process and improving security of data. It was also the objectives of improved accuracy and real-time access to data that prompted Shafie, Al-Ajlan, Aldrawiesh, Bajahzar and Al-Saawy (2011) to develop a personalised IS model for an HEI’s entrance examination on-line registration system.

The design and implementation of a new on-line course registration system are discussed and presented in a paper by Peng, Liu, Li and Shao (2012). The new course was put into use at Tsinghua University in April 2009, but it was only after 2 years and extensive attention from top management, academics, cooperation from staff and students that the system was continually improved and was deemed a success, having solved some of the original problems, such as incorrect registration numbers and incorrect course selection.

With the aim of an on-line registration system being to make the registration process easier and more convenient for students and staff, Tchouakeu, Hills, Jarrahi and Du (2012) embarked on a study that took a closer look at the e-Lion system at the Pennsylvania State University. Using interviews and surveys, the researchers used the Delone and McLeane ISs success model lens as a means of assessing the usability of the system and providing insight into the importance of system usability. In a similar study by Olasina (2011), the focus was on the acceptance of major and minor features of the on-line registration system that was implemented at Ladoke Akintola University of Technology, with the results showing that the student’s perception of use of the on-line system was superior to the perception of the manual system.

In summary, it is observed, from literature, that none of the previous studies focussed on the factors that are critical for the implementation of an on-line registration system, which becomes a further motivation for this study.

2.6 Chapter summary

This chapter presented an overview of literature that exists in the major research areas within which this study falls, namely, ERP systems and CSFs. Firstly, an ERP system was introduced with particular reference to the benefits that they bring to both organisations as well as to HEIs. However, for the benefits to be realised, the implementation needs to be successful. Literature highlights an abundance of failed implementations as well as challenges that exist which could affect the implementation success. These benefits and challenges exist for both organisations as well as HEIs, with many being common to both. Due to the numerous similarities that are alluded to in literature between organisations and HEIs, the researcher established that the challenges and benefits that exist for organisations can also be applied to institutions of higher education. In this chapter, the researcher highlights the lack of literature that exists for ERP systems at HEIs when compared to the abundance of literature that exists for organisations.

After a thorough presentation on what literature divulges about ERP implementation, the researcher then focussed on critical success factors (CSFs). Research shows that CSFs are used in a variety of situations as a means of identifying those areas that should receive the most attention in order for a project to succeed, or those areas that need special attention to overcome the challenges that affect the success of a project. It follows that CSFs would, therefore, exist for the successful implementation of an on-line registration system, but, once again, a lack of literature, specific to CSFs for ERPs at HEIs and even less specific to on-line registration systems, is established. With a plethora of research available for the CSFs for implementation of ERPs in organisations, and having already established that the challenges and benefits specific to ERPs at organisations can also be applied to ERPs at HEIs and because an on-line registration system implementation can be treated as an ERP implementation, the researcher concludes that the CSFs applicable to ERP implementations at organisations can be applied to the implementation of an on-line registration system. The researcher establishes a lack of literature in this area and highlights the need to identify the CSFs for implementation of an on-line registration system as a means of improving the success rate of these system implementations. It is also in this section that objective 1 of the study is accomplished*: To* ***define criticality in the context of successful on-line registration implementation.***

With the on-line registration system being the focus of this study, the researcher identifies this system as an additional module, which is added to an existing, operational ERP. This additional implementation falls into the new module phase of the ERP implementation life cycle. Due to literature acknowledging that implementing a new module, like the on-line registration system, follows the full implementation life cycle, it follows that all the challenges and benefits relating to an ERP, in turn, should relate to the on-line registration system. This chapter highlights the lack of literature specific to the new module phase with most literature exploring the entire ERP implementation life cycle. Through a thorough review of literature focussing on CSFs for ERP implementation, and, thereafter, using content analysis, the researcher establishes a set of success factors to take to the fieldwork. This set of factors satisfies the second objective of the study: To ***establish, refine and categorise a set of factors that are deemed necessary for successful on-line registration implementation through literature for use in the field work.***

The researcher ends the chapter with a section on identifying where on-line registration system research is focused. This seems to be more on the system itself and the usability and acceptance of these systems after implementation, rather than on the implementation process and the challenges that exist.

The chapter makes a case for a lack of literature with respect to a number of areas: ERP implementations at HEIs, and CSFs for a new module being added to an existing ERP and CSFs for an on-line registration system. This shortcoming calls for further investigation to understand those factors that are relevant to on-line registration, in particular. The next chapter (chapter 3) showcases the research framework for the study.

CHAPTER 3: Research Design and Methods

The research methodology represents a pathway for the study, which assists in achieving the researcher's objectives and, in turn, attempts to answer the research questions. A discussion of the paradigms, research approaches and philosophical assumptions that underpin the study is presented and forms the basis for the analysis and findings in later chapters. This chapter, therefore, describes the methodology in such a manner that the study is placed or positioned in the greater research ambit that is aligned with Creswell (2013).

The dichotomy of quantitative versus qualitative research can be classified into three dimensions (Gliner, Morgan and Leech 2011). The first relates to the philosophical or theoretical underpinning, with quantitative and qualitative referring to the understanding about the nature of the research, the researcher's perception of the world and the rationale of the research. The second dimension refers to the data collection methods employed and the type of data collected, with Gliner, Morgan and Leech (2011) showing concern that this is often the only dimension considered when referring to the dichotomy of qualitative and quantitative research. The last dimension is that of the type of data analysis used in the study.

A qualitative research approach deals with and looks at the in-depth *qualities* and understanding of a phenomenon, with the researcher investigating *what* interactions exist, *how* these interactions take place and *why* certain patterns that emerge exist (Henning, Van Rensburg and Smit 2004). This is opposed to quantitative research that generally deals with the *quantity* of understanding. A quantitative study involves empirically testing a predetermined set of variables that are controlled with the focus being on how the variables relate to input from the research subjects. This researcher is of the belief that variables (a set of key success factors) will be inferred through an in-depth analysis of existing literature, with these variables being necessary for a complete and comprehensive field study to be performed. This is in line with a quantitative study. The researcher will, thereafter, gather data in the form of preference chains from participants, using the qualitative approach, as the number of participants is small and the participants base their answers on their own knowledge and experience. The ADVIAN classification tool is used to identify the most critical factors, and aligns the statistical measures to a quantitative study.

A mixed methods approach is defined as "the class of research where the researcher mixes or combines qualitative and quantitative research techniques, methods, approaches, concepts or languages into a single study" (Johnson and Onwuegbuzie 2004: 17). It offers "a method for selecting methodological mixes that can help researchers to better answer many of their research questions" (Johnson and Onwuegbuzie 2004: 17). According to Brady and Collier (2010), the potential that exists for a mixed method is due to the realisation that both strengths and weaknesses exist in both qualitative and quantitative methods, with the lack of quantification being a weakness of qualitative studies. A combination of both methods allows the integration of qualitative as well as quantitative data collection and analysis techniques (Creswell 2013) with Mackenzie and Knipe (2006) recommending that researchers should understand the mixed methods approach rather than perceiving the qualitative and quantitative dichotomies as competing paradigms. The researcher believes that, for the research questions to be answered, both qualitative as well as quantitative methods need to be applied. This study, therefore, conforms to a mixed methods study.

The research philosophy underpinning a research undertaking provides an orientation for the study, reflects the stance of the researcher and better positions the study in the bigger research arena (Creswell 2013). Among others, the following three types of research philosophies exist, namely, the interpretive, post-positivist and critical research.

Interpretive research attempts to gain a deeper understanding of what is being studied and often relies on in-depth observation which requires close examination of the use of language and perspectives (Olivier 2009). Interpretive research requires that the researcher immerse himself/herself in the daily activities and rituals in order to gain an "as-lived" reality of a group of participants.

Critical research is often referred to as "undoing of the positivist or post positivist objective paradigm" (Henning, Van Rensburg and Smit 2004: 22) such that the researcher analyses previous claims and theories and attempts to find fault with prior studies. This type of research also attempts to create awareness of oppressive ideologies and social inequalities with the purpose of studies in this area focussing on "improving" or "changing" existing ideologies or practices.

The *post-positivistic approach* is derived from positivism and dates back to the early 19^{th} century. According to Creswell (2013), a post-positivistic research paradigm is one that encompasses the determination (a cause-and-effect relationship), reductionism (reducing ideas and variables into hypotheses and research questions), empirical observation and measurement (measuring the objects that exist) and theory verification (testing, validating and verifying theories). The post-positivist researcher places importance on multiple measures and observations such that triangulation across the sources of data result in a better grasp on reality. Creswell (2013) proposes that an accepted approach to post-positivistic research starts with an initial theory, follows with the collection of data to support or refute the theory, revisions are then performed and final testing is done. The current study relies on an initial set of CSFs that are formulated and inferred from the literature. This inference was performed during the literature review, and done prior to the fieldwork. The methodology, thereafter, gathers data from the expert participants through an on-line survey. This approach, therefore, accommodates for further observation or other measurements, and is supported by Henning, Van Rensburg and Smit (2004), who claim that postpositive, qualitative studies can be more controlled, by using other instruments to capture data.

The researcher acknowledges the need for minimal interaction with participants for data collection and also understands that the researcher's participatory role in on-line registration could lean towards interpretive research. However, due to the nature of participant interaction and the limited researcher participation, these reasons are not strong enough for alignment with interpretive research. The data, collected in this study, have particular emphasis on the causal relationship between independent variables (critical success factors) and a dependent variable (on-line registration system implementation success) and also rely on multiple data collection measures (content analysis to infer CSFs and a survey). The study is post-positivist in nature. Further, the aim of the study is confirmatory in nature, confirming which of the CSFs are relevant, by using an expert panel and the ADVIAN analysis tool, which is closely aligned with a post-positivist philosophy. It is for these reasons that the researcher believes that the study has a closer alignment to a post- positivist philosophy.

3.1 Phase One - Data Collection and Analysis

The site used for data collection was the DUT, geographically situated in Durban and Pietermaritzburg, in the province of KwaZulu-Natal, South Africa. The site was chosen due to it being the place of work of the researcher. The institution caters for approximately about 27 000 higher education students. DUT, a member of the International Association of Universities, is a multi-campus university of technology that is a result of the merger in April 2002 of two Technikons, viz., ML Sultan and Technikon Natal. The university has ITS ERP implemented, with an on-line registration system having been implemented and integrated into the existing ERP as a separate project, with the rollout commencing in 2011. The on-line registration system is a system that deals with the registration of all students for modules within qualifications. It is the researcher's intention to use this implementation as a means of gathering data from various experts regarding the dimensions or factors which they deem critical to the successful implementation of the system.

The objective of this study is to produce a comprehensive, authoritative list of factors that need special attention when an HEI is implementing an on-line registration system. It is necessary to identify the factors and ascertain which are most important or critical and how these factors influence each other.

The first phase of data collection was to determine an initial set of relevant success factors. These factors were determined through a thorough review of existing literature, regardless of their criticality, because, at this stage of the study, the objective was to obtain a list of factors already identified by other researchers. These factors are presented in table 2.3 of chapter 2. Papers by prominent researchers in ERP implementation were examined and the critical success factors identified by them were extracted through the process of content analysis. This list was, thereafter, used in phase 2, in which further data collection was done through the use of an on-line survey.

As mentioned, to identify the factors in existing literature, the researcher made use of content analysis, which assisted in a systematic study of natural language text. By using this method, each factor was examined extensively to ensure that the exhaustive meaning could be attached to it. This method enabled the researcher to group together these factors that were named differently by different researchers, but carried similar meanings. Eliminating the repetitions was an improvement on a key weakness in many other research articles on CSFs. Content analysis is a method that has been used successfully by other authors for identifying CSFs (Al-Mudimigh, Zairi and Al-Mashari 2003; Umble, Haft and Umble 2003; Finney and Corbett 2007) with the advantage of being able to group factors that have different names but have similar meanings (Al-Mashari and Al-Mudimigh 2003). In contrast, a limitation to this method lies in the way many factors in the literature are merely listed, with no explanation of the factor nor its relationship with other factors (Ngai, Law and Wat 2008). Added to this disadvantage is the limitation of many studies, with some studies only focussing on the actual implementation process, with no regard for the pre-implementation and post-implementation phases (Esteves and Pastor 2000; Ngai, Law and Wat 2008) and several others focussing on a specific geographical area (Xue, Liang, Boulton and Snyder 2005; Zhang *et al.* 2005; Supramaniam and Kuppusamy 2010), or a particular type of organisation (King, Kvavik and Voloudakis 2002; Abugabah and Sanzogni 2010; Rico 2012). It is due to these limitations that the inferred list of literature is not used on its own, but rather taken to the field for further data gathering.

The researcher's academic institution subscribes to many prominent MIS journals and DBs. By logging in to the portals through the library service, the researcher was able to make extensive searches through DBs, journals and conference proceedings. A total of 38 articles from journals and conference papers were reviewed. to The literature search included various combinations of the following words and phrases: "ERP", "enterprise resource planning", "CSF", "critical success", "critical factor", "success factor" and "implementation". Each factor that presented itself was reviewed and categorised, with the update of the frequency of the factor, as presented in table 2.3. From the 38 documents analysed, 94 different factors were identified, but, after analysing the meaning of each factor and considering the frequency of each, 20 different factors were retained. These are those factors with a frequency of five or above.

3.2 Phase Two – Data Collection using Surveys

The literature review using content analysis, discussed above, partially fulfil objective two of the current study, *(2): To establish, refine and categorise a set of factors that are deemed necessary for successful on-line registration implementation through literature for use in the field work.* Hence, further investigation was needed to achieve this objective.

In order for data analysis to be done accurately, CIM of the impacts that one factor has on another needed to be created. Due to the participants in the study needing to have expert knowledge in the area of ERP implementation, the researcher chose to use expert judgement (see section 3.2.1). The researcher then explored various research techniques that could be adopted to gather data. The first to be considered was a case study, which involves an in-depth study or examination of people or groups of people with data being collected through various means such as questionnaires, interviews, observations and documented accounts of subjects (Nieswiadomy 2008). However, case studies are characterised by intensive analysis and description of a bounded system or unit with focus being in the process employed as opposed to the outcome obtained (Merriam 1998). For this research, there is no need to examine people or groups of people to identify the necessary factors. Therefore, the case study technique was rejected.

The second technique explored was the grounded theory approach, which begins with the researcher observing the interest area or participants and allowing the theory to emerge from what is being observed. The process is cyclical and continues until the observation or interviewing of new participants yields no new input (Olivier

2009). It is only once the theory or concepts have been identified that the researcher consults literature to determine if any similarities might already exist that, according to Leininger (1985), prevents the researcher from entering the research setting with preconceived ideas. The reasons for the researcher concluding that grounded theory was not an appropriate approach include: the study relies on a set of inferred CSFs that are then taken to the fieldwork after the literature review is complete (this is in contrast to only consulting literature after theories emerge); there will be no interviewing nor observations (it is the contrary that is required as the researcher requires minimal participation so as not to influence participants input); and lastly, grounded theory is exploratory in nature and more aligned to a purely qualitative study, with the current research using a mixed methods approach that is rather confirmatory in nature.

The final technique explored was that of the Delphi approach, which is defined as "a methodical and interactive research procedure for obtaining the opinion of a panel of independent experts concerning a specific subject" (Skinner, Nelson, Chin and Land 2015). Skinner *et al.* (2015) propose that this approach is particularly relevant to the IS research issues that require specialized knowledge from experts. It has been said that Delphi "is exceptionally useful where the judgement of individuals are needed to address the lack of agreement or incomplete state of knowledge", and "Delphi is particularly valued for its ability to structure and organize group communication" (Powell 2003). The researcher was initially certain that the Delphi technique was relevant to the research being conducted. To produce a CIM, an expert panel was required, anonymity was important and a number of iterative rounds would be needed that would enable the experts to receive feedback and be able change their input till consensus was achieved. However, after reviewing the available literature on CIMs and identifying a number of limitations (elaborated on later in the chapter), the researcher ascertained that the CIM could be generated by collecting individual preference chains from the participants (algorithm and proof later in the chapter). The expert participants would, therefore, only be required to answer the questionnaire once, and there would be no need for consensus nor repeated rounds. This process, therefore, negated the need for consensus, iteration and feedback and the need for the extensive Delphi process.

By gathering data in the form of preference chains using an on-line questionnaire, and generating a CIM from these chains, a major limitation of the CIM, which is the number of impacts or pairwise comparisons to assess, is eliminated. The researcher was, therefore, able to merely use an on-line questionnaire with expert judgement as the data collection tool and technique. Expert judgement has been commended by other researchers (Soja 2006; Ganesh and Mehta 2010) for its importance in finding concrete IS success factors, with several other CSF and ERP studies supporting the use of questionnaires that include a variety of stakeholders in the study (Esteves and Pastor 2000; Zhang *et al.* 2003; Finney and Corbett 2007; Ngai, Law and Wat 2008). This study includes various stakeholders of the on-line registration system, with experts from various departments within the institution, from the ERP vendor as well as from the project management company responsible for the implementation.

The on-line survey tool needed to gather background information about the participant as well as preference lists or preference chains (to be discussed later) that would generate the CIM. After doing research into some of the free survey tools available on-line, it was apparent that the tools could not perform all the functionality and validation that was required for this study. The researcher looked at the various question types that were provided by tools such as Google forms, Survey Monkey as well as Qualtrics, but all had limitations and, in some cases, no functionality of the building of these chains. These chains need to be built such in a manner that each chain can have between 2 and 20 factors, with no repetition of a single factor in the same chain. The participant should also be able to build any number of chains. The researcher wanted the participant to be able to clear a chain, delete a chain, save a chain or start over. It is due to the limitations of the freely available tools that the researcher chose to develop an application that could be used as the data collection tool. This application will be discussed in chapter 4.

3.2.1 Expert Participants

There are many approaches that can be used to identify the expert participants for a study, but due to the limited number of experts that are available for the study, the researcher selected a convenience sample based on the researcher's knowledge of experts in the area. This method is supported by Baldwin-Morgan (1993); McCubbrey (1999); Schmidt, Lyytinen and Mark Keil (2001). The experts were selected according to the following characteristics which Kuusi (1999) identifies as being a good "expert fit": 1) Being at the top of his/her field of technical or scientific knowledge; 2) Interested in a wide range of knowledge, not only in his/her field but everything around it; 3) Able to see national and international connections, present and future developments, and connections that exist between different fields of science; 4) Can disregard traditional viewpoints and can regard problems from unconventional angles; and 5) Is interested in being part of creating something new.

Along with the characteristics listed above, it is highly recommended that the participants are as heterogeneous as possible (Powell 2003). This recommendation is due to new approaches and solutions very often only identified by using participants from different backgrounds, differing levels of education and different amounts of experience (Lilja, Laakso and Palomki 2011). For the current study, experts were from a variety of departments as well as employees of the HEI implementing the ERP, from the developers as well as from the external project management company. Although students are stakeholders at the institution, they were not included as participants as they do not have the required technical system implementation knowledge.

Due to the researcher's minimal participation in the project and close working relationship with many experts, the researcher was able to identify those participants that are experts in the field being studied. The size of the expert panel was estimated to contain between 10 and 15 experts, which, according to Worrell, Di Gangi and Bush (2013) is an acceptable number. Twelve participants were invited to take part in the study, with 10 eventually becoming involved. A detailed covering letter was emailed to each participant specifying the objectives of the study as well as the requirements from each expert.

3.2.2 Limitations of Expert Judgement

The researcher is fully aware that there could be limitations to using an expert panel. These limitations are:

- **Expert selection –** the definition of an expert is left to the researcher. The credentials of each expert must be carefully evaluated. For this study, only experts that had worked extensively with the system or had been part of the implementation or development team were selected as participants, as can be seen in chapter 4, section 4.3, table 4.1;
- **Anonymity of experts –** The anonymity of experts is more often seen as a strength, but, according to Sackman (1975), this anonymity could lead to a lack of responsibility and accountability for the respondents. The researcher is the only person who knows the identity of the experts, thereby ensuring total anonymity. The study is more technical in nature. Therefore, the researcher is of the opinion that the participants would answer the survey honestly, by merely ranking technical factors;
- **Bias –** This is one of the major criticisms of expert participants. It is appropriate for participants to express their bias and opinions, but the researcher must not add bias to the questions. The researcher must refrain from asking leading or limiting questions and must be mindful of this shortcoming when the survey is developed. The nature of the current study is such that the on-line questionnaire is administered and completed by the participant at will, with no interaction taking place with the researcher, thus, eliminating all bias. There are no questions asked in the survey, since the participants select factors and place them in preference chains; and
- **Generalization** – it has been said that, due to the use of expert opinions, generalising the findings and opinions to a larger population might be problematic (Worrell, Di Gangi and Bush 2013). However, Worrell, Di Gangi and Bush (2013) mention that expert participants have expertise and insights

that are beyond a representative sample group, with the results from the participants having potential benefits for researchers as well as practice. The researcher will not be generalizing the findings to the larger population.

3.3 Phase Two - Data Analysis

Once data collection is complete, the data need to be analysed. It is necessary to use analysis tools that will identify the critical factors, identify direct as well indirect relationships that may exist between factors as well as identify how factors might impact on each other and on the system. It is through the data analysis tool that the criticality, integration and stability will be ascertained as well as the unveiling of those factors that are precarious, driving and driven. It is through data analysis that the last 3 objectives of the study will be realised:

(3): To uncover relationships that exist between factors and establish how each might impact on the on-line registration system implementation;

(4): To identify the criticality, stability and integration of each factor; and

(5): To determine which factors should be used for intervention strategies by identifying the following for each factor: precarious, driving and driven.

After these objectives have been met, the primary research question can be answered.

Some of the more popular tools that could assist with the analysis of the data in order to answer the research questions or meet the objectives are discussed.

3.3.1 Impact Analysis

Impact analysis is a method used by organisations to gain an insight into current challenges being faced and what decision making strategies are worth further investigation (Linss and Fried 2009). These methods use a system-metaphor to make system elements and their interdependencies more understandable (Cole, Allen, Kilvington, Fenemor and Bowden 2007) and are used nowadays to map the relationships that exist between identified tangible and intangible resources that are associated with performance measurements (Linss and Fried 2009). Impact analysis could also be used to identify direct and indirect relationships that may exist between impact factors (like critical success factors) and establish which factors are the most important in influencing the optimisation and the success of the system (Linss and Fried 2009).

According to Linss and Fried (2009), impact analysis methods have long been used to determine relationships between factors and for identifying those factors that are most likely to have an impact on the entire system. Therefore, impact analysis is important for optimisation process. Additionally, they contend that impact analysis does not measure the condition of the impact factor, but rather measures the interaction between the factors and it does not give a current status of the system. All the various impact analysis methods, generally, adhere to a similar methodology, which includes identifying impact factors, scoring the direct influences in a particular manner, calculating direct and indirect relationships and, lastly, classifying the factors according to certain criteria (Linss and Fried 2009). One method used for the identification of factors and scoring their influences is a CIM.

3.3.2 Cross Impact Matrix

The CIM technique was developed in the 1960's (Gordon and Hayward 1968) and has been used extensively for long-range planning (Schlange and Jüttner 1997) and in a number of business contexts (Schlange and Jüttner 1997; Vecchiato and Roveda 2010; Bañuls and Turoff 2011; Guertler and Spinler 2015). The strength of the method lies in its ability to identify those factors in the system that play an important role in the future evolution of the system (Asan and Asan 2007).

The impact matrix has dimensions equivalent to the number of impact factors squared, but it is recommended for effective use of cross-impact analysis (CIA). The number of factors under consideration should be limited to 40 (Heuer and Pherson 2010). Using a CIM ensures that no potential interrelations are omitted, with each interrelation (or pairwise comparison) being assigned an intensity or strength value by expert participants, thereby forcing these participants to be explicit regarding the relationships they believe are relevant (Schlange and Jüttner 1997). The diagonal of the matrix is filled with 0's as a factor cannot influence itself. The participants ask 'If variable A were to change, what would be its direct impact on variable B'. Use is made of the following four strength levels: '0' – 'no impact', '1' – 'weak impact', '2' – 'medium impact', '3' – 'strong impact', '4' (Schlange and Jüttner 1997). After populating the matrix, the active sum (AS) and the passive sum (PS) are calculated. The AS refers to the sum of all strength values for a factor and is an indication of how that factor acts on the system (the sum of the row) (Schlange and Jüttner 1997).

The filled-in cross-impact matrix includes n = 10 factors. The interrelationship between a factor i and an affected factor a is represented by $R_{i,\, a.}$ The direct AS of a factor r shows the strength of its direct impact on the system and is represented by $dAS(r)$. It is calculated by adding up all interrelationships in a row of the cross-impact matrix, as shown in section 3.3.3.3, equation (Eq.).

The direct PS refers to the sum of all strength values on a factor and is an indication of how that factor is affected by other factors (the sum of the column) (Schlange and Jüttner 1997). The example in figure 3.1 below will be used throughout to illustrate the various analysis methods.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	AS
F1	0	3	1	3	0	0	2	2	0	1	12
F2	1	0	3	0	2	1	0	1	0	0	8
F3	0	2	0	0	3	2	0	0	0	0	7
F4	0	3	3	0	0	0	2	0	0	0	8
F5	0	0	0	0	0	0	0	2	0	0	2
F6	3	0	0	0	1	0	2	1	0	0	7
F7	1	1	1	1	0	2	0	1	0	2	9
F8	0	0	1	1	0	0	0	0	0	1	3
F9	1	3	0	3	0	0	0	0	0	2	9
F10	3	3	3	2	0	1	3	3	1	0	19
PS	9	15	12	10	6	6	9	10	1	6	

Figure 3.1: Impact Matrix for a simple example (automotive industry)
Source: Linss and Fried (2010)

3.3.3 Cross Impact Matrix Analysis Tools

To analyse the CIM, several impact analysis methods exist, some of which include "Papiercomputer" (Paper computer) (Vester 1987), MICMAC (Matrice d'Impacts Croisés Multiplication Appliquée à un Classement (Duperrin and Godet 1973), a fuzzy approach (Asan, Bozdağ and Polat 2004) and ADVIAN (Linss and Fried 2009). The first two of these methods are the most commonly used, with ADVIAN being a newer method aimed at further developing existing models as well as considering indirect relationships that may exist (Linss and Fried 2009). Earlier techniques of CIM analysis, such as "Papiercomputer", did not allow the analysis of indirect relationships (Guertler and Spinler 2015). It was for this reason that Duperrin and Godet (1973) developed the MICMAC approach for analysis of CIMs.

Both "Papiercomputer" and MICMAC have deficiencies, with the most important being the reliance on the grid system (Guertler and Spinler 2015). Threshold values of the active and passive sums are used to divide the matrix into distinctive areas which are, thereafter, used to classify the purpose of the factor. This results in definite category divisions, such that slight changes in a factor's position can move that factor into a different area, which results in the factor moving to a different category. In addition, if an extreme factor changes, the whole system grid might be affected and other factors might be categorized (Guertler and Spinler 2015).

It was due to these deficiencies that Fried and Linss (2005), Linss and Fried (2009) and Linss and Fried (2010) developed an advanced impact analysis method (ADVIAN), which is a modified CIA methodology capable of analysing both direct and indirect interrelationships. The methodology calculates additional measures such as "integration", "criticality" and "system stability" for each factor and can be calculated for any combination of AS and PS regardless of whether an impact strength is zero or not (Linss and Fried 2010).

The overarching goal of this study is to ascertain both direct and indirect relationships that exist between success factors in order to gain insight into their behaviour and criticality. Due to the direct and indirect interconnections playing an important role, the advanced impact analysis (ADVIAN) tool has been selected as a method of analysis in this study.

3.3.3.1 "Papiercomputer"

The "Papiercomputer" approach only takes direct impacts into account and does not account for or look at the indirect impacts that might exist between factors (Linss and Fried 2009). It is for this reason that this approach will not be used in this study. In this method, the CIM is populated with impact strengths, using values in the range 0 – 3 with the diagonal filled with '0' because a factor cannot impact itself. The AS and PS are then calculated (as per figure 3.2). The metrics of AS and PS are used to give a ranking as to the factor's importance in the system. The factors with a high AS are considered very active as they have a strong impact on other factors, whereas factors with a high PS are highly reactive or highly influenced by other factors. Figure 3.2 shows that factors 10 and 1 are highly active because they have ASs of 19 and 12, respectively. It can also be seen that the most influenced or most reactive factors are factors 2 and 3, having PSs of 15 and 12, respectively. It is obvious that the metrics of AS and PS do not take indirect relationships into cognisance.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	AS
F1	0	3	1	3	0	0	2	2	0	1	12
F2	1	0	3	0	2	1	0	1	0	0	8
F3	0	2	0	0	3	2	0	0	0	0	7
F4	0	3	3	0	0	0	2	0	0	0	8
F5	0	0	0	0	0	0	0	2	0	0	2
F6	3	0	0	0	1	0	2	1	0	0	7
F7	1	1	1	1	0	2	0	1	0	2	9
F8	0	0	1	1	0	0	0	0	0	1	3
F9	1	3	0	3	0	0	0	0	0	2	9
F10	3	3	3	2	0	1	3	3	1	0	19
PS	9	15	12	10	6	6	9	10	1	6	

Figure 3.2: Cross Impact Matrix (automotive industry)
Source: Linss and Fried (2010)

To illustrate the impact of one factor on another, use will be made of the abbreviation =>. To indicate that F1 has an impact on F2, the abbreviation F1 => F2 will be used. Figure 3.2 shows strong impacts between F1=>F2, F2=>F3, F3=>F5, therefore there are strong impacts F1=>F2=>F3=>F5. It follows that there are indirect impacts

F1=>F5, but these indirect impacts are not captured and, therefore, may lead to factor ranking importance as questionable.

3.3.3.2 MICMAC

MICMAC is an approach that was developed in the sixties by Duperrin and Godet (1973) as a method for analysis of indirect relationships. Although the method also makes use of a CIM, only the values of "0" (no impact) and "1" (has an impact) are used (Duperrin and Godet 1973). This is a downfall of the method as the strength or intensity of the impact factor is being neglected and all impact strengths are considered equal. The example in figure 3.2 has the impact strengths of 0, 1, 2 and 3 that need to be modified such that there are only impact strengths of 0 and 1. Linss and Fried (2009) propose that a common way to do this is to identify impact strengths of 0 and 1 as a 0, and impact strength of 2 and 3 as a 1. It follows that weak impact strength is ignored whilst the medium and strong impact strengths are set equal. Therefore, the MICMAC matrix has uncertainties (Schlake 1996).

The MICMAC method is based on multiplying the CIM by itself, resulting in a new matrix containing the number of indirect relationships with a chain length of 2. The resulting matrix is then multiplied by the original matrix resulting in a new matrix containing the number of indirect relationships that have a chain length of 3. Therefore, the matrix squared results in a new matrix that contains the number of indirect impacts with a length matrix to the power of 2. It follows that a matrix to the power of n will result in a matrix that contains indirect relationships with a chain length of n (Linss and Fried 2009). The metrics of AS and PS are used to rank the factors. The higher the value, the higher the factor ranking, but the ranking could change as the number of iterations occur. According to Duperrin and Godet (1973), the ranking will stabilize after a certain number of multiplications, but it has been established that the matrices of power 6 and 7 still have changed rankings for the PS (Linss and Fried 2009).

It becomes apparent that a major drawback of the MICMAC method is the neglect of impact strength and, as suggested by Schlake (1996), the method is more suitable for analysing interdependencies than as a tool for impact analysis. The ranking of the factors is also only done once stability is established, but, at this point, only the numbers of impact factors in that matrix are considered while all previous indirect relationships from shorter chain lengths are omitted. With the need for current research to identify factors that are most critical and MICMAC neglecting the strength of the factor, it is the opinion of the researcher that MICMAC is not the ideal analysis tool.

3.3.3.3 ADVIAN (Advanced Impact Analysis)

ADVIAN was developed as an enhanced methodology that overcomes the shortfalls of other methods, by considering the indirect impacts, the strength of the impact factor as well as being applicable to any system regardless of the number of impact factors (Linss and Fried 2010). It has been used as a tool to gain additional insight into the relationships between supply risk indicators (Guertler and Spinler 2015) and identified resources (Fried 2010). This was demonstrated in a study by Fried (2010), which resulted in 8 resources being identified as driving forces in the study. ADVIAN also makes use of a CIM like the other methods, using an impact strength of 0, 1, 2 or 3. However, other (positive) impact strengths can be used (for example 0-5 can also be used as per Cole *et al.* (2007)). This study will use impact strengths of 0 – 1 that are derived from a normalised CIM. This is discussed in more detail later.

ADVIAN makes use of the AS and PS values (direct impacts), as per "Papiercomputer", as well as indirect impacts. Eq. (3.1) is used to calculate the direct AS for factor *f*, represented by *dAS(f).* This is the sum of the interrelationships in a row of a CIM, with *n* number of factors. The influencing factor *i* and the affected factor *a* are represented by F_{ia}. The direct AS of a factor *f* shows the strength of its direct impact on other factors.

$$dAS(f) = \sum_{a=1}^{n}(F_{fa}) \tag{3.1}$$

Eq. (3.2) is used to calculate the direct PS for factor *f*, represented by *dPS(f).* This is the sum of the interrelationships in a column of a CIM, with *n* number of factors. The influencing factor *i* and the affected factor a, are represented by F_{ia}. The direct PS shows the degree to which a factor is directly affected by other factors.

$$dPS(f) = \sum_{a=1}^{n}(F_{af}) \quad (3.2)$$

Like MICMAC, different orders are calculated, these being different orders of 'activity' and 'passivity', with the 1st order activity being equivalent to the activity sum (AS) in a CIM and the 1st order passivity being equivalent to the PS of the CIM. The 1st order, therefore, only accounts for direct impacts. The 2nd order of activity and passivity takes into account the 1st order as well as the indirect impacts with a chain length of 2. The 3rd order takes into account the 2nd order as well as the indirect impacts with a chain length of 3. The higher orders of activity and passivity are built accordingly. In order that all possible interrelationships are included, the process is repeated until the order $k=n-1$ where n represents the number of factors (Linss and Fried 2009).

The AS for a factor f of order k is represented by Eq. 3.3 and the PS by Eq. 3.4.

$$d(AS_k(f) = \sum_{a=1}^{n}(F_{fa} * dAS_{k-1}(a)) \quad (3.3)$$

$$d(PS_k(f) = \sum_{i=1}^{n}(F_{if} * dPS_{k-1}(i)) \quad (3.4)$$

Let $iAS(f)$ *and* $iPS(f)$ represent the indirect AS and indirect PS, accordingly, for factor f. $iAS(f)$ is calculated by adding all the direct ASs from the 1st order to order k (Eq. 3.5). The $iPS(f)$ is calculated by adding all the direct PSs from the 1st order to order k (Eq. 3.6).

$$iAS(f) = \sum_{k=1}^{n}(dAS_k(f)) \quad (3.5)$$

$$iPS(f) = \sum_{k=1}^{n}(dPS_k(f)) \quad (3.6)$$

The following step involves the conversion of active and passive sums to relative values, with the maximum of all active and passive sums set to 100, such that all values are in the range 0 – 100. According to Linss and Fried (2010), this makes the ADVIAN classification approach amenable to any system of factors. Eq. 3.7 and 3.8 are used to accomplish this amenability.

$$dAS'(f) = \frac{dAS(f)}{max_{f=1}^{n}\{dAS(f);dPS(f)\}} * 100 \tag{3.7}$$

$$dPS'(f) = \frac{dPS(f)}{max_{f=1}^{n}\{dAS(f);dPS(f)\}} * 100 \tag{3.8}$$

The indirect active and passive sums are also converted to relative values as per Eq. 3.9 and 3.10.

$$iAS'(f) = \frac{iAS(f)}{max_{f=1}^{n}\{iAS(f);iPS(f)\}} * 100 \tag{3.9}$$

$$iPS'(f) = \frac{iPS(f)}{max_{f=1}^{n}\{iAS(f);iPS(f)\}} * 100 \tag{3.10}$$

According to Linss and Fried (2010) and based on this approach, factors can be classified according to three criteria: “criticality”; “integration”; and “stability” as well as being ranked according to “precarious”, “driven” or a “driving” value of a factor. The first three classifications are used to describe the state of the system of impact factors while the second group of classifications shows the perspectives for an organisation and the intervening activities that may be necessary.

Factors that are deemed “critical” are those that have a strong impact on other factors as well as being heavily affected by other factors (Guertler and Spinler 2015). They are, therefore, unpredictable with slight changes to them causing dramatic changes to the system. These factors, therefore, require special attention. The criticality *C* of factor *f* is calculated by the geometric mean of $iAS'(f)$ and $iPS'(f)$, as in Eq. 3.11.

$$C(f) = \sqrt{iAS'(f) * iPS'(f)} \tag{3.11}$$

A simple measurement of the level of “integration” of a factor in the whole system is to calculate the arithmetic average or mean of the relative indirect AS and relative indirect PS. Due to the values being in the range of 0 – 100, the integration will also be a value between 0 and 100. A high level of integration indicates that the factor has strong interrelations with other factors in the system (Guertler and Spinler 2015). The integration *I* of a factor *f* is represented in Eq. 3.12.

$$I(f) = \frac{iAS'(f) + iPS'(f)}{2} \tag{3.12}$$

The "stability" of a factor can be calculated by subtracting the harmonic mean of $iAS'(f)$ and $iPS'(f)$ from 100. A system of factors is said to be stable if the factors are distributed closely to the axis of the AS and the axis of the PS (Müller 2000). This distribution would mean that there are factors that are controlling the system (those that are close to the AS axis) and factors that are controlled by the system (those that are close to the axis of the PS). The stability *S* of a factor *f* is calculated using formula Eq. 3.13.

$$S(f) = 100 - \frac{2}{\left(\frac{1}{iAS'(f)} + \frac{1}{iPS'(f)}\right)} \tag{3.13}$$

The above calculations are measures for different criteria and will be used together with the relative indirect active and passive sums to develop a ranking scheme as presented below.

"Precarious" impact factors are the first ranking scheme in which the geometric mean of criticality and the AS are calculated (Linss and Fried 2010). A factor with a high value has a critical impact factor with a high active part and the factor cannot be influenced by external factors but influences the system strongly. These factors should be used for intervening activities. The precariousness *P* of a factor *f* is calculated using the formula Eq. 3.14.

$$P(f) = \sqrt{C(f) * iAS'(f)} \tag{3.14}$$

The next ranking is "driving" impact factors, which are the non-critical impact factors that have a high AS. These factors influence other factors, but do not have a strong feedback in the system. They are, therefore, a very good starting point for intervening activities (Linss and Fried 2010). The driving factor ranking *D* for factor *f* is calculated as the geometric mean of the AS and non-criticality (100-criticality) as per formula Eq 3.15.

$$D(f) = \sqrt{(100 - C(f)) * iAS'(f)} \qquad (3.15)$$

The last ranking is the "Driven" impact factors, which are the non-critical factors with a high PS. These factors are guided by internal system impacts and are not easily changed by intervening activities (Linss and Fried 2010). However, they can be used as a good indication of the success of extrinsic actions that may be taken on driving impact factors. The driven factor ranking *T* for factor *f* is calculated as the geometric mean of the PS and non-criticality (100-criticality) as per formula Eq 3.16.

$$T(f) = \sqrt{(100 - C(f)) * iPS'(f)} \qquad (3.16)$$

According to Linss and Fried (2010), the most suitable factors to select after ranking is done for improvements to the system are those with the highest "driving" ranking. Thereafter, in order to reduce the number of factors, the "precarious" ranking can be used to eliminate those factors with the highest "precarious" ranking. The success of the intervening activities is indicated by those factors with the highest "driven" ranking.

The ADVIAN classification method was used in this study to determine the level of criticality of factors, as well as other interrelations that might exist between various factors and the impact they might have on each other. This includes factors contributing to system stability as well as the factor's level of integration. ADVIAN will also be used to identify both the driving factors as well as the driven factors. ADVIAN also avails the researcher with the opportunity of identifying which factors should receive additional support and consideration in order to improve the system. The reason for not choosing the "Papiercomputer" or the MICMAC approach is due to the former not considering indirect factors and the latter not considering the strength of the factor. ADVIAN attempts to overcome these limitations. It has been shown in studies by Linss and Fried (2009) as well as Guertler and Spinler (2015) that ADVIAN is a suitable method for identifying key impact factors as well as showing that the limitations of the other methods are overcome.

3.3.4 Limitations of ADVIAN and Cross Impact Matrices

There are a number of limitations associated with cross impact matrices, some of which have already been alluded to in the previous discussions. These include the recommendation that the matrix be limited to 40 factors (Heuer and Pherson 2010). This limitation is due to the large number of impact scores that need to be identified or collected from experts. The number of impact scores is calculated as follows: $s(n) = n^2 - n$. Therefore, for a matrix of 40 factors, 1 560 impact scores need to be evaluated by the participants. This could be rather tiresome for the participants. Even for a small matrix consisting of 10 factors, there are 90 impact values that need to be assessed. The CIM relies on expert consensus, which could also be problematic and time consuming for a high number of factors. Another problem proposed by the researcher is the reliance on the expert participants being familiar with and understanding all factors being presented. There only exist 4 options for each factor value (0, 1, 2 or 3), with no option for the participants to indicate that they are unsure of the factor value. The researcher also believes that the ratings of no impact (0), low impact (1), medium impact (2) and high impact (3) lead to uncertainty and are highly subjective. What one participant considers a medium impact might be viewed as a low impact by a different participant.

It is for these reasons that the researcher proposes an alternate method for creating the CIM, using preference chains (concept chains). By using preference chains, all expert participants will be able to make their own contributions, without the need for consensus. Preference chains eliminate the need to evaluate a 40x40 matrix and, therefore, takes less time. The number of factors is also not limited to 40, but rather can include as many factors as are deemed necessary by the researcher. When expert consensus is needed, as in the case of a CIM, the number of experts is generally limited (Skinner *et al.* 2015), but, by using preference chains, the number of participants does not need to be limited. Using the preference chain methodology, the strength of the impact is rather determined by the chain and the placement of the factor in the chain rather than being determined by the participants, thereby, eliminating subjectivity.

The researcher has developed an algorithm that converts preference chains (concept chains) to a CIM as well as an algorithm to convert the CIM to preference chains (concept chains). These algorithms, as well as an existing CIM, are used to prove that a CIM can be generated from preference chains.

3.3.5 Preference Chain to Cross Impact Matrix Algorithm

Before presenting the algorithm to convert preference chains to a CIM, it is, firstly, necessary to prove that a CIM can be presented in the form of preference chains and that these preference chains can then be converted back to the same CIM. An existing CIM, figure 3.3 shown below, is used for the proof.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	AC
F1	0	3	1	3	0	0	2	2	0	1	12
F2	1	0	3	0	2	1	0	1	0	0	8
F3	0	2	0	0	3	2	0	0	0	0	7
F4	0	3	3	0	0	0	2	0	0	0	8
F5	0	0	0	0	0	0	0	2	0	0	2
F6	3	0	0	0	1	0	2	1	0	0	7
F7	1	1	1	1	0	2	0	1	0	2	9
F8	0	0	1	1	0	0	0	0	0	1	3
F9	1	3	0	3	0	0	0	0	0	2	9
F10	3	3	3	2	0	1	3	3	1	0	19

Figure 3.3: Cross Impact Matrix.
Source: Götze (1991)

3.3.6 Proof of the Matrix_to_Chain Algorithm

According to the algorithm provided in figure 3.4, there were 34 iterations of the while loop until a zero matrix was achieved, resulting in all preference chains being generated. Due to constraints imposed on the length of the dissertation, the researcher will explain steps 1 to 8 for the first iteration of the while loop and generation of the first preference chain so that the reader gains an understanding of the steps. The remaining 33 preference chains can be viewed in a public dropbox file (use the password: MICT01) at:

https://www.dropbox.com/s/aw3as4iam2xjyk7/R_Thompson_mast_add_doc.pdf?dl=0

Algorithm 1: matrix_to_chain
Input: Cross Impact Matrix
Output: List of concept chains (preference chains)
While (concept matrix is not a zero matrix)
Begin

1. Calculate the active sum for each factor.
2. Select the impact factor with the highest activity sum.
3. If more than one factor has the highest activity sum, then select the first one.
4. Build a concept chain, using the selected impact factor as the root. All impacted factors within the selected factor become branches of the chain, with each branch forming sub branches.
5. Select that concept chain that has the longest length.
6. If two chains have the same length, select the chain that has the highest impact value and store this in the matrix of concept chains.
7. If the impact values are the same, then select the first one and store it in the matrix of concept chains.
8. In the cross impact matrix, subtract 1 from the impact value of each corresponding relationship that occurs for each pair of factors in the concept chain.

END While
End Algorithm

Figure 3.4 Cross Impact Matrix to Preference Chain Algorithm
Source: Researcher's own construction

Step 1 - **Calculate the AS for each factor**. The AS is calculated and displayed in the last column of the figure. The AS is the sum of all values for that row. For example, the AS for F1 is 12, this is the sum of all values in row 1 (0+3+1+3+0+0+2+2+0+1).

Step 2 - **Select the impact factor with the highest AS**. The highest AS is 19, which is the AS for **F10.**

Step 3 - **If more than one factor has the highest AS, then select the first one**. There is only one factor that is the highest. Therefore, this step becomes irrelevant.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	AS	
F1	0	3	1	3	0	0	2	2	0	1	12	
F2	1	0	3	0	2	1	0	1	0	0	8	
F3	0	2	0	0	3	2	0	0	0	0	7	
F4	0	3	3	0	0	0	2	0	0	0	8	
F5	0	0	0	0	0	0	0	2	0	0	2	
F6	3	0	0	0	1	0	2	1	0	0	7	
F7	1	1	1	1	0	2	0	1	0	2	9	
F8	0	0	1	1	0	0	0	0	0	1	3	
F9	1	3	0	3	0	0	0	0	0	2	9	
F10	3	3	3	2	0	1	3	3	1	0	19	highest

Figure 3.5: Iteration 1 - Cross Impact Matrix
Source: Researcher's own construction

Step 4 - **Build a concept tree, with concept chains, using the selected impact factor as the root. All impacted factors within the selected factor become branches of the chain, with each branch forming sub-branches:** The factor with the highest AS is F10. Therefore, F10 becomes the root factor in the set of concept chains, for the first iteration. The factors (F1, F2, F3, F4, F6, F7, F8 and F9) at the first level are those factors that are impacted on by F10. When looking at figure 3.5 above, they are those factors that have an impact value greater than 0 in the row of the selected factor (F10). The first level in the concept chain can be seen in figure 3.6 below.

The second level of the chain is created by identifying factors that are impacted by the factor in the first level. Figure 3.6 below shows the subsequent levels for the first impacted factor, F1, with the rest of the first level factors shown in figures 3.7 through 3.10 due to space limitations.

Looking at figure 3.5, it can be seen that the second level (for F1) consists of F2, F3, F4, F7 and F8. These factors were identified by looking at the CIM row, in figure 3.5 above, that correspond with F1. In that row, it can be seen that the factors which F1 has an impact on (that is those with an impact value >0) are F2, F3, F4, F7, F8, F10. All have become nodes on level 2, except F10, which is already the root node. It is only those factors that are also in the prior level that can become nodes in the current level.

Level 3 is created in the same manner. Looking at F2, on level 2, it can be seen that the only factors that exist at level 3 for factor F2 are F3 and F8. The CIM in figure 3.5 shows F2 having an impact on F1, F3, F5, F6 and F8, but only F3 and F8 appear at the prior level (level 2). Therefore, only these 2 factors become nodes at level 3 for F2. The same process continues for the other factors on level 2 (F3, F4, F7 and F8), and also continues for all subsequent levels. No further level is created if there exists no further factor that has an impact on the other factors from the prior level. The other concept chains for F10 are given in figures 3.7 to 3.10.

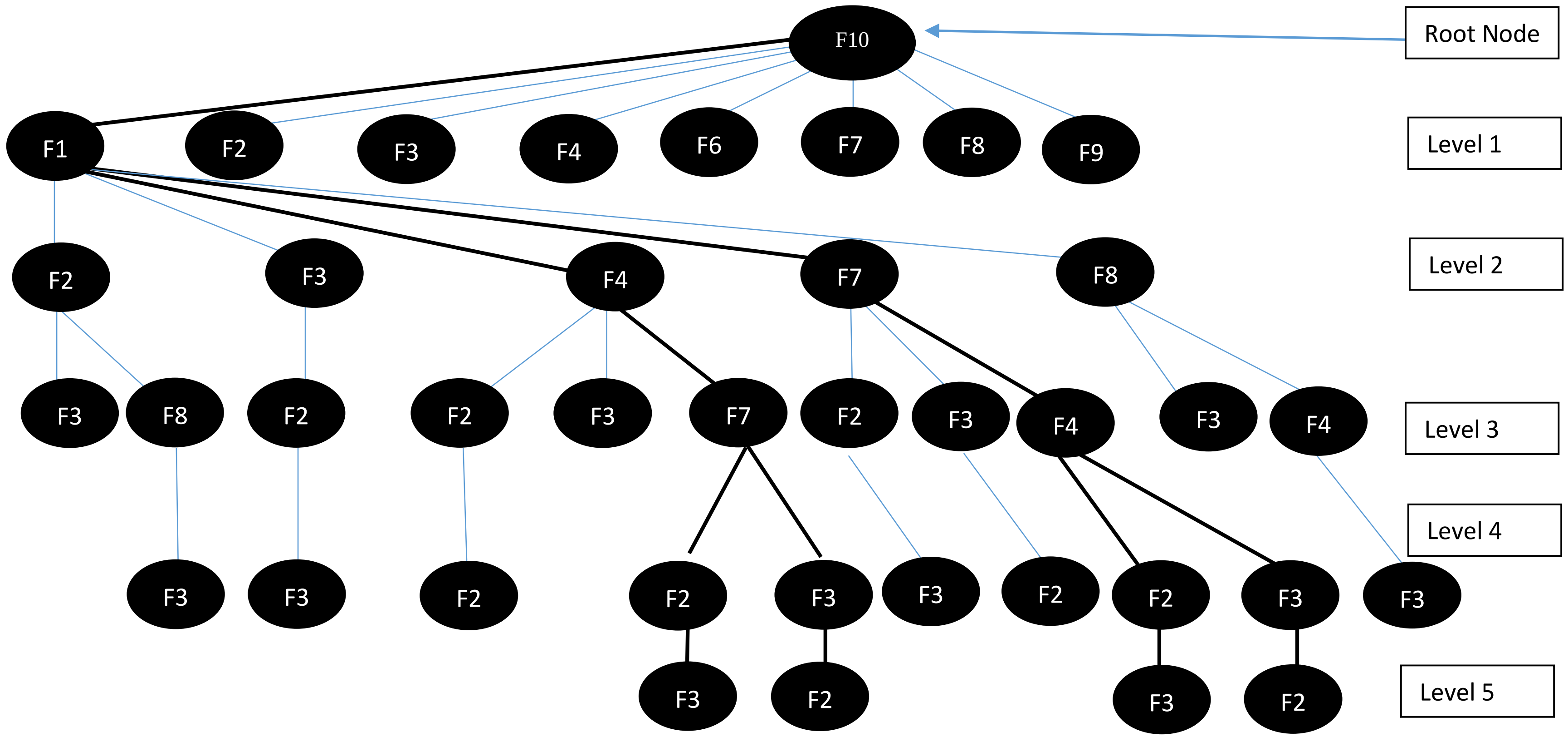


Figure 3.6 Concept chain for F10: F1 branch
Source: Researcher's own construction

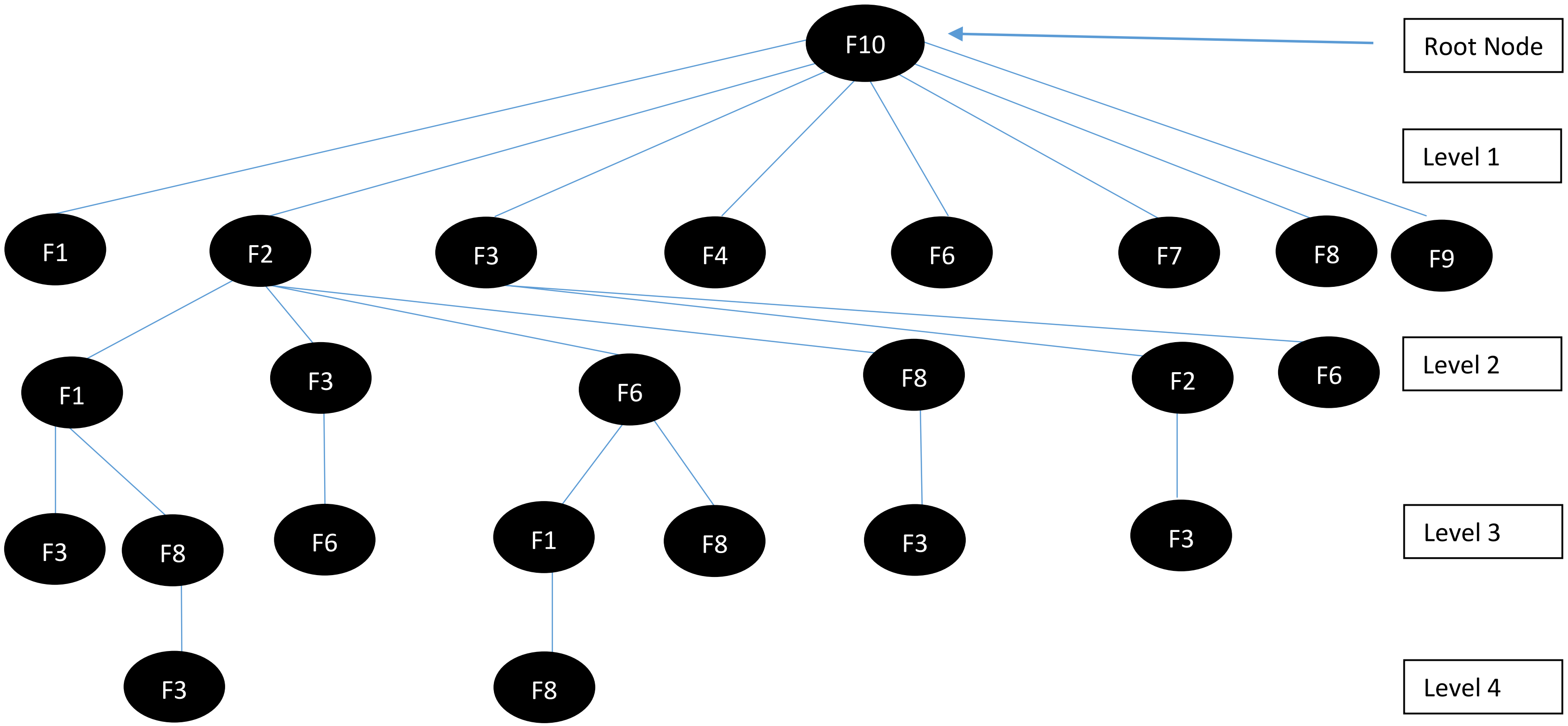


Figure 3.7: Concept chain for F10: F2 and F3 branches
Source: Researcher's own construction

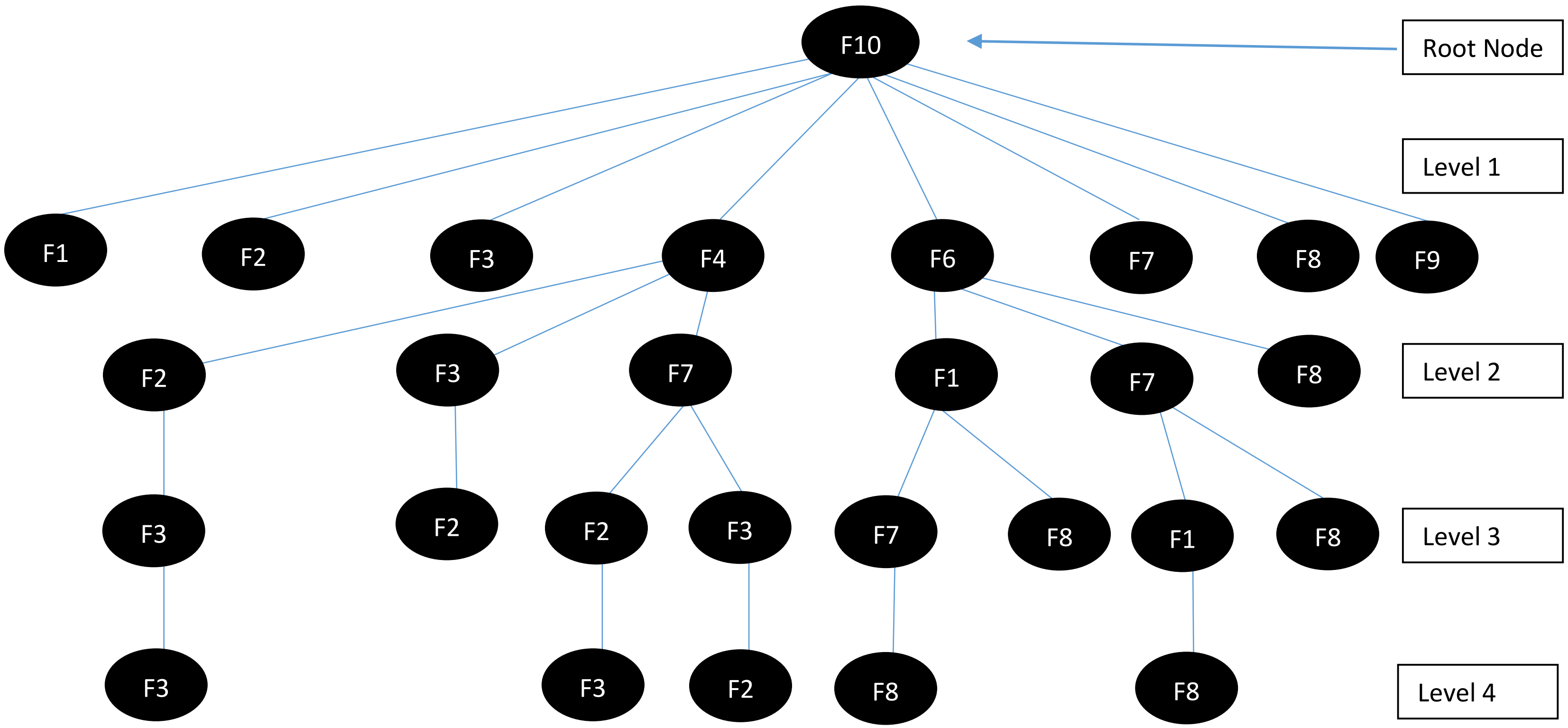


Figure 3.8: Concept chain for F10: F4 and F6 branches
Source: Researcher's own construction

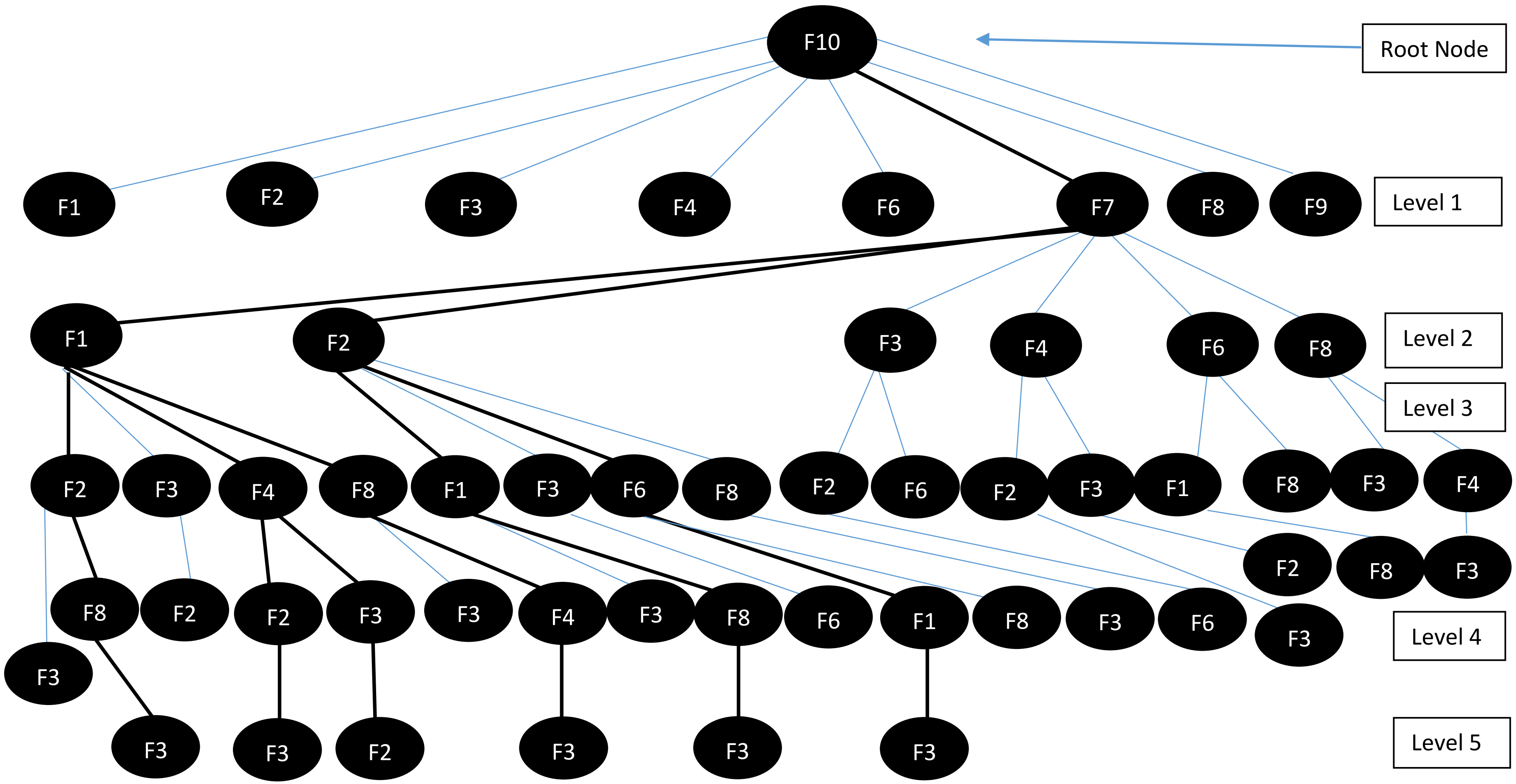


Figure 3.9: Concept chain for F10: F7 branch
Source: Researcher’s own construction

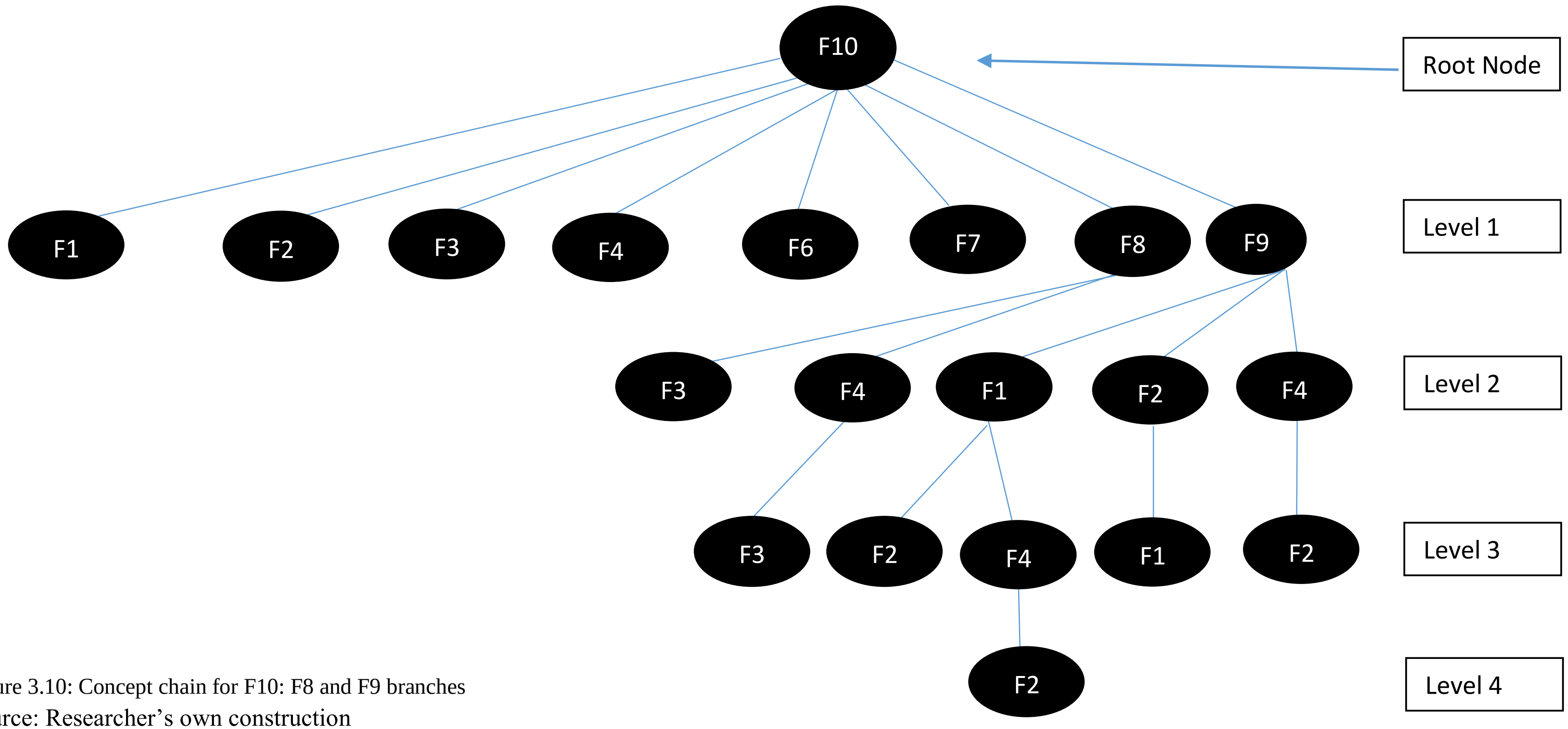


Figure 3.10: Concept chain for F10: F8 and F9 branches
Source: Researcher's own construction

Step 5 - **Select that concept chain that has the longest length.** From the concept tree created above in figures 3.6, 3.7, 3.8, 3.9 and 3.10, the longest concept chains are identified. It can be seen that many concept chains have a length of 6 (i.e. from the root node, the chain spans 5 levels). These chains are indicated by using a darker line in the figures above. All the concept chains with a length of 5 are placed in table 3.1 below:

Table 3.1 Longest Concept Chains

<table>
<tr><td colspan="10">Concept chains showing impact values for relationships</td></tr>
<tr>
<td>F10
F1 ⎤
F4 ⎦ 3
F7
F2
F3</td>
<td>F10
F1 ⎤
F4 ⎦ 3
F7
F3
F2</td>
<td>F10
F1 ⎤
F7 ⎦ 2
F4
F2
F3</td>
<td>F10
F1 ⎤
F7 ⎦ 2
F4
F3
F2</td>
<td>F10
F7 ⎤
F1 ⎦ 1
F2
F8
F3</td>
<td>F10
F7 ⎤
F1 ⎦ 1
F4
F2
F3</td>
<td>F10
F7 ⎤
F1 ⎦ 1
F4
F3
F2</td>
<td>F10
F7 ⎤
F1 ⎦ 1
F8
F4
F3</td>
<td>F10
F7 ⎤
F2 ⎦ 1
F1
F8
F3</td>
<td>F10
F7 ⎤
F2 ⎦ 1
F6
F1
F3</td>
</tr>
<tr><td colspan="10">Concept chains of Highest impact value relationship</td></tr>
<tr>
<td>F10
F1
F4
F7
F2 ⎤
F3 ⎦ 3</td>
<td>F10
F1
F4
F7
F3 ⎤
F2 ⎦ 2</td>
<td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td>
</tr>
</table>

Strongest CONCEPT CHAIN for iteration 1 is **F10-F1-F4-F7-F2-F3**

Step 6 - **If two chains have the same length, select the chain that has the highest impact value and store this in the matrix of concept chains.** In table 3.1, 10 concept chains were all identified as having the same length. It is, therefore, necessary to identify the strongest chain. The strongest chain is that chain that has the strongest impact value. The impact values are listed next to each chain in table 3.1. It can be seen that the first 2 chains have impact values between levels 1 and 2 of 3, whereas the rest of the impact values are less than 3. These 2 chains are, therefore, the strongest of all the chains. The impact value comes from the CIM in figure 3.5, where, in the row for F1, the impact on F4 is a 3 and in row F1, the impact on F7 is 2.

The 2 strongest chains are then compared to find the stronger of the two. Due to all the factors in the 2 chains being the same until the last 2 factors, it is the impacts of the last 2 factors that are compared. The impact of F2 on F3 is 3, whereas the impact of F3 on F2 is 2. It is the first concept chain that then gets stored in the matrix of concept chains.

Step 7 - **If the impact values are the same, then select the first one and store it in the matrix of concept chains.** This step is not necessary for this iteration as the final impact values being compared are not the same.

Step 8 - **In the CIM, subtract 1 from the impact value of each corresponding relationship that occurs for each pair of factors in the concept chain.** The relationships are based on the concept of transitivity of preference, which is based on the assumption that, if A is preferred to B and B is preferred to C, it should follow that A is preferred to C (Birnbaum and Bahra 2012). Therefore, each item in the preference chain has a relationship with the prior preferences. For the concept chain stored from the first iteration, F10>F1>F4>F7>F2>F3, the following transitive relationships exist:

F10>F1	F10>F4	F10>F7	F10>F2	F10>F3	F1>F4
F1>F7	F1>F2	F1>F3	F4>F7	F4>F2	F4>F3
F7>F2	F7>F3	F2>F3			

The algorithm specifies that 1 is subtracted from each impact value for each of the transitive relationships in the chain. This results in the new CIM in figure 3.11.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	AC
F1	0	2	0	2	0	0	1	2	0	1	8
F2	1	0	2	0	2	1	0	1	0	0	7
F3	0	2	0	0	3	2	0	0	0	0	7
F4	0	2	2	0	0	0	1	0	0	0	5
F5	0	0	0	0	0	0	0	2	0	0	2
F6	3	0	0	0	1	0	2	1	0	0	7
F7	1	0	0	1	0	2	0	1	0	2	7
F8	0	0	1	1	0	0	0	0	0	1	3
F9	1	3	0	3	0	0	0	0	0	2	9
F10	2	2	2	1	0	1	2	3	1	0	14

Figure 3.11: New Cross Impact Matrix
Source: Researcher's own construction

The while loop is repeated as the matrix is not yet a zero matrix, with steps 1-8 being applied to the new matrix in figure 3.11. All iterations can be seen in the public dropbox file (use the password: MICT01), accessible at:

https://www.dropbox.com/s/aw3as4iam2xjyk7/R_Thompson_mast_add_doc.pdf?dl=0.

Once a zero matrix is achieved, the following chains (table 3.2.) had been generated:

Table 3.2: The output – Concept Chains / Preference Chains

F10-F1-F4-F7-F2-F3	F7-F10	F4-F3	F4-F7
F10-F6-F1-F7-F8	F9-F10	F5-F8	F5-F8
F10-F9-F1-F4-F2	F3-F2	F6-F1	F6-F7
F2-F3-F6-F5	F4-F3	F7-F6	F7-F10
F7-F6-F1	F7-F4	F9-F4	F8-F10
F9-F4-F2	F9-F2	F10-F7	F9-F10
F10-F2-F8-F3	F10-F3	F1-F10	F10-F8
F3-F2-F5	F1-F2	F2-F1	
F1-F8-F4	F3-F5	F3-F6	

3.3.7 Cross Impact Matrix to Preference Chain Algorithm

The algorithm presented in section 3.3.5 above was used to create the preference chains in table 3.2. In order to prove that these preference chains or concept chains can be converted back to the same CIM, the following algorithm was

Algorithm 2: chain_to_matrix
Input: List of concept chains (preference chain)
Output: Cross Impact Matrix (initially was set to zero)
For each concept chain in the list of concept chains
Begin

1. Generate $c(n)^1 = \frac{n!}{(n-2)!2!}$ number of relationships between pairs of corresponding factors on the concept chain, where n is the number of factors in the concept chain.
2. At the corresponding entry defined by the relation in 1 above, add 1 to the cross impact matrix

END For
Normalise the cross impact matrix such that each entry is between 0 and 1 by dividing each entry by the highest value.
End Algorithm

Figure 3.12: Cross Impact to Preference Chain Algorithm
Source: Researcher's own construction

The normalisation of the matrix ensures that the computation of the indirect relationships does not inflate the impact strength of indirect relationships. This normalisation model also ensures that direct relationships are usually stronger than indirect relationships. The strength of a relationship is automatically determined as the number of DIRECT relationships between two factors with the strength of the relationship within an interval number from 0 – 1 and not as a whole number which is used in ADVIAN's conventional CIA method. The interval method ensures that uncertainty is better captured. The impact strengths can, therefore, be explained as follows:

[0 – 0.25] – no impact (0.26 – 0.5) – low impact
[0.51 – 0.75) – medium impact [0.76 – 1.00] – high impact

3.3.8 Proof of the Chain_to_Matrix Algorithm

Using the chains that were created from the first algorithm and presented in table 3.2, the researcher will prove that these chains will result in the original CIM (figure 3.5), by applying the algorithm in figure 3.12. Only the conversion of the first of 34 chains will be shown here. The rest are available in a public dropbox file (use the password: MICT01) at:
https://www.dropbox.com/s/aw3as4iam2xjyk7/R_Thompson_mast_add_doc.pdf?dl=0

Concept Chain: F10-F1-F4-F7-F2-F3

Step1: **Generate** $c(n)^1 = \frac{n!}{(n-2)!2!}$ **a number of relationships between pairs of corresponding factors on the concept chain, where** n **is the number of factors in the concept chain.** For the concept chain, the number of relationships that exists is: $c(6)^1 = \frac{6!}{(6-2)!6!}$ = 15. The following 15 transitive relationships exist:

F10>F1	F10>F4	F10>F7	F10>F2	F10>F3	F1>F4
F1>F7	F1>F2	F1>F3	F4>F7	F4>F2	F4>F3
F7>F2	F7>F3	F2>F3			

Step 2: **At the corresponding entry defined by the relation in step 1 above, add 1 to the CIM.** 1 is added to the matrix for each of the transitive relationships above. The resulting matrix is displayed in figure 3.13 below:

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	AS (ACTIVITY SUM)
F1		1	1	1			1				4
F2			1								1
F3											0
F4		1	1				1				3
F5											0
F6											0
F7		1	1								2
F8											0
F9											0
F10	1	1	1	1			1				5

Figure 3.13: Cross Impact Matrix – Concept Chain **F10-F1-F4-F7-F2-F3**
Source: Researcher's own construction

The same process is followed for all of the remaining 33 concept chains. Once all concept chains have been processed, the final CIM is obtained. It can be seen that this matrix is identical to the matrix that was used in figure 3.3.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	AS (ACTIVITY SUM)
F1		3	1	3			2	2		1	12
F2	1		3		2	1		1			8
F3		2			3	2					7
F4		3	3				2				8
F5								2			2
F6	3				1		2	1			7
F7	1	1	1	1		2		1		2	9
F8			1	1						1	3
F9	1	3		3						2	9
F10	3	3	3	2		1	3	3	1		19

Figure 3.14: Final Cross Impact Matrix (identical to original ADVIAN matrix)
Source: Researcher's own construction

The researcher is of the belief that using an unnormalised matrix for data analysis will result in inflated impact strengths of indirect relationships which, sometimes, results in the indirect relationships having stronger strengths than direct relationships. Using a normalised CIM will result in the impact strength being in the interval from 0 – 1, which allows for far more accuracy, but also allows for the data to be converted back to a CIM of 0,1, 2 or 3 impact values by using the following scale:

[0 – 0.25] – no impact =0 (0.26 – 0.5) – low impact = 1

[0.51 – 0.75) – medium impact = 2 [0.76 – 1.00] – high impact = 3

Final step: **Normalise the CIM such that each entry is between 0 and 1 by dividing each entry by the high value** of impact score - Each entry in the CIM is divided by the highest value (3) in order to normalise the results, as shown in figure 3.15.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1		1	0.333	1			0.667	0.667		0.667
F2	0.667		1		0.667	0.333		0.333		
F3		0.667			1	0.667				
F4		1	1				0.667			
F5								0.667		
F6	1				0.333		0.667	0.333		
F7	0.333	0.333	0.333	0.333		0.667		0.333		0.667
F8			0.333	0.333						0.333
F9	0.333	1		1						0.667
F10	1	1	1	0.667		0.333	1	1	0.333	

Figure 3.15: Final Normalised Cross Impact Matrix
Source: Researcher's own construction

3.4 Theory Formulation

All research frameworks need an accepted way of generating a theory or a method to describe how results were obtained and conclusions made. The current study uses content analysis to infer a list of factors from the literature. These factors are, thereafter, taken to the field, where a questionnaire is used to ascertain which of these factors are critical for the successful implementation of an ERP. For this study, theory is, therefore, formulated deductively, as opposed to inductively. Deductive research is a top-down approach which moves from the general to the more specific (Trochim, Donnelly and Arora 2015). This starts with a theory about a topic which is narrowed down into more specific hypotheses that can be tested. Data are collected to address the hypotheses, after which the hypotheses are tested and the original theory is confirmed or not confirmed. It is apparent that this type of research is, therefore, confirmatory in nature. In conforming to the philosophical underpinning of the study, deduction conforms to the post-positivist philosophy (Crowther and Lancaster 2012).

In contrast, induction can be seen as a means of theory generation, which moves from the specific to the general with no pre-conceived notions of theories from the start (Ormerod 2009; Rule and Vaughn 2011). The inductive approach is a bottom-up approach which starts with observation. From the observations, patterns emerge, which are tested and general theories are developed. This type of research is normally exploratory in nature and often includes open-ended type questions (Trochim, Donnelly and Arora 2015).

3.5 Reliability and Validity

It is important for any study that the researcher establishes that the research being undertaken is both reliable and valid. Joppe (2006) contends that reliability refers to the extent to which the results of a study remain consistent over a period of time, with Kirk and Miller (1986) identifying three areas of reliability; viz., the extent to which results will repeatedly remain unchanged; the stability of the result over time; and the similarity of the results in a given time frame. The validity of the research is described by Joppe (2006), as the degree to which the study truly measures what it intends to measure.

The current study uses algorithmic development to create an algorithm that converts a series of preference chains to a CIM. The proof that the algorithm produces the correct CIM is shown in section 3.3.8, with the on-line application being tested using the same preference chains to produce the same sample CIM in section 3.3.6. It is shown that both the algorithm and the on-line application display correct, consistent, reliable and valid results which can be repeated numerous times at different intervals, all producing the same CIM. It follows that the study is reliable and valid.

3.6 Chapter Summary

This chapter presented the approach that was followed by the researcher in conducting the study. Research strategies were discussed as well as philosophies so that the research could be placed in the greater research perspective. It was evident that this study fell into a post-positivist paradigm with the methodology making use of a mixed methods approach. Two methods of data gathering were discussed and implemented, i.e., content analysis and questionnaire. The questionnaire was completed using the researcher's own designed on-line data gathering application, and the participants were experts that were identified in the field. A number of other strategies were explored and included the Delphi, grounded theory and case study approaches. The reason for the selection of the expert participants was discussed in detail. The ADVIAN data analysis tool was selected for the study, but instead of the expert participants creating a CIM, the CIM was generated by the researcher's application, from the preference chains gathered. Due to the researcher making use of algorithmic development, it follows that the results will be both valid and reliable.

The next chapter presents and discusses the results of ADVIAN data analysis.

CHAPTER 4: Results of ADVIAN Data Analysis

The purpose of this chapter is to present and discuss the findings of the data collected and analysed through the techniques that were adopted and presented in chapter 3. Through the data analysis, the final three objectives of the study are achieved. The first objective of the study was: To ***define criticality in the context of successful on-line registration implementation***. This was defined by the researcher in chapter 2, section 2.4.1 (the literature review). The second objective: To ***establish, refine and categorise a set of factors that are deemed necessary for successful on-line registration implementation through literature for use in the fieldwork,*** was established in chapter 2, section 2.4.3, where a table of factors was presented. The final three objectives will be met in this chapter, viz., 3) To ***uncover relationships that exist between factors and establish how each might impact on the on-line registration system implementation; 4***) To ***identify the criticality, stability and integration of each factor; and 5***) To ***determine which factors should be used for intervention strategies by identifying the following for each factor: precarious, driving and driven.***

The chapter begins with a look at the researcher's on-line application and follows with a discussion of the expert participants and the demographic data that were collected. This data was used as a means of assessing the validity of the chosen expert sample. The discussion of the results from the data collected starts foremost with the presentation of the CIM that is generated from the preference chains, using the software written by the researcher. Thereafter, the results of the ADVIAN analysis are presented in the form of tables and graphs. These are used to discuss how each factor impacts on others and on the overall success of the system implementation. Classifications to be presented include integration, system stability and criticality, while the factors are ranked according to factors that are precarious, driving and driven.

4.1 The researcher's on-line application for data collection

This study used a CIM that was generated from preference chains obtained from the participants. As mentioned in chapter 3, there appears to be no existing methodology or framework that can take preference chains as input and produce a CIM. The researcher, therefore, used the algorithm presented in section 3.3.5 to generate the CIM to be used with the ADVIAN analysis tool. Furthermore, the researcher developed an on-line application (http://csfsurvey.biz.ht/index.php) for the gathering of data in the form of preference chains. The on-line survey developed by the researcher was developed using HTML, PHP and a MYSQL DB. A link to this survey as well as a unique username were emailed to the expert participants so that they could complete the survey when it suited them. The application was first tested on a variety of laptops, desktops, tablets and smart phones as well as various operating systems to ensure its user friendliness and portability. Figure 4.1 shows the Login page of the survey where the participant logs in with the username supplied.

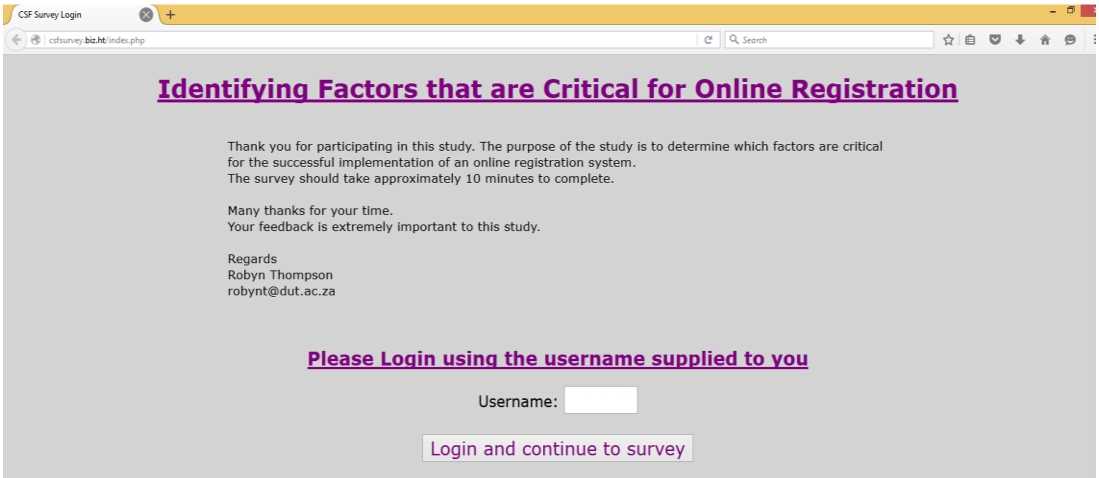


Figure 4.1: Login page
Source: Researchers own app, available at: http://csfsurvey.biz.ht/index.php

Once logged in, the user is directed to the background information gathering page shown in figure 4.2, where various personal and background information is captured. Should the user already have logged in previously and have entered data and preference chains, the application will redirect the participant to the summary page in figure 4.5. If this is the first login, the participant is directed to the Preference chain page, as shown in figure 4.3. This page provides a list of factors on the left hand side of the screen. It must be noted that the factors presented were presented in more detail than the factors identified in chapter 2. This was to ensure that the participants fully understood the meaning of the factor. As the participant clicks on these factors, the factor will be removed so that the factor cannot be selected more than once in a single chain. As the chain is built, it is displayed on the right hand side, with options under the chain to save the chain or clear the chain. Already created chains are displayed in the middle. The participant has the option to delete an already created chain by clicking on the red cross. While a chain is being created, the “finish” button is deactivated. Note that this button is not visible in figure 4.3, but is visible in figure 4.4 because figure 4.3 shows a chain that is being created.

When the participant clicks “finish”, the summary page in figure 4.5 is displayed. The participant has the following options: update or change any personal information; remove any chains not required; create more chains; clear all data; and restart the survey; click on “finish”. Clicking on “create more chains” will redirect the participant back to the preference chain page so that more chains can be created. By activating the “clear all and restart survey” option, all the participant’s background information as well as preference chains are deleted and the participant is redirected back to the first Login page.

The final page (figure 4.6) thanks the participant and also gives the participant the option to view the CIM that is generated. Figure 4.7 shows an example of a CIM that is generated by the application. It is at this point that the CIM can be exported to excel in order for data analysis to take place on the data. The excel generated spreadsheet is shown in figure 4.8.

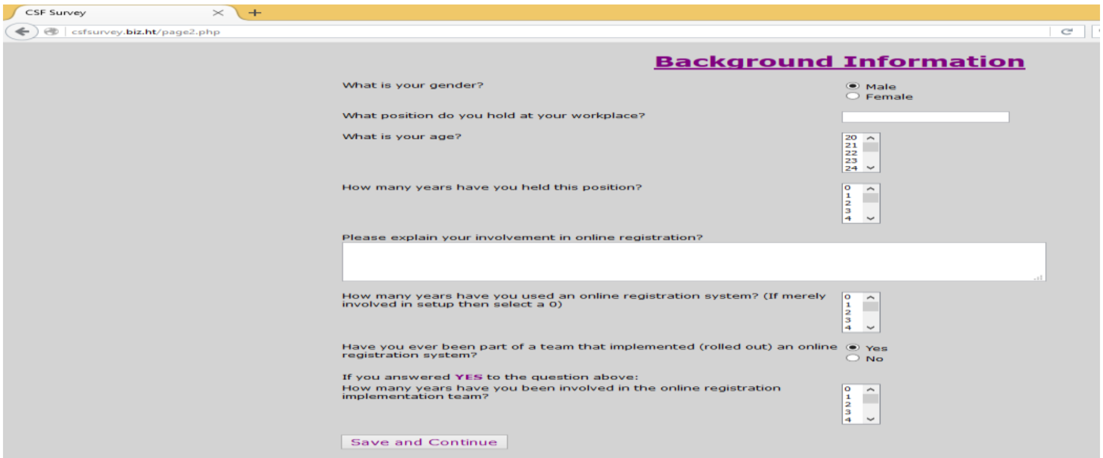


Figure 4.2: Background Information Page
Source: Researchers own app, available at: http://csfsurvey.biz.ht/index.php

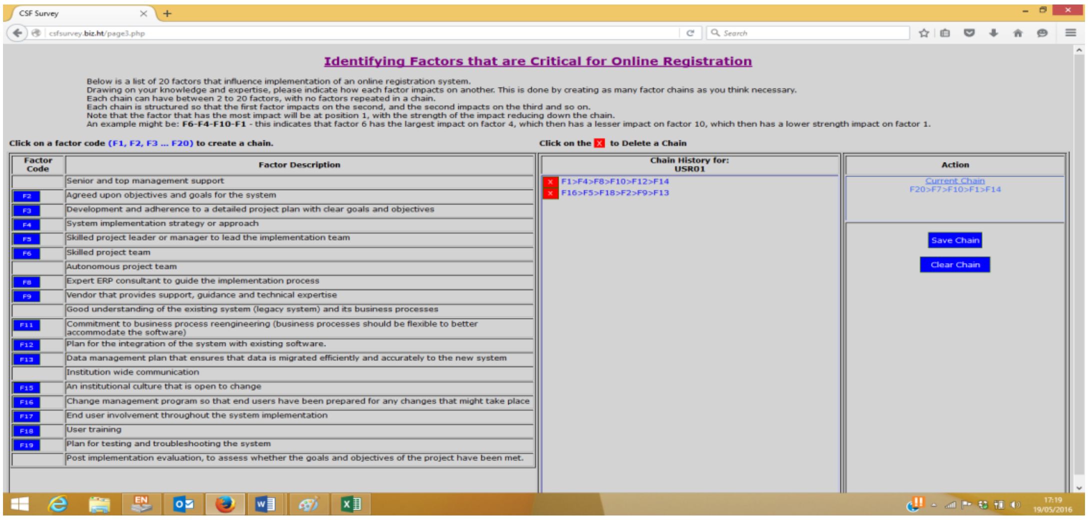


Figure 4.3: Preference Chain Page – Example 1
Source: Researchers own app, available at: http://csfsurvey.biz.ht/index.php

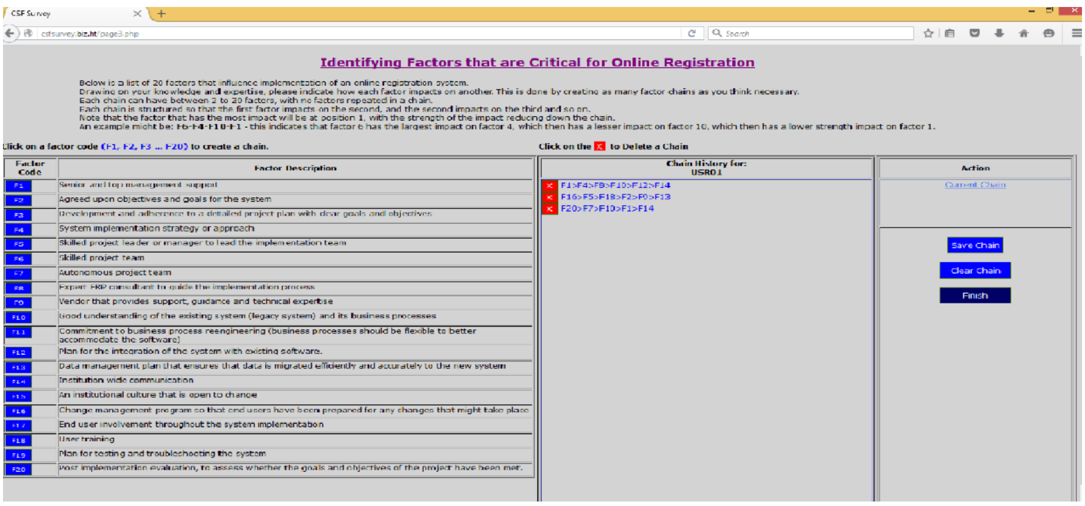


Figure 4.4: Preference Chain Page – Example 2
Source: Researchers own app, available at: http://csfsurvey.biz.ht/index.php

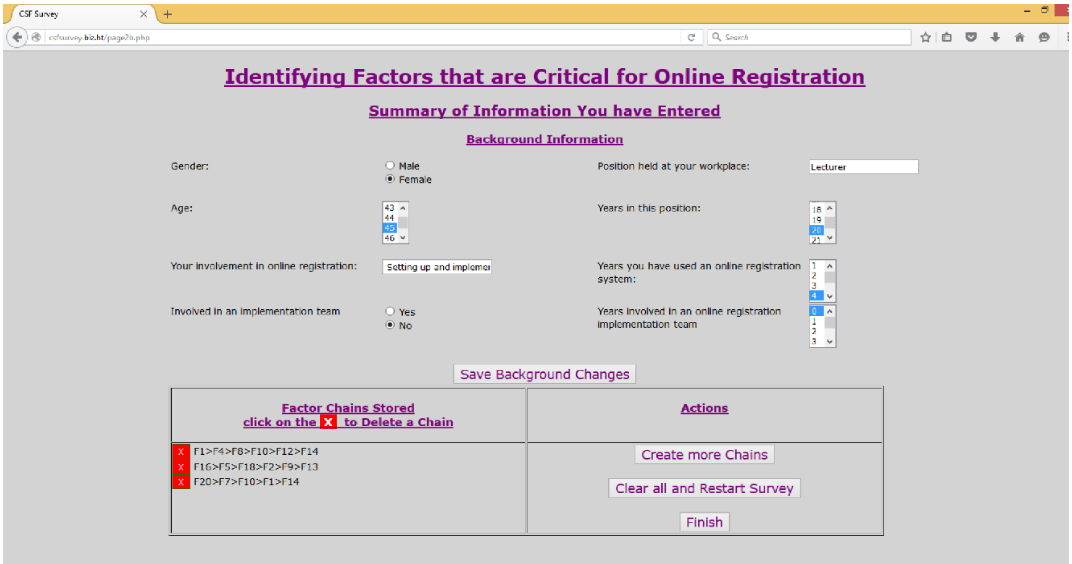


Figure 4.5: Summary page
Source: Researchers own app, available at: http://csfsurvey.biz.ht/index.php

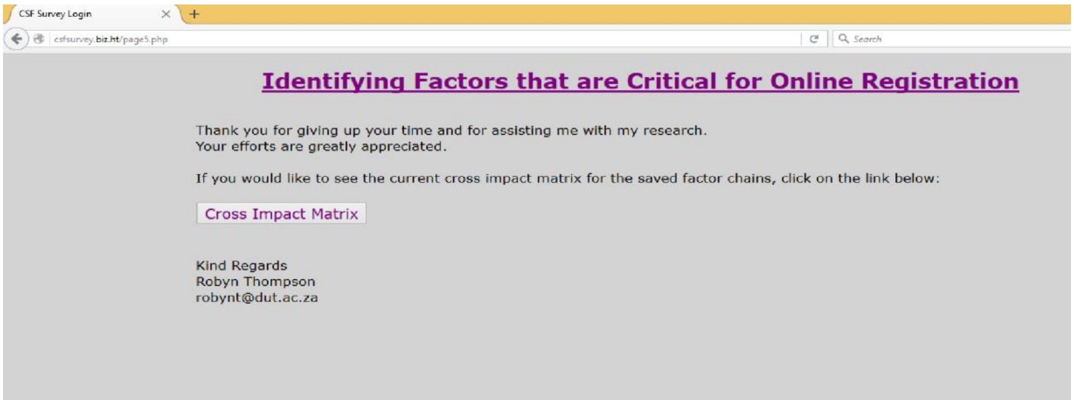
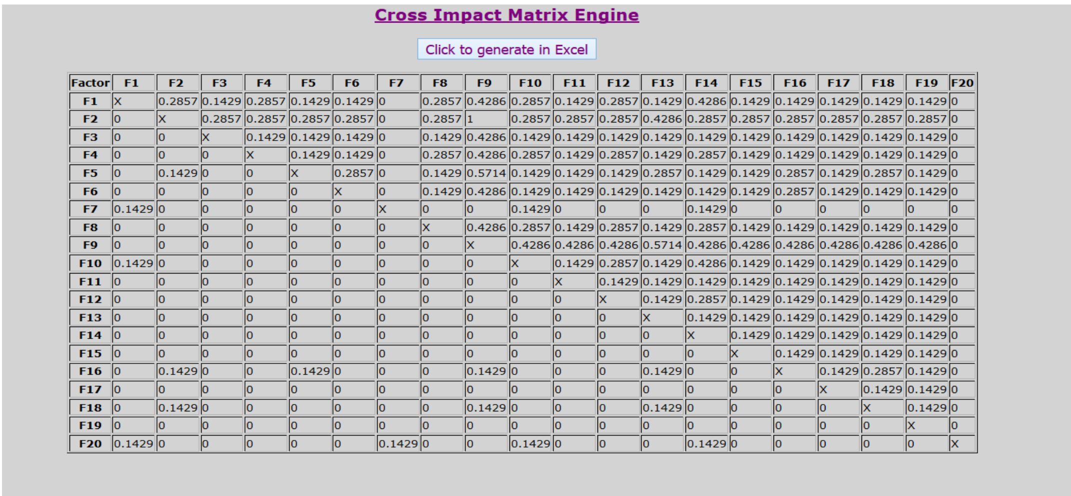


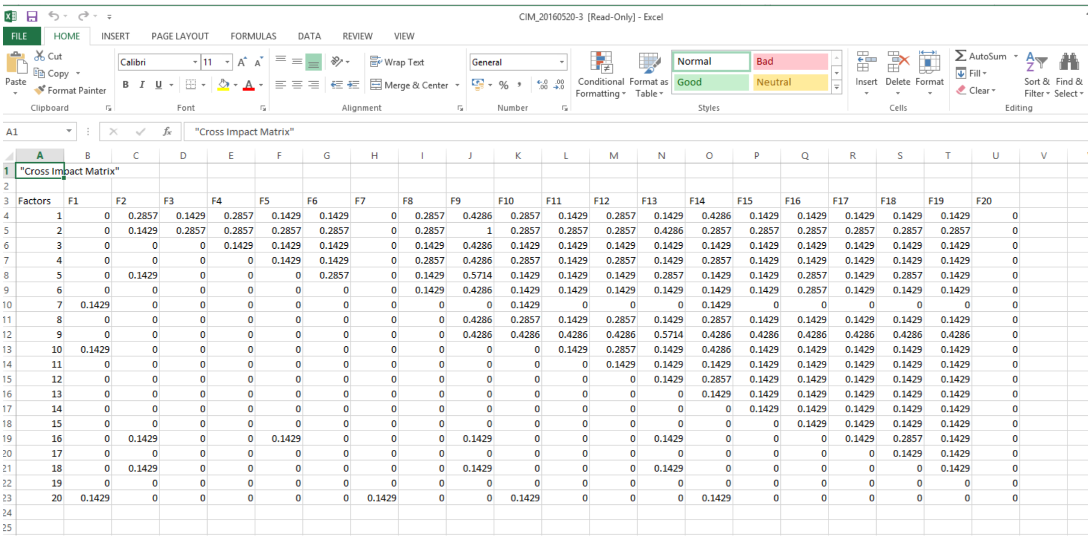
Figure 4.6: Final Page
Source: Researchers own app, available at: http://csfsurvey.biz.ht/index.php


Cross Impact Matrix Engine

Click to generate in Excel

Factor	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
F1	X	0.2857	0.1429	0.2857	0.1429	0.1429	0	0.2857	0.4286	0.2857	0.1429	0.2857	0.1429	0.4286	0.1429	0.1429	0.1429	0.1429	0.1429	0
F2	0	X	0.2857	0.2857	0.2857	0.2857	0	0.2857	1	0.2857	0.2857	0.2857	0.4286	0.2857	0.2857	0.2857	0.2857	0.2857	0.2857	0
F3	0	0	X	0.1429	0.1429	0.1429	0	0.1429	0.4286	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0
F4	0	0	0	X	0.1429	0.1429	0	0.2857	0.4286	0.2857	0.1429	0.2857	0.1429	0.2857	0.1429	0.1429	0.1429	0.1429	0.1429	0
F5	0	0.1429	0	0	X	0.2857	0	0.1429	0.5714	0.1429	0.1429	0.1429	0.2857	0.1429	0.1429	0.2857	0.1429	0.2857	0.1429	0
F6	0	0	0	0	0	X	0	0.1429	0.4286	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.2857	0.1429	0.1429	0.1429	0
F7	0.1429	0	0	0	0	0	X	0	0	0.1429	0	0	0	0.1429	0	0	0	0	0	0
F8	0	0	0	0	0	0	0	X	0.4286	0.2857	0.1429	0.2857	0.1429	0.2857	0.1429	0.1429	0.1429	0.1429	0.1429	0
F9	0	0	0	0	0	0	0	0	X	0.4286	0.4286	0.4286	0.5714	0.4286	0.4286	0.4286	0.4286	0.4286	0.4286	0
F10	0.1429	0	0	0	0	0	0	0	0	X	0.1429	0.2857	0.1429	0.4286	0.1429	0.1429	0.1429	0.1429	0.1429	0
F11	0	0	0	0	0	0	0	0	0	0	X	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0
F12	0	0	0	0	0	0	0	0	0	0	0	X	0.1429	0.2857	0.1429	0.1429	0.1429	0.1429	0.1429	0
F13	0	0	0	0	0	0	0	0	0	0	0	0	X	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0
F14	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0.1429	0.1429	0.1429	0.1429	0.1429	0
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0.1429	0.1429	0.1429	0.1429	0
F16	0	0.1429	0	0	0.1429	0	0	0	0.1429	0	0	0	0.1429	0	0	X	0.1429	0.2857	0.1429	0
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0.1429	0.1429	0
F18	0	0.1429	0	0	0	0	0	0	0.1429	0	0	0	0.1429	0	0	0	0	X	0.1429	0
F19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0
F20	0.1429	0	0	0	0	0	0.1429	0	0	0.1429	0	0	0	0.1429	0	0	0	0	0	X

Figure 4.7: Cross Impact Matrix Page
Source: Researchers own app, available at: http://csfsurvey.biz.ht/index.php



"Cross Impact Matrix"

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
1	0	0.2857	0.1429	0.2857	0.1429	0.1429	0	0.2857	0.4286	0.2857	0.1429	0.2857	0.1429	0.4286	0.1429	0.1429	0.1429	0.1429	0.1429	0
2	0	0.1429	0.2857	0.2857	0.2857	0.2857	0	0.2857	1	0.2857	0.2857	0.2857	0.4286	0.2857	0.2857	0.2857	0.2857	0.2857	0.2857	0
3	0	0	0	0.1429	0.1429	0.1429	0	0.1429	0.4286	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0
4	0	0	0	0	0.1429	0.1429	0	0.2857	0.4286	0.2857	0.1429	0.2857	0.1429	0.2857	0.1429	0.1429	0.1429	0.1429	0.1429	0
5	0	0.1429	0	0	0	0.2857	0	0.1429	0.5714	0.1429	0.1429	0.1429	0.2857	0.1429	0.1429	0.2857	0.1429	0.2857	0.1429	0
6	0	0	0	0	0	0	0	0.1429	0.4286	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.2857	0.1429	0.1429	0.1429	0
7	0.1429	0	0	0	0	0	0	0	0	0.1429	0	0	0	0.1429	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0.4286	0.2857	0.1429	0.2857	0.1429	0.2857	0.1429	0.1429	0.1429	0.1429	0.1429	0
9	0	0	0	0	0	0	0	0	0.4286	0.4286	0.4286	0.4286	0.5714	0.4286	0.4286	0.4286	0.4286	0.4286	0.4286	0
10	0.1429	0	0	0	0	0	0	0	0	0	0.1429	0.2857	0.1429	0.4286	0.1429	0.1429	0.1429	0.1429	0.1429	0
11	0	0	0	0	0	0	0	0	0	0	0	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0.1429	0.2857	0.1429	0.1429	0.1429	0.1429	0.1429	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1429	0.1429	0.1429	0.1429	0.1429	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1429	0.1429	0.1429	0.1429	0
16	0	0.1429	0	0	0.1429	0	0	0	0.1429	0	0	0	0.1429	0	0	0	0.1429	0.2857	0.1429	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1429	0.1429	0
18	0	0.1429	0	0	0	0	0	0	0.1429	0	0	0	0.1429	0	0	0	0	0	0.1429	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0.1429	0	0	0	0	0	0.1429	0	0	0.1429	0	0	0	0.1429	0	0	0	0	0	0

Figure 4.8: Excel download of cross impact matrix
Source: Researchers own app, available at: http://csfsurvey.biz.ht/index.php

4.2 Proof for Researcher's Application

The application was tested to ensure that the CIM generated was correct. Using the application, the researcher captured the preference chains (shown in figure 4.9) that were generated from the automotive example. The captured preference chains can be seen in table 3.2. The CIM was then generated by the application, as shown in figure 4.10, this matrix being identical to the original matrix from the original automotive example (see example in figure 3.3). As was previously mentioned, for the purpose of additional refinement and accuracy, the CIM was be normalised such that real values between 0 and 1 were used instead of integers 0 to 3.

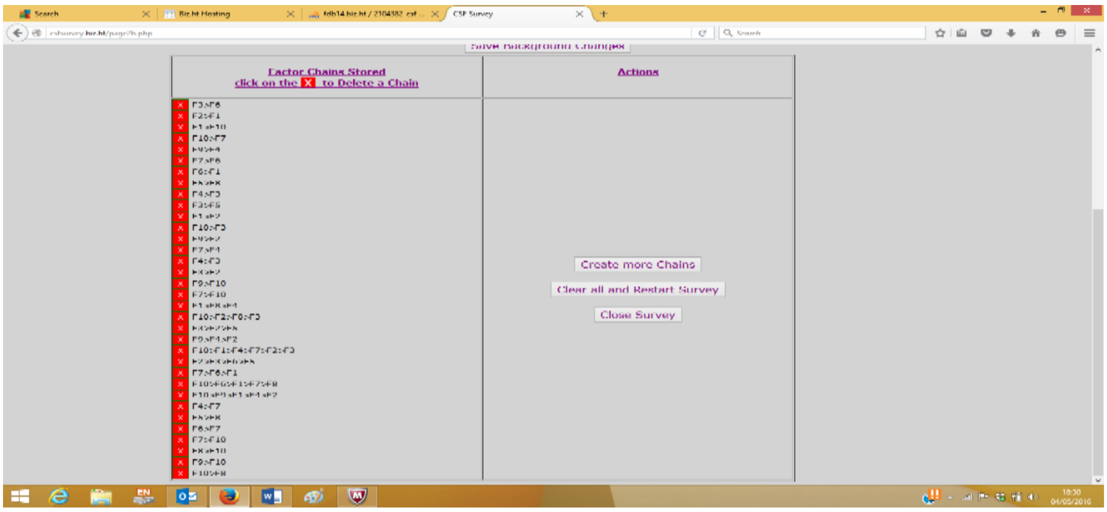
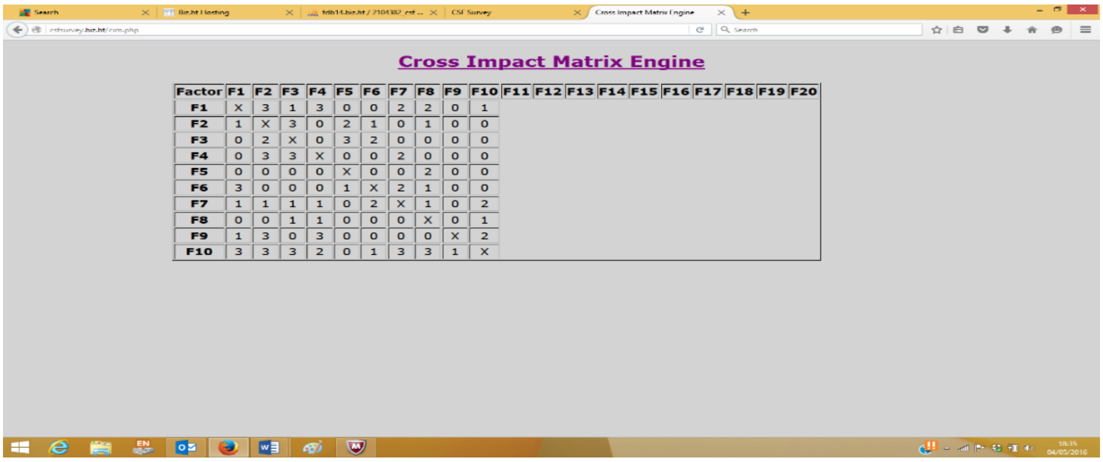


Figure 4.9: Preference Chains Captured for Testing the Application
Source: Researchers own app, available at: http://csfsurvey.biz.ht/index.php



Factor	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
F1	X	3	1	3	0	0	2	2	0	1										
F2	1	X	3	0	2	1	0	1	0	0										
F3	0	2	X	0	3	2	0	0	0	0										
F4	0	3	3	X	0	0	2	0	0	0										
F5	0	0	0	0	X	0	0	2	0	0										
F6	3	0	0	0	1	X	2	1	0	0										
F7	1	1	1	1	0	2	X	1	0	2										
F8	0	0	1	1	0	0	0	X	0	1										
F9	1	3	0	3	0	0	0	0	X	2										
F10	3	3	3	2	0	1	3	3	1	X										

Figure 4.10: Cross Impact Matrix Generated from Application
Source: Researchers own app, available at: http://csfsurvey.biz.ht/index.php

For the analysis of data to take place, the researcher created a spreadsheet that automates the calculations of equations 3.1 through 3.16. Once again, these calculations were validated against the original values for the example on automotive CIM presented by Linss and Fried (2010). The values matched those from the original example. The spreadsheet formulae were, therefore, deemed to be valid and correct. The data analysis made use of a variety of graphs for the plotting of: integration, system stability, criticality, precarious factors, driving factors and driven factors. Each graph has contour lines plotted as well as scatter points for each of the factors being analysed. The researcher used excel to plot the graphs, with the relative indirect AS being on the x axis and the relative indirect PS being on the y axis. The graphs were, once again, considered valid and correct as they were identical to those plotted by Linss and Fried (2010).

4.3 The expert participants

The data analysed in this study was based on the opinions of 10 expert participants that were identified as being key role players in the implementation of the on-line registration system at DUT. A total of 12 experts were identified in consultation with two other staff members at DUT who were responsible for driving the implementation of the system. Unfortunately, two of the participants, from positions in management, who were invited to take part in the survey, declined the invitation, one due to other work commitments and the other due to the expert being of the opinion that the system and technical knowledge the expert had were not sufficient to complete the questionnaire. All the data gathered from the 10 expert participants was usable.

The demographic details gathered include age, gender, position at workplace, number of years in that position, number of years involved in on-line registration, an explanation of this involvement and number of years involved in the implementation team. This data was used in the study but does give an indication as to the number of years the participant has worked in their field, his/her area of expertise as well as conforming to the need to have a sample that is as heterogeneous as possible, as specified by Powell (2003). The data collected also validated the sample collection, as it can easily be seen that the experts have years of experience and positions that place them at the top of their respective fields, which is a requirement mentioned by Kuusi (1999).

The expert participants were predominantly (40%) in the 40 – 50 age category, with the average age being 46, demonstrating that the experts are possibly in the more mature category and would have many years experience and a wide knowledge area. It can also be seen that the experts have many years of experience in their respective positions, with most of the experts (50%) falling into the 5 – 10 years category. This information supports the selection of these participants as experts in their fields. In support, it can also be seen that most of the experts (4) have been involved with the on-line registration system for 4 – 6 years. Importantly, the on-line registration was only implemented 6 years ago, so 6 is the maximum number of years possible. The 4 experts that responded that they have 0 years of experience with on-line registration are those experts that are from areas that do not require them to be involved in the system, for example, those that are directors or project managers. When evaluating the number of years of involvement with the implementation of the system, it can be seen that the average number of years is 4.6, with the majority (5) of the expert participants falling within the 3 – 6-year category. When considering that ERPs have only been implemented at HEIs in the past 10 – 15 years, the average of 4.6 years indicates that the experts selected have a lot of experience in this area.

When considering the heterogeneous sample recommendation, it is evident that an equal number of male and female expert participants were used in the study as well as experts with a wide range of ages (from 34 to 61). Moreover, the experts have varying job descriptions (as can be seen in table 4.1). The experts were also not only from the DUT, but also from the vendor company as well as an independent project management organisation. Table 4.1 below summarises the demographic data that were collected from the participants.

Table 4.1: Experts' Demographics (n=10)

Item	Range	Frequency	Percentage (%)	Average
Gender	Female	5	50%	N/A
	Male	5	50%	
Age	below 30	0	0%	46 years
	31 – 40 years	3	30%	
	41 – 50 years	4	40%	
	50+ years	3	30%	
Position	Directorship or Management	2	20%	N/A
	IT Specialists (includes DB, systems and Technology)	3	30%	
	Programmer, analysts or developer	2	20%	
	Project Manager, Task Team co-ordinators	3	30%	
Years in the Position	Below 5 years	3	30%	8 years
	5 – 10 years	5	50%	
	11 – 15 years	1	10%	
	16 – 20 years	1	10%	
Years Involved with On-line Registration	0 years	4	40%	2.7 years
	1 – 3 years	2	20%	
	4 - 6 years	4	40%	
Years Involved in the Implementation Team	Below 3 years	3	30%	4.6 years
	3 – 6 years	5	50%	
	7 – 10 years	2	20%	
Involvement in On-line Registration	System testing			
	ERP development, testing and maintenance			
	Project management			
	Technical support			
	Task team co-ordination			
	Deployment of system including training and post implementation enhancements			

4.4 Presentation of ADVIAN Results

Once the demographic details of the expert participants were gathered, the on-line application gathered data in the form of preference chains from each participant. As discussed in chapter 3, the preference chains can generate a CIM. The CIM that was generated from these preference chains is presented in figure 4.11 below. The formed matrix consists of 20 columns and 20 rows, each representing the factors that were presented to the participant. The matrix was normalised to a value between 0 and 1.0, as described in chapter 3.

Factor	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
1	0	0.5	0.7	0.5	0.7	0.6	0.4	0.3	0.5	0.4	0.5	0.4	0.5	0.8	0.7	0.6	0.7	0.6	0.6	0.6
2	0.1	0	0.4	0.6	0.2	0.2	0.1	0.2	0.1	0.5	0.2	0.4	0.5	0.4	0.4	0.4	0.7	0.7	0.6	0.7
3	0	0.1	0	0.5	0.4	0.3	0.2	0.2	0	0.3	0.3	0.4	0.6	0.4	0.4	0.6	0.6	0.6	0.5	0.4
4	0.1	0	0	0	0.3	0.2	0	0.3	0.2	0.5	0.2	0.5	0.5	0.3	0.3	0.4	0.4	0.7	0.5	0.5
5	0.1	0.2	0.1	0.3	0	0.8	0.4	0.2	0.3	0.5	0.2	0.5	0.4	0.5	0.5	0.6	0.5	0.6	0.6	0.4
6	0	0.1	0.1	0.2	0	0	0.4	0.2	0.4	0.4	0.2	0.4	0.3	0.4	0.4	0.5	0.4	0.5	0.6	0.3
7	0	0.1	0.1	0.2	0.1	0.2	0	0.1	0.2	0.3	0.2	0.4	0.3	0.3	0.3	0.5	0.3	0.3	0.4	0.2
8	0	0.1	0.1	0.2	0.2	0.1	0.1	0	0.2	0.6	0.4	0.7	0.6	0.2	0.2	0.3	0.4	0.5	0.5	0.6
9	0	0.4	0.4	0.4	0.2	0.2	0.1	0.1	0	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.6	0.4
10	0	0.1	0.1	0.2	0	0.1	0	0.1	0.2	0	0.5	0.9	0.6	0.3	0.4	0.5	0.6	0.8	0.9	0.7
11	0	0.1	0.1	0.2	0.1	0.1	0	0	0.1	0.1	0	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.7	0.6
12	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0.3	0.4	0.7	0.6	0.6	0.9	0.7
13	0	0	0	0	0	0	0	0.1	0	0	0	0.1	0	0.2	0.2	0.5	0.6	0.6	0.7	0.7
14	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0.5	0.6	0.7	0.6	0.3	0.5
15	0.1	0	0	0	0	0	0	0	0	0	0.1	0	0.1	0.5	0	0.5	0.6	0.5	0.4	0.6
16	0	0	0	0	0	0	0	0.1	0	0.1	0	0	0.1	0	0.2	0	0.8	0.7	0.9	0.7
17	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0.1	0.2	0	1	0.5	0.7
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2	0.2	0	0.5	0.7
19	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0.4	0.4	0	0.9
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0

Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Project management to implement the project plan; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP consultant; (9) ERP Vendor support and guidance; (10) Legacy system and business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational culture; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.

Figure 4.11: Cross Impact Matrix for Factors

Source: Researchers own construction

4.4.1 Direct Relationships

After generating the CIM and exporting it to excel, the active and passive sums were calculated according to Eq.1 and 3.2, which were presented in chapter 3. These results are summarized in table 4.2 below. The AS demonstrates the degree to which a factor has a direct impact on the system, whereas the PS indicates the degree to which a factor is affected by the system. These values are converted to relative values such that all active and passive sums reflect a value between 0 and 100 (see equations 3.7 and 3.8). This conversion, according to (Linss and Fried 2010), allows the method to be used for any system with any number of factors. According to the relative direct ASs, factor 1 (Senior and top management support) has the highest impact (97.2477) on other factors, with factor 5 (Skilled project leader) and factor 2 (Project plan with clearly agreed upon objectives and goals) also having a high direct influence on the system implementation success. These 2 factors have ASs of 70.6422 and 67.8899, respectively. The factors directly influenced by the system are mostly those presenting a high PS. The highest relative PS of 100 was found for factor 20 (Post-implementation evaluation). This factor is, therefore, found to be directly affected or influenced by the other factors the most. Other factors that are also directly affected by the system to a large degree are factors 18 (User training) and 19 (Software testing and troubleshooting), with PSs of 99.0826 each.

The factors that have been presented in the following sections are those that were inferred from the literature and presented to the participants of the study. Once the results of the ADVIAN data analysis were complete, a lens was then required as a means of establishing which of the 20 factors were most relevant for each particular attribute or classification. This study will focus on those factors that exceed a particular attribute's average of two-thirds of the standard deviation. This is in line with the method used in a study conducted by Guertler and Spinler (2015). The factors that exceed the average of two-thirds of the standard deviation have been highlighted in the relevant tables.

Table 4.2: Direct Active and Direct Passive Sums

Factors	Active Sum (*dAS*)	Relative Direct Active Sum (*dAS'*)	Ranking by *dAS'*	Passive Sum (*dPS*)	Relative Direct Passive Sum (*dPS'*)	Ranking by *dPS*
1	10.6	97.2477	1	0.4	3.66972	20
2	7.4	67.8899	3	1.7	15.5963	18
3	6.8	62.3853	5	2.1	19.2661	16
4	5.9	54.1284	7	3.5	32.1101	11
5	7.7	70.6422	2	2.2	20.1835	14
6	5.8	53.211	10	2.8	25.6881	13
7	4.5	41.2844	12	1.7	15.5963	18
8	6	55.0459	6	1.9	17.4312	17
9	5.9	54.1284	7	2.2	20.1835	14
10	7	64.2202	4	4.1	37.6147	10
11	5.9	54.1284	7	3.1	28.4404	12
12	5	45.8716	11	5.6	51.3761	8
13	3.7	33.945	13	6.3	57.7982	6
14	3.3	30.2752	16	5.5	50.4587	9
15	3.4	31.1927	15	6	55.0459	7
16	3.7	33.945	13	8	73.3945	5
17	2.6	23.8532	17	9.4	86.2385	4
18	1.7	15.5963	19	10.8	99.0826	2
19	2.1	19.2661	18	10.8	99.0826	2
20	0.1	0.91743	20	10.9	100	1

Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Project management to implement the project plan; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP consultant; (9) ERP Vendor support and guidance; (10) Legacy system and business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational culture; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.

4.4.2 Indirect Interrelationships

The third objective of this study was to ***uncover relationships that exist between factors and establish how each might impact on the on-line registration system implementation.*** This was achieved by identifying the indirect interrelationships that factors have on each other, as well as the indirect influence that factors have on the system (on-line registration implementation) and the indirect influence that the system has on each factor. In order to calculate these indirect active and passive sums, different orders of influence were calculated, as per equations 3.3 and 3.4. This was performed up to order 19 (using the calculation $k=n-1$, where n is the number of factors). The indirect active and passive sums for each factor can then be calculated, as shown in equations 3.5 and 3.6. Thereafter, the active and passive sums were converted to relative values (equations 3.9 and 3.10). Tables 4.3, 4.4 and 4.5 below have been extracted from the excel spreadsheet to show the indirect and relative active and passive sums with their ranking order (table 4.3), the activity orders (table 4.4) and the orders of passivity (table 4.5).

From table 4.4, it can be seen that the average relative direct active and passive sums are virtually equal (45.4587 and 45.4128, respectively), and the average relative indirect active and passive sums (22.81) are equal. It can, therefore, be said the factors directly and indirectly affect the system to the same degree that the factors are affected by the system. The existence of strong interrelationships between the factors is revealed by the change in average relative active and passive sums across the orders, with the average relative direct active and passive sums in order 1 being 45, but changing to an average of 23 for both the relative indirect active and passive sums in order 20. The strength of the impact that each of the factors has on the system and on other factors diminishes with the increasing orders, with all the relative indirect ASs being less than their corresponding relative direct AS values. Table 4.4 also shows how the ranking of the factors, according to active and passive sum, changes slightly when taking into account the interrelationships that exist between factors, with most significant changes taking place for factor 10 (Legacy system and business processes), moving from a ranking of 4 for direct activity to 9, when indirect interrelationships are considered. The influence of this factor, therefore, decreases with the increasing orders, but the passive ranking remains largely the same, indicating that the influence on the factor when accounting for indirect interrelationships has little effect on the ranking factors. Factor 9 (ERP Vendor support and guidance) moved three positions in activity ranking, up to position 4, indicating that, with the inclusion of interrelationships, the provision of vendor support and guidance plays a more crucial role in the influence it plays on other factors and the system. The only marked difference in the ranking of the PSs is seen in factor 8 (Expert ERP consultant to guide the implementation process), where the ranking of the relative indirect PS moved to position 13, showing that this factor is influenced by the system and other factors to a greater degree when interrelationships are observed.

The behaviour of factors will now be discussed, with focus being on those factors that exceed a particular attribute's average by two-thirds of the standard deviation (as mentioned at the beginning of the section).

It is evident that the factor that has the most influence on other factors is factor 1 (Senior and top management support) with a relative indirect AS of 80.7. From the generated CIM in figure 4.11, factor 1 has the strongest effect (with impact values of 0.7 or 0.8) on factors 14 (Effective organisation wide communication), 3 (Project management to implement the project plan), 5 (Project leader), 15 (Organisational culture) and 17 (User involvement). Factor 1, therefore, has a significant, direct effect on the successful implementation of an on-line registration system and neglecting this factor may increase the probability of the implementation failing.

Factor 5 (Project leader), factor 2 (Project plan with agreed upon objectives and goals), factor 9 (ERP vendor support and guidance) and factor 3 (Project management to implement the project plan), with relative indirect ASs of 48.6, 43, 39 and 37.9, respectively, although not as significant as factor 1, also have a considerable impact on other factors. Both factors 2 and 3 have strong impacts on factors 17 (User involvement) and 18 (User training), along with not having a project plan with clear, agreed upon objectives and goals (factor 2) which also has a marked effect on the post-implementation evaluation (factor 20), with an interrelation existing between these factors. Factor 3, which deals with project management and the implementation of the project plan, has notable interrelations with other plans, such as factor 13 (data management) and factor 16 (change management).

Another interrelationship that exists is between the project leader (factor 5) and the skilled project team (factor 6). The final factor that has a high relative indirect AS is that of factor 9 (ERP vendor support and guidance), whose highest impact is on factor 19 (Software testing and troubleshooting). Without selection of the correct vendor, it is evident that there would be an effect on the testing of the system and handling all troubleshooting.

High indirect PSs are identified for factors 20 (Post-implementation evaluation), 18 (User training), 19 (System testing and troubleshooting) and, to a lesser extent, 17 (User involvement). The strongest effect exerted on factor 20 is by factor 19 (System testing and troubleshooting). User training (factor 18) as well as system testing and troubleshooting (factor 19) are both highly reactive to the legacy system and business processes (factor 10). Additionally, software integration (factor 12) and change management (factor 16) impact highly on the testing and troubleshooting plan (factor 19). While, change management (factor 16) has a high impact on user involvement (factor 17). However, the strong interrelationship that exists between two factors is the effect that user involvement throughout implementation (factor 17) has on user training (factor 18).

Table 4.3: Indirect and Relative Active and Passive sums

Factor	Relative Direct Active Sum (*dAS'*)	Relative Direct Passive Sum (*dPS'*)	Ranking by *dAS'*	Ranking by *dPS*	Indirect Active Sum (*iAS*)	Indirect Passive Sum (*iPS*)	Relative Indirect Active Sum (*iAS'*)	Relative Indirect Passive Sum (*iPS'*)	Ranking by Indirect Active Sum	Ranking by Indirect Passive Sum
1	97.2477	3.66972	1	20	1804476787	35985497	80.7370514	1.61008606	1	20
2	67.8899	15.5963	3	18	961896708.6	51120787.31	43.0377961	2.28727887	3	18
3	62.3853	19.2661	5	16	847125787.3	57044158.73	37.9026423	2.55230614	5	17
4	54.1284	32.1101	7	11	719637486.9	212232112.4	32.1984795	9.49582455	6	10
5	70.6422	20.1835	2	14	1085720477	72022131.41	48.5779981	3.22246014	2	16
6	53.211	25.6881	10	13	699108594.6	87440572.05	31.2799627	3.91232185	8	14
7	41.2844	15.5963	12	18	563927527.7	45873314.09	25.2316051	2.05249308	10	19
8	55.0459	17.4312	6	17	703028690.6	112627162.7	31.4553581	5.03923635	7	13
9	54.1284	20.1835	7	14	871594205.7	81810337.72	38.9974239	3.66041031	4	15
10	64.2202	37.6147	4	10	567741647.1	179486763	25.4022589	8.03071123	9	11
11	54.1284	28.4404	7	12	462072703	138324232.8	20.6743516	6.18899105	11	12
12	45.8716	51.3761	11	8	173265523.9	256415029.4	7.75235659	11.4726848	13	9
13	33.945	57.7982	13	6	131405883.1	369952641.6	5.87944584	16.5526571	15	8
14	30.2752	50.4587	16	9	111998447.5	393514985.3	5.01110598	17.6068985	16	7
15	31.1927	55.0459	15	7	181963983.8	560031611.8	8.14154863	25.0572916	12	6
16	33.945	74.3119	13	5	130206609.3	845406252.6	5.82578717	37.8257058	14	5
17	23.8532	86.2385	17	4	75671837.29	1261365153	3.38575761	56.4368042	17	4
18	15.5963	99.0826	19	2	37686748.85	1623827783	1.68620456	72.6543384	19	2
19	19.2661	99.0826	18	2	65138395.39	1576800798	2.91446363	70.5502271	18	3
20	0.91743	100	20	1	2617847.268	2235004569	0.11712939	100	20	1
Avg	45.4587	45.4128					22.8104364	22.8104364		
Std Dev							20.8230728	29.0960736		
Avg + $\frac{2}{3}$ Std Dev							36.6924849	42.2078188		

Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Project management to implement the project plan; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP consultant; (9) ERP Vendor support and guidance; (10) Legacy system and business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational culture; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.

Table 4.4: Activity up to the 19th order

Factor	AS	1 order	2 order	3 order	4 order	5 order	6 order	7 order	8 order	9 order	10 order	11 order	12 order	13 order	14 order	15 order	16 order	17 order	18 order	19 order
1	10.6	47.83	161.577	461.951	1219.03	3107.48	7814.71	19556.2	48857.2	121993	304554	760281	1897919	4737834	11827190	29524550	73702970	183986817	459291516	1146542459
2	7.4	29.29	91.956	253.407	657.455	1664.31	4174.58	10437.4	26067.9	65083.5	162476	405598	1012508	2527552	6309601	15750836	39319259	98153783	245024076	611660562
3	6.8	27.27	83.439	226.205	582.456	1469.77	3682.14	9202.29	22979.8	57370.8	143220	357527	892505	2227985	5561783	13884037	34659116	86520535	215983668	539166167
4	5.9	23.36	71.169	192.564	495.075	1248.51	3127.32	7815.3	19515.9	48722.7	121631	303632	757966	1892133	4723385	11791121	29434509	73478201	183425721	457890838
5	7.7	32.25	102.924	285.211	741.429	1878.23	4712.32	11782.9	29428.9	73475.3	183426	457897	1143063	2853463	7123181	17781798	44389206	110810034	276618236	690529962
6	5.8	22.76	69.539	187.617	481.657	1213.87	3039.67	7595.44	18966.2	47349.7	118203	295075	736605	1838807	4590266	11458811	28604954	71407359	178256220	444986065
7	4.5	18.71	56.631	151.92	389.178	980.002	2453.34	6129.71	15305.7	38210.8	95388.5	238122	594431	1483895	3704288	9247120	23083849	57624867	143850592	359098319
8	6	24.08	72.48	192.175	488.045	1224	3059.37	7639.55	19072	47610.4	118851	296691	740637	1848872	4615392	11521534	28761532	71798229	179231959	447421830
9	5.9	25.28	81.522	227.692	593.754	1505.95	3779.94	9452.87	23610.7	58949.7	147165	367375	917092	2289364	5715005	14266528	35613939	88904086	221933796	554019640
10	7	23.71	64.028	160.912	399.663	994.435	2478.81	6184.29	15434.7	38527.2	96174.2	240081	599319	1496096	3734747	9323155	23273657	58098692	145033415	362051034
11	5.9	19.51	51.944	130.208	324.299	808.573	2017.32	5034.7	12567.2	31370.9	78311.3	195490	488007	1218225	3041090	7591559	18951025	47307983	118096261	294807051
12	5	12.44	25.737	55.401	128.405	310.956	767.607	1908.87	4759.3	11876.3	29644	73998.9	184724	461132	1151136	2873613	7173481.7	17907367	44702668	111592541
13	3.7	8.41	17.836	40.2003	95.5983	233.947	579.728	1443.56	3600.69	8986.29	22431.1	55994.4	139780	348936	871058.3	2174448	5428135.4	13550409	33826271	84441480.6
14	3.3	7.81	15.938	34.6935	81.8352	199.999	495.737	1234.73	3080.19	7687.68	19190	47904	119584	298520	745204.7	1860276	4643859.2	11592598	28938932	72241077.6
15	3.4	8.83	21.011	51.1749	127.417	318.55	796.085	1988.31	4964.5	12394	30940.2	77237.7	192811	481320	1201534	2999423	7487544.5	18691370	46659799	116478181
16	3.6	7.58	16.063	37.7818	91.3194	224.6725	556.7443	1383.435	3440.860	8560.624	21300.18	52999.59	131875.	328138.	816488	2031621.	5055169.	12578488.	31298336.	77877867.2
17	2.6	4.49	9.396	22.0148	53.7641	133.223	331.795	827.698	2065.81	5156.69	12872.6	32134.3	80217.7	200250	499889.2	1247888	3115137.2	7776405.7	19412462	48459881.5
18	1.7	2.72	5.238	11.5391	27.3715	67.0968	166.492	414.833	1034.99	2583.27	6448.44	16097.3	40184.1	100313	250413.2	625113.7	1560489	3895493.2	9724430.3	24275371.7
19	2.1	3.44	7.868	18.667	45.9563	114.226	284.801	710.744	1774.13	4428.77	11055.7	27598.6	68895.1	171985	429330.9	1071751	2675442.5	6678783.1	16672436	41619875.9
20	0.1	0.21	0.344	0.7868	1.8667	4.59563	11.4226	28.4801	71.0744	177.413	442.877	1105.57	2759.86	6889.51	17198.49	42933.09	107175.1	267544.25	667878.31	1667243.61

Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Project management to implement the project plan; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP consultant; (9) ERP Vendor support and guidance; (10) Legacy system and business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational culture; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.

Table 4.5: Passivity up to the 19th order

Factor	PS	1 order	2 order	3 order	4 order	5 order	6 order	7 order	8 order	9 order	10 order	11 order	12 order	13 order	14 order	15 order	16 order	17 order	18 order	19 order
1	0.4	1.34	3.621	9.5637	24.4471	61.404	153.313	381.925	950.662	2365.73	5886.67	14647.6	36446.8	90688.4	225654.86	561484.1	1397109	3476346.2	8649994.09	21523287.01
2	1.7	3.09	6.675	15.1113	36.0081	88.3225	218.657	543.183	1350.93	3361	8362.71	20808.3	51776	128831	320563.85	797640.82	1984724	4938476.2	12288128.8	30575850.24
3	2.1	3.42	7.456	16.9094	40.2393	98.596	244.035	606.157	1507.49	3750.46	9331.71	23219.4	57775.3	143759	357707.62	890063.55	2214694	5510698	13711955.6	34118677.19
4	3.5	8.55	22.073	57.1972	144.71	362.591	904.573	2252.73	5606.89	13952.5	34717.9	86387.2	214953	534854	1330847.4	3311471.6	8239746	20502490	51015176.3	126938154
5	2.2	3.81	8.505	20.3514	49.9522	123.717	307.476	764.844	1902.97	4734.98	11781.8	29316	72945.3	181506	451630.28	1123765.9	2796203	6957631.7	17312278.3	43077154.92
6	2.8	5.36	10.947	25.2972	61.1574	150.646	373.631	928.817	2310.52	5748.75	14304.1	35591.9	88561.4	220362	548314.88	1364340.7	3394811	8447115.6	21018476.2	52299075.74
7	1.7	3.16	6.183	13.6842	32.4754	79.3767	196.291	487.482	1212.3	3016.02	7504.29	18672.4	46461.3	115607	287658.43	715764.14	1780995	4431548.8	11026770.2	27437283.64
8	1.9	5.16	12.745	31.4737	77.9758	193.474	480.9	1196.16	2975.97	7404.63	18424.3	45844	114071	283836	706252.93	1757328.9	4372661	10880244	27072689.9	67363430.52
9	2.2	4.7	10.218	23.501	57.0775	140.855	349.507	868.959	2161.71	5378.57	13383	33300.2	82859	206173	513009.3	1276491.9	3176222	7903212.2	19665112.2	48931577.37
10	4.1	9.25	21.13	50.7004	124.573	308.509	766.461	1906.25	4742.56	11800.2	29361.6	73058.6	181787	452331	1125510.4	2800543.4	6968433	17339154	43144027.3	107352822.9
11	3.1	7.28	16.665	39.4907	96.354	238.093	590.963	1469.29	3655.08	9094.13	22628	56303.7	140097	348596	867391.87	2158281.8	5370330	13362685	33249607.2	82733101.63
12	5.6	14.5	32.327	74.7862	180.145	442.673	1096.57	2724.5	6776.13	16858.4	41946.3	104372	259702	646201	1607905.5	4000859.8	9955112	24770737	61635611.6	153364377.7
13	6.3	18.84	45.415	107.38	259.765	638.727	1582.32	3931.17	9776.82	24323.4	60519.9	150587	374695	932332	2319867.6	5772394.4	14363120	35738933	88927149.1	221272354.3
14	5.5	16.46	43.369	109.014	271.456	675.228	1679.7	4178.95	10397.7	25871.3	64373.7	160177	398559	991712	2467620.7	6140039.9	15277911	38015155	94590941.7	235365246.3
15	6	20.76	58.384	151.811	383.37	958.504	2388.55	5945.86	14796.5	36818.2	91613.3	227956	567210	1411357	3511799.5	8738210.1	21742790	54101343	134617287	334960517.7
16	8	30.47	87.543	228.871	578.663	1446.98	3605.8	8975.85	22336.5	55579.8	138297	344116	856243	2130541	5301303	13190929	32822237	81669700	203214057	505645950.5
17	9.4	39.98	123.83	334.51	856.916	2153.46	5375.55	13388.9	33324.2	82924.9	206341	513428	1277534	3178815	7909663.9	19681165	48971518	121853035	303199958	754435163.7
18	10.8	48.32	154.289	424.946	1097.82	2767.6	6916.44	17233.3	42898	106753	265634	660965	1644643	4092272	10182565	25336694	63043849	156868412	390326722	971227723.6
19	10.8	47.76	150.98	413.204	1066.28	2687.56	6716.12	16734.1	41655.5	103661	257941	641823	1597013	3973757	9887671.9	24602929	61218063	152325412	379022636	943100409.7
20	10.9	56.97	198.34	568.291	1494.44	3794.49	9507.33	23709.9	59036.8	146927	365610	909738	2263654	5632522	14015083	34872929	86772316	215910603	537238038	1336778771

Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Project management to implement the project plan; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP consultant; (9) ERP Vendor support and guidance; (10) Legacy system and business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational culture; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.

4.4.3 ADVIAN Classification: Criticality, Integration and System Stability

The forth objective of the study was to ***identify the criticality, stability and integration of each factor.*** This objective was met by using the ADVIAN equations, presented in chapter 3, to classify the success factors according to different criteria, namely, integration, stability and criticality. These criteria show the conditional state of the system of factors, with table 4.6 displaying a summary of the values that were calculated using an excel spreadsheet.

In order for the graphs to be plotted, all the equations that have been presented in chapter 3 must be expressed in terms of either the relative indirect PS (y axis) or the relative direct AS (x axis). The formulae that are required to plot the contour lines are presented with each of the graphs.

Integration (*I*): According to equation 3.12, $I(f) = \frac{iAS'(f) + iPS'(f)}{2}$. If I represents integration, a represents the relative indirect AS and p represents the relative indirect PS, then the equation can be represented as:

$$I = \frac{a+p}{2} \text{ or rather } p = \frac{2I}{a} \quad (4.17)$$

System Stability (*S*): According to equation 3.13, $S(f) = 100 - \frac{2}{\left(\frac{1}{iAS'(f)} + \frac{1}{iPS'(f)}\right)}$. If S represents system stability, a represents the relative indirect AS and p represents the relative indirect PS, then the equation can be represented as:

$$S = 100 - \frac{2}{(\frac{1}{a} + \frac{1}{p})} \text{ or rather } p = \frac{2(100*a) - (S*a)}{((2*a) + S - 100)} \quad (4.18)$$

Criticality (*C*): According to equation 3.11, $C(f) = \sqrt{iAS'(f) * iPS'(f)}$. If C represents criticality, a represents the relative indirect AS and p represents the relative indirect PS, then the equation can be represented as:

$$C = \sqrt{a * p} \text{ or rather } p = \frac{C^2}{a} \quad (4.19)$$

Precarious (*P*): According to equation 3.14, $P(f) = \sqrt{C(f) * iAS'(f)}$. If *Pr* represents precarious, *C* represents criticality, *a* represents the relative indirect AS and *p* represents the relative indirect PS, then the equation can be represented as:

$Pr = \sqrt{C * a}$, but $C = \sqrt{a * p}$ therefore $Pr = \sqrt{\sqrt{a * p} * a}$ or rather $p = \frac{Pr^4}{a^3}$

(4.20)

Driving (*D*): According to equation 3.15, $D(f) = \sqrt{(100 - C(f)) * iAS'(f)}$. If *D* represents driving, *C* represents criticality, *a* represents the relative indirect AS and *p* represents the relative indirect PS, then the equation can be represented as:

$D = \sqrt{(100 - C) * a}$, but $C = \sqrt{a * p}$. Therefore, $D = \sqrt{(100 - \sqrt{a * p}) * a}$ or rather $p = (100 - \frac{D^2}{a})^2 * \frac{1}{a}$ (4.21)

Driven (*T*): According to equation 3.16, $T(f) = \sqrt{(100 - C(f)) * iPS'(f)}$. If *D* represents driving, *C* represents criticality, *a* represents the relative indirect AS and *p* represents the relative indirect PS, then the equation can be represented as:

$T = \sqrt{(100 - C) * p}$, but $C = \sqrt{a * p}$. Therefore, $T = \sqrt{(100 - \sqrt{a * p}) * p}$ or rather $a = (100 - \frac{T^2}{p})^2 * \frac{1}{p}$ (4.22)

The first of the classifications is the **criticality** of factors, with changes to a critical factor possibly having significant effects on the system that could result in changes of a higher magnitude. The critical factors are those that have both high relative indirect active and passive sums. It can be seen from table 4.6 and figure 4.12 that none of the success factors presented have high criticality values as there exist no factors with both a high relative indirect active and passive sum. However, it can be seen from table 4.6 that the factors that are the most critical to the success of the system are factors 4 (ERP strategy and implementation methodology), 16 (Change management), 19 (System testing and troubleshooting), 15 (Organisational culture), 10 (Legacy system and business processes) and 17 (User involvement). Changes that take place to any of these factors may need to be identified as early as possible so that corrective action can take place. More light will be shed on the criticality of these factors later when a discussion on the driven ranking of each factor is identified.

Table 4.6: ADVIAN Classification

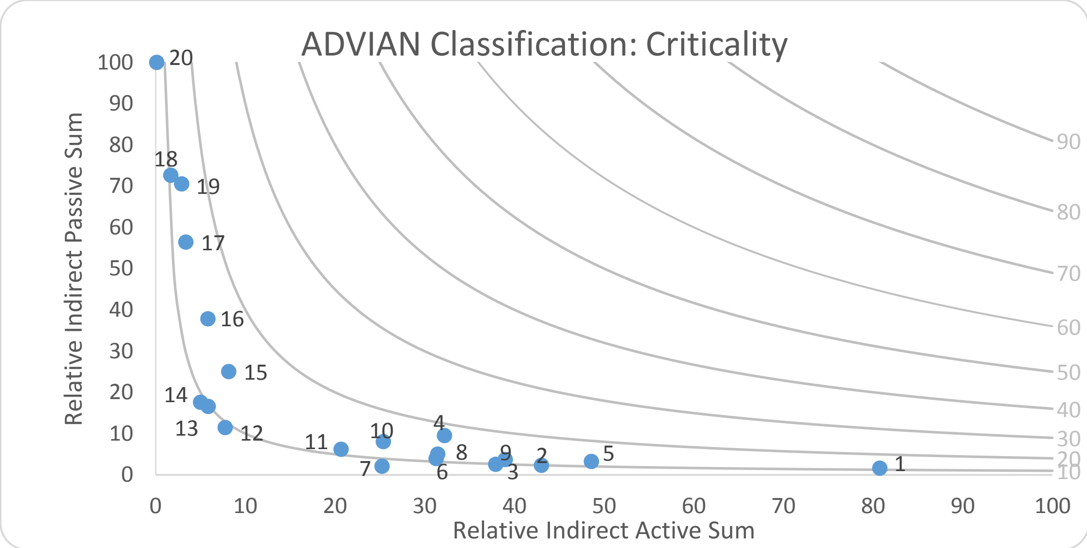
Factor	Classification		
	Integration	Criticality	Stability
1	41.1735687	11.40147363	96.84279
2	22.6625375	9.92166527	95.656292
3	20.2274742	9.835606058	95.217438
4	20.847152	17.48574024	85.333675
5	25.9002291	12.51162111	93.956012
6	17.5961423	11.06242656	93.045221
7	13.6420491	7.196366787	96.203818
8	18.2472972	12.59011454	91.31318
9	21.3289171	11.94765971	93.307369
10	16.7164851	14.28279405	87.796585
11	13.4316713	11.31164785	90.473756
12	9.61252069	9.430818816	90.747448
13	11.2160515	9.865112806	91.323109
14	11.3090022	9.39308438	92.198248
15	16.5994201	14.28303742	87.710103
16	21.8257465	14.84467956	89.903461
17	29.9112809	13.82321741	93.61173
18	37.1702715	11.06842701	96.704084
19	36.7323453	14.33931906	94.402316
20	50.0585647	3.422417161	99.766015
Average	**22.8104364**	**11.50086147**	**92.775633**
Std Dev	**10.9784796**	**3.071282194**	**3.5542683**
AVG + $\frac{2}{3}$ Std Dev	**30.1294228**	**13.54838293**	**95.145145**
	SYSTEM STABILITY		**92.775633**

Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Project management to implement the project plan; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP consultant; (9) ERP Vendor support and guidance; (10) Legacy system and business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational culture; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.

The next classification criterion is the simple measure of the **integration** of the various factors into the entire system of factors. Factors that have a higher level of integration have a stronger connection with the factors in the system and could possibly present feedback loops. The factors with the highest levels of integration are factor 20 (Post-implementation evaluation), with the highest value of 50.1, followed by factor 1 (Senior and top management support) with a value of 41.17, factor 18 (User training) and, lastly, factor 19 (Software testing and troubleshooting). There appears to be mutual connections between factors 18 and 19, with the CIM in figure 3.5 showing that factor 18 impacts on factor 19 as well as factor 19 impacting on factor 18. Along with the existence of mutual connections, indirect feedback loops could also exist within factors. One such example is factor 4 (ERP strategy and implementation methodology) and factor 5 (Project leader) having a mutual connection through the impact on factor 1 (Senior and top management), creating a feedback loop between the three factors. However, these feedback loops are not strong and are controllable, as evidenced by the system stability (which will be discussed with stability).

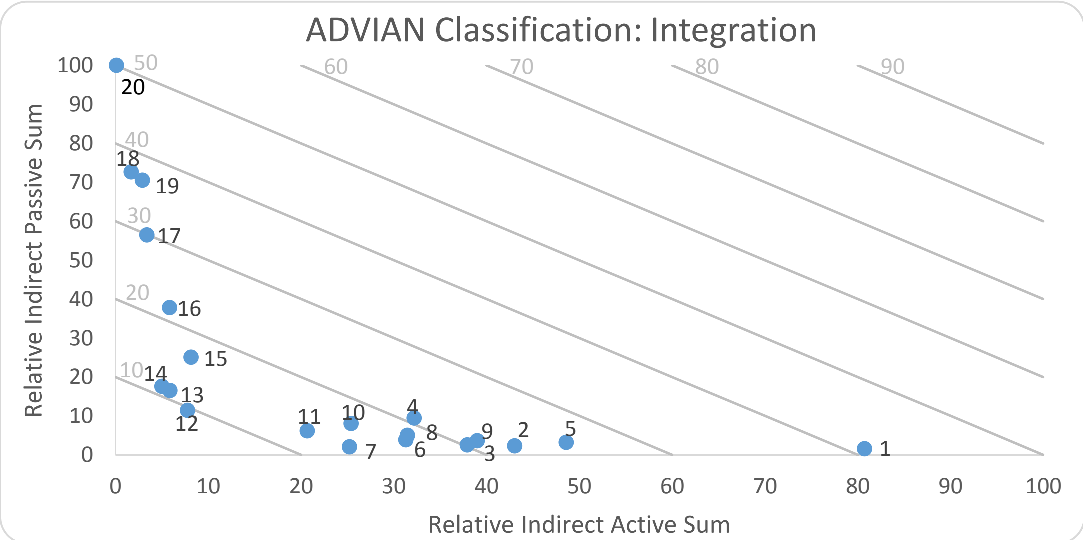
A system of factors is considered to be very **stable** if the factors are distributed close to the axes of the passive and active sums. In other words, there exist factors that control the system (those with a high AS, but low PS) and other factors that are controlled by the system (factors with a high PS but low AS). When this is the case, then any feedback loops that possibly exist will be controllable (Linss and Fried 2010). Table 4.6 shows the stability value for each factor as well as the average stability of the entire system of factors. An extremely high system stability value of 92.78 was achieved, indicating that the system of factors is in a very stable state. The factors that contribute most to the stability of the system, with high ASs compared to their PSs, are factors 1 (Senior and top management support), 7 (Autonomous project team), 2 (Project plan with clearly agreed upon objectives and goals) and 3 (Project management to implement the project plan), while factors 20 (Post-implementation evaluation) and 18 (User training) also contribute to the stability of the system with their high PSs but low ASs. Along with having a high stability, factor 7 (Autonomous project team) also has a very low integration value of 13.65. This finding indicates that this factor can hardly be altered by the other factors in the system, and seems independent of changes that occur in other factors.

The figures below show the graphs and contour lines for criticality, integration and stability.



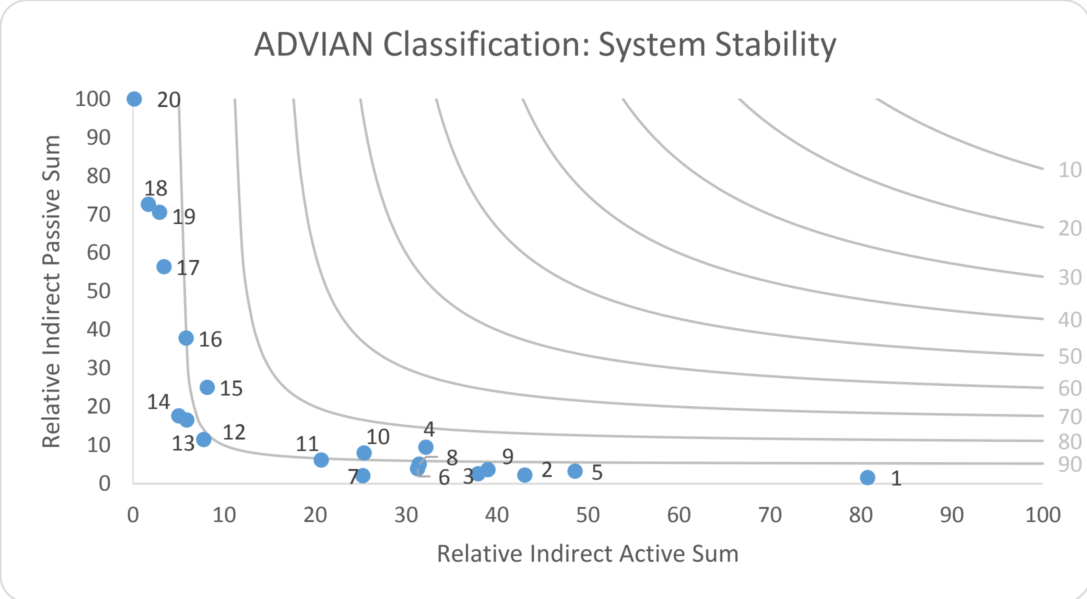
Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Project management to implement the project plan; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP consultant; (9) ERP Vendor support and guidance; (10) Legacy system and business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational culture; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.

Figure 4.12: Criticality of Success Factors
Source: Researchers own construction



Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Project management to implement the project plan; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP consultant; (9) ERP Vendor support and guidance; (10) Legacy system and business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational culture; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.

Figure 4.13: Integration of Success Factors
Source: Researchers own construction



Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Project management to implement the project plan; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP consultant; (9) ERP Vendor support and guidance; (10) Legacy system and business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational culture; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.

Figure 4.14: Stability of Success Factors
Source: Researchers own construction

4.4.4 ADVIAN Classification Ranking: Precarious, Driving and Driven Factors

The last objective of the study was to ***determine which factors should be used for intervention strategies by identifying the following for each factor: precarious, driving and driven.*** This objective was achieved by using ADVIAN, which offers calculations in the form of equations, presented in chapter 3, that classify and rank the factors according to three ranking criteria, namely, precarious, driving and driven. These rankings assist in presenting the various perspectives for intervening activities in an organisation.

The first of these provides a value for the ranking of **"precarious"** impact factors. Factors with a high precarious ranking indicate that they have both a high criticality as well as a high indirect AS. It is these factors that are not affected by external elements, but rather exert the most influence on the system. In the section above on criticality, it was established that none of the factors presented a high value for their criticality. Due to the precarious value being calculated in terms of criticality, low precarious values have presented themselves, with the highest precarious value being 30.34. The most precarious factors in the system, according to table 4.7 and figure 4.15, are factors 1 (Senior and top management support), 2 (Project plan with clearly agreed upon objectives and goals), 4 (ERP strategy and implementation methodology), 5 (Project leader), 8 (Expert ERP consultant) and 9 (ERP vendors support and guidance). These factors should not be influenced by external elements and should not be used for intervening activities, but, due to their low precarious rating values, this may be incorrect (a further discussion will be provided when discussing driving factors). It is those factors with lower precarious values that are identified as being candidates to be used for intervention activities. The factors with the lower precarious values have been identified as those that exceed the average less two-thirds of the standard deviation. This results in six factors, all with precarious values under 9.1 (this is easily seen in figure 4.15 where contour lines are shown). It is these factors that are candidates for any intervening activities that organisations might want to implement. Factors 20 (Post implementation evaluation), 18 (User training), 19 (System testing and troubleshooting), 17 (User involvement), 14 (Organisation wide communication), 13 (Data management) and 12 (Software integration) are the factors identified as possibly being the most effective for intervention by the organisation.

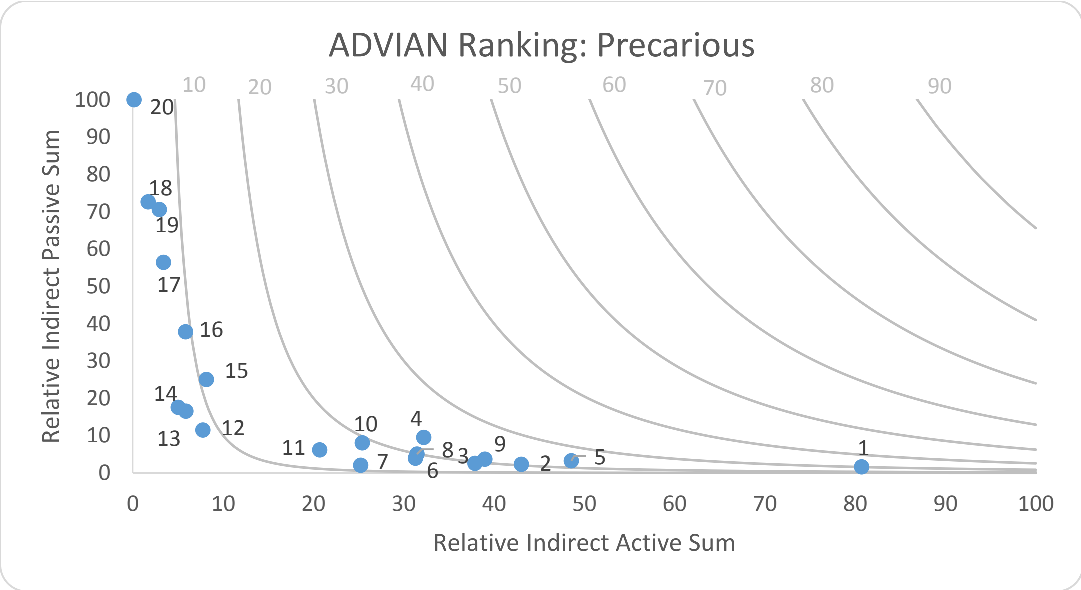
The second ranking is according to the **driving** impact of the factor. These are the factors that are not critical to the system but have a high activity. They are highly active and react to external influences. The performance of the entire system or success of implementation can be improved by controlling these factors as they have a high influence on other factors and do not cause any strong feedback. Table 4.7 and figure 4.16 identify factors 1 (Senior and top management support), 5 (Project leader), 2 (Project plan with clearly agreed upon objectives and goals), 3 (Project management to implement the project plan) and 9 (ERP vendor's support and guidance) as those factors that are highest according to their ability to drive a successful implementation.

The last of the three ranking classifications deals with those factors that are more reactive in nature. These **driven** factors are the non-critical factors that have a high indirect PS. This is why they are deemed to be more reactive in nature. Due to these factors being highly impacted on by other internal factors, external intervening activities will have no impact on them. These factors can, however, be used as an indicator of the impact that external intervention taken on driving factors has had on implementation success. From table 4.7 and figure 4.17, one can identify factors 20 (Post-implementation evaluation), 18 (User training), 19 (System testing and troubleshooting), 17 (User involvement) and 16 (Change management) as being the most driven factors. Therefore, these factors will be the most affected by external changes.

Table 4.7: ADVIAN Ranking

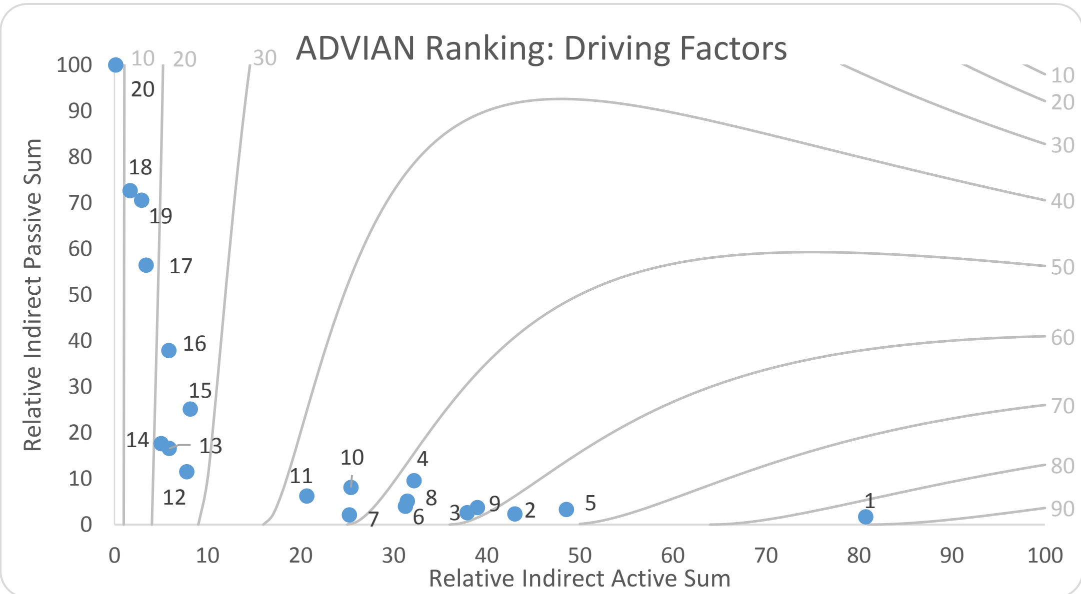
Factor	Ranking of Factors					
	Precarious	Precarious Ranking	Driving	Driving Ranking	Driven	Driven Ranking
1	30.340095	1	84.5764966	1	11.94366997	20
2	20.664138	5	62.2637375	3	14.35389396	18
3	19.307912	7	58.4591205	5	15.16994185	17
4	23.727921	3	51.5444827	8	27.99180118	10
5	24.653387	2	65.1921031	2	16.79070618	16
6	18.601943	9	52.7443265	6	18.65348256	14
7	13.47501	11	48.3899228	9	13.80140627	19
8	19.900416	6	52.4357631	7	20.9875933	13
9	21.585364	4	58.598758	4	17.95292997	15
10	19.047709	8	46.6627331	10	26.23680866	11
11	15.292514	10	42.8202543	11	23.42843183	12
12	8.5505012	14	26.4976336	12	32.2346346	9
13	7.6158648	15	23.0204949	14	38.6260518	8
14	6.8607391	16	21.3082345	16	39.94129147	7
15	10.783601	12	26.4172069	13	46.34474	6
16	9.2995669	13	22.27323	15	56.75438395	5
17	6.8412034	17	17.0813845	17	69.73910101	4
18	4.3201426	19	12.2456859	19	80.38199176	2
19	6.4646287	18	15.8004728	18	77.73918246	3
20	0.6331395	20	3.36334262	20	98.27389421	1
AVG	**14.39829**		**39.5847692**		**37.36729685**	
Std Dev	**8.0123564**		**21.6622633**		**25.93276163**	
AVG + $\frac{2}{3}$ Std Dev	**19.739861**		**54.0262781**		**54.6558046**	
AVG - $\frac{2}{3}$ Std Dev	**9.0567189**					

Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Development and adherence to a detailed project plan with clear goals and objectives; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP; (9) Vendor that provides support, guidance and technical expertise; (10) Good understanding of the existing system (legacy system) and its business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.



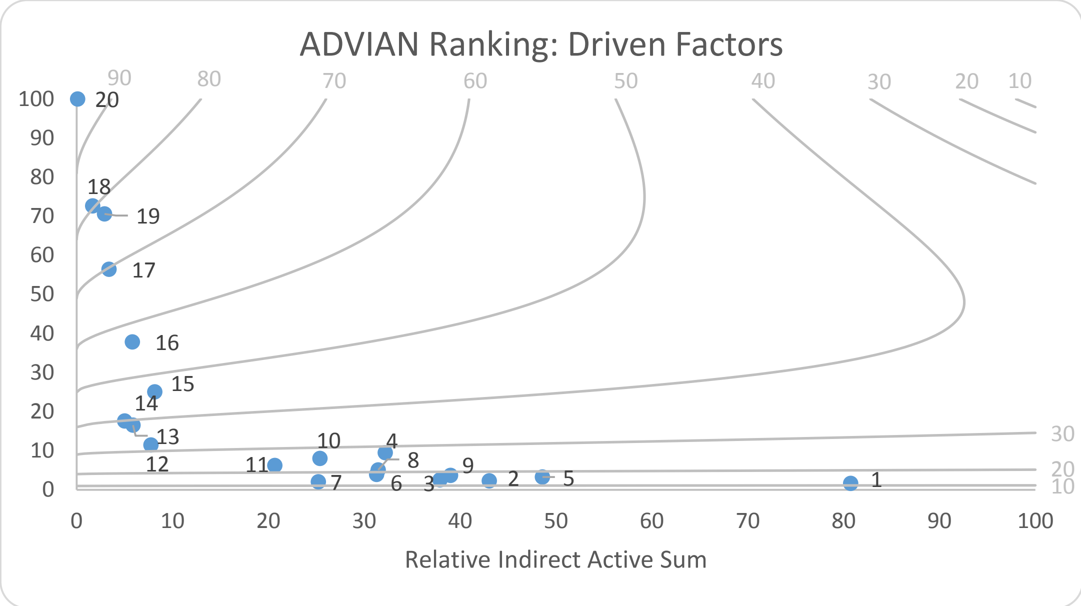
Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Project management to implement the project plan; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP consultant; (9) ERP Vendor support and guidance; (10) Legacy system and business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational culture; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.

Figure 4.15: ADVIAN Classification: Precarious Success Factors
Source: Researchers own construction



Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Project management to implement the project plan; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP consultant; (9) ERP Vendor support and guidance; (10) Legacy system and business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational culture; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.

Figure 4.16: ADVIAN Classification: Driving Success Factors
Source: Researchers own construction



Factors: (1) Senior and top management support; (2) Project Plan with clear agreed upon objectives and goals; (3) Project management to implement the project plan; (4) ERP strategy and implementation methodology; (5) Project leader; (6) Skilled project team; (7) Autonomous project team; (8) Expert ERP consultant; (9) ERP Vendor support and guidance; (10) Legacy system and business processes; (11) Business process reengineering (BPR) and minimal customisation; (12) Software integration; (13) Data management; (14) Effective organisation wide communication; (15) Organisational culture; (16) Change management; (17) User involvement; (18) User training; (19) Software testing and troubleshooting; (20) Post implementation evaluation.

Figure 4.17: ADVIAN Classification: Driven Success Factors
Source: Researchers own construction

4.5 Chapter Summary

This chapter discussed the results obtained from the analysis of the survey data that were gathered from expert participants using the researcher's on-line application. The preference chains gathered from participants were converted, using the algorithm presented in chapter 3, into a CIM. The CIM was used to calculate various orders, up to the nineteenth order. This enabled the researcher to calculate the relative indirect active and passive sums for all the success factors, giving rise to an indication of which success factors have the strongest interrelationships with other success factors and which of the success factors are most influenced by other success factors. By uncovering these relationships, objective 3 of the study was achieved: To ***uncover relationships that exist between factors and establish how each might impact on the on-line registration system implementation.***

The factors found to have the most influence on other factors are listed below, with senior and top management support having a much higher influence on factors than the others that were identified: Senior and top management support; Project plan with clear, agreed upon objectives and goals; Project management to implement the project plan; Project leader; and, lastly, ERP vendors' support and guidance.

The factors identified as being the most reactive, and being highly influenced by other factors were User involvement, User training, System testing and troubleshooting and, finally, Post-implementation evaluation.

The ADVIAN analysis tool was then used to calculate the levels of integration, criticality and stability that each of the factors have, which achieved objective 4 of the study: ***To identify the criticality, stability and integration of each factor***. Integration is a measure of how strongly a factor is connected to the other factors, which could result in feedback loops. The factors that emerged as having the highest **integration** value were Senior and top management support, User training, Software testing and troubleshooting and Post-implementation evaluation

Although there might be the presence of feedback loops, it was ascertained by the stability measures, that, due to all factors as well as the system having high stability values, all and any feedback loops would be controllable.

The **stability** of a factor is a measure of how active or reactive a factor is. It indicates how stable the factor is and to what extent the factor contributes to the overall stability of the system. It was found that the system is in a high state of stability, with an average stability value of 92.76 and all factors having a value in excess of 85. The factors that provide the most stability for a successful implementation are Senior and top management support, Project plan with clear, agreed upon objectives and goals, Project management to implement the project plan, Autonomous project team, User training and Post-implementation evaluation

If a factor has both high stability and low integration, then extrinsic changes made will not affect this factor. This was evident for factor 7, having an autonomous project team.

Factors that are found to have a high **criticality** value are those that are both highly active and reactive. All factors presented low values of criticality with an average of a mere 11.5. The factors that do present with the highest criticality values are ERP strategy and implementation methodology, Legacy system and business processes, Organisational culture, Change management and Software testing and troubleshooting

Change management program so that end users have been prepared for any changes that might take place; end user involvement throughout the system implementation; and plan for testing and troubleshooting the system were also positioned as the higher critical factors, but they were eliminated due to them having higher driving values, indicating their non-criticality.

The final objective of the study was to ***determine which factors should be used for intervention strategies by identifying the following for each factor: precarious, driving and driven.*** ADVIAN was again used to determine these rankings. The success factors showing a high **precarious** ranking are those factors that are NOT affected by extrinsic elements and are, therefore, NOT advised for intervention strategies, and those with a low ranking being ideal for intervention strategies. The factors identified as having the lowest precarious ranking are Post- implementation evaluation**,** User training**,** System testing and troubleshooting**,** User involvement**,** Effective organisation wide communication, Data management and Software integration.

The ranking of **driving factors** gives a good indication of where an organisation could start with respect to intervention. These factors are not critical to the system, but are highly active. The factors identified as having high driving ranking are Senior and top management support, Project plan with clear, agreed upon objectives and goals, Project management to implement the project plan, Project leader and ERP vendors support and guidance.

Driven factors are those factors that can be observed or monitored to establish whether any extrinsic interventions are effective or not. This is due to these being highly reactive and should react to changes to any driving factor. The factors that are ranked highly as driven are Change management, User involvement, User training, System testing and troubleshooting and, lastly, Post-s implementation evaluation.

Table 4.8 below shows a summary of the results, while Chapter 5 will follow with the interpretation of the findings from the current chapter.

Table 4.8: Summary of ADVIAN data analysis classifications

CSF	Highly Active	Highly Passive	Integration	Criticality	Stability	Precarious	Driving	Driven
ERP ENVIRONMENT								
ERP Vendor Support and Guidance	✓					✓ (high)	✓	
Expert ERP Consultant						✓(high)		
Software integration						✓(low)		
Software testing and troubleshooting		✓	✓	✓		✓(low)		✓
ERP USER								
User Training		✓	✓		✓	✓ (low)		✓
User Involvement		✓		✓		✓ (low)		✓
ORGANISATION								
Senior and Top Management Support	✓		✓		✓	✓ (high)	✓	
Project Plan with clear agreed upon objectives and goals	✓				✓	✓ (high)	✓	
Effective, organisation / institution wide communication						✓(low)		
Organisational Culture				✓				
Legacy System and the Business Processes				✓				
ERP IMPLEMENTATION PROJECT								
Project Management to implement project plan	✓				✓		✓	
ERP Strategy & Implementation methodology				✓		✓(high)		
Business Process Re-engineering (BPR) and Minimal Customisation								
Change Management				✓				✓
Data Management						✓(low)		
Project Leader	✓					✓ (high)	✓	
Skilled Project Team	✓							
Autonomous Project Team					✓			
Post Implementation Evaluation		✓	✓		✓	✓ low		✓

CHAPTER 5: Interpretation of the Results

This chapter is dedicated to interpreting the findings by looking at each success factor separately and deliberating over its contribution to the discourse of implementation of the on-line registration system.

5.1 ERP Vendor support and guidance

DUT relies on the ERP vendor for guidance, support, technical expertise and, often, requires training throughout the implementation process. The vendor needs to be financially stable so it can provide the highest level of support to the institution (Bingi, Sharma and Godla 1999; Al-Mashari and Al-Mudimigh 2003; Somers and Nelson 2004) in order to improve the probability of a successful on-line registration system. The data analysis illuminates ERP vendor support and guidance as one of the factors that presents a high activity indicating that this factor does have the ability to influence the other factors in the system with the highest impact being found to be on software testing and troubleshooting. This factor is also one of the factors that is ranked high on the driving scale indicating that it can be influenced by extrinsic forces and can be used for interventions as it will impact the system and other factors. Although the analysis presents ERP vendor support and guidance as a factor that should not be used for intervening activities, due to it being high in the precarious ranking, the factor has a low precarious value (21.8), and a low criticality (11.9). The factor can, therefore, be eliminated from the factors that are not suitable for intervention. Shaul and Tauber (2010) identified this as a critical factor within the new module phase of ERP implementation, with it also being identified as a CSF in higher education studies by Aldayel, Aldayel and Al-Mudimigh (2011), Karande, Jain and Ghatule (2012), Upadhyay and Dan (2008), Dezdar and Sulaiman (2009), Supramaniam and Kuppusamy (2010) and Shaul and Tauber (2013). This finding is in line with the results of this study.

5.2 Expert ERP Consultant

Ifinedo (2008) stresses that having an external ERP consultant is the most critical factor for a successful ERP implementation, being more critical than senior and top management support and devising a project plan with clear, agreed upon objectives and goals. It is further suggested that this consultant would be able to compensate for any inadequacies with senior and top management support or any deficiencies in internal expertise. It may also be detrimental to the institution or organisation if the expertise lies only with the external consultant and is not disseminated to the institution. This factor was found to be a CSF in 13 of the 38 articles reviewed in the literature review. In this study, it was identified as one with a higher precarious ranking (with a value of 19.9), with factors showing high precarious values not being affected by external forces. The low precarious value of 19.9 is due to the factor also having a low criticality of 12.59. Therefore, the researcher is of the opinion that the expert ERP consultant does not fall into the category of high precarious factors and could be affected by external influences. In support of this expert ERP consultant, although not falling into the category of having a high AS, it has an AS of 31.46, falling just outside the benchmark of 36.7. Due to the factor not establishing itself firmly in any of the classifications, it does not appear to have a major impact on the success or failure of the on-line registration system.

5.3 Integration

For the on-line registration to be successful, it needs to be fully integrated into the institution's existing ERP software (ITS) (Bingi, Sharma and Godla 1999; Holland, Light and Kawalek 1999). Researchers have established this factor as critical to the successful implementation of an ERP (Esteves and Pastor-Collado 2001; Al-Mudimigh, Zairi and Al-Mashari 2003; Dezdar and Sulaiman 2009; Wickramasinghe and Gunawardena 2010; Karande, Jain and Ghatule 2012). The factor presented itself in the precarious rankings where it had a low ranking value of 8.55, indicating that software integration could be a candidate for measures of intervention. However, due to the factor having a very low driving value of 26.5 and having a low AS of 7.75, it does not appear to be influential enough to be used for interventions.

5.4 Software Testing and Troubleshooting

Prior to any system going live, a number of testing and simulation runs should be performed to ensure the system is running effectively, efficiently, is integrating with existing systems and is meeting the objectives and goals set out in the project plan (Kumar, Van Hillegersberg and Experiences 2000; Fui-Hoon Nah, Lee-Shang Lau and Kuang 2001; Al-Mashari and Al-Mudimigh 2003). Despite the need for a plan for testing and troubleshooting, the software was only cited as critical in 10 of the 38 articles reviewed. This factor did present itself under five of the ADVIAN classifications. It is listed as one of the factors that is most influenced in the system due to the high PS of 70.55. In support of this finding, the factor is ranked third in the list of driven factors, identifying the factor as highly driven and being ideal for monitoring the effect of any intervention that is done on the system. Software testing and troubleshooting was also listed as having the fifth highest integration value, indicating that it is strongly connected to other factors, as well as the third highest value for criticality, thereby identifying this as a factor to observe for any changes that would require immediate intervention. A factor with a high integration value should have both a high active and passive sum, but with an integration value of only 36.7 and an AS being extremely low (2.9), this factor is highly passive and not highly active and, therefore, does not have strong interrelationships with other factors. Similarly, a factor that is highly critical should have both high active and passive sums. Again, system testing and troubleshooting can be disregarded from the list of highly critical factors due its low passivity and low criticality (14.3).

5.5 User Training

Sumner (1999) contends a direct link between the effort put into user training and the success of the ERP implementation. Umble, Haft and Umble (2003) opine that the system will only be used to its full potential if a solid understanding of the system is achieved through user training. There will also be a reduction in user resistance to the system should thorough training take place (Sumner 1999). This study establishes that user training is highly influenced by other factors (with a PS of 72.65), with user involvement and legacy system and business processes having the highest impact. Both have a project plan with clear, agreed upon objectives and goals and have good project management to implement that project plan and a marked effect on the user training. User training is, therefore, highly influenced by many external factors, including the project plan and the management thereof, the extent to which users are involved in the implementation of the system and whether there is an understanding of the systems in place and the business processes that exist. It is for these reasons that this factor has emerged as one of those ranked highest in the list of driven factors, with a change in many other factors having an effect on training. User training can, therefore, be used to monitor the success of the system implementation when interventions are effected. User training is also identified as highly integrated (with a value of 37.17) as well as being ranked second to lowest in the precarious rankings. Due to the low integration value, combined with a high passivity and low activity for the factor, the researcher is of the opinion that this factor does not have strong connections with other factors and should, therefore, not be deemed highly integrated. As far as the precarious ranking is concerned, although the precarious value is extremely low and this factor may be a candidate for intervention, the factor is not high in the driving rankings and is rather a driven factor than a driving factor. User training also presents itself as a factor that contributes to the stability of the on-line registration implementation, with a stability value of 96.7. This is due to the factor being close to the passive axis, indicating its elevated levels of passivity when compared to the activity.

5.6 User Involvement

The importance of participation in concert with good communication with users has been established as an important CSF across all levels in organisations by researchers such as Nah, Zuckweiler and Lee-Shang Lau (2003) and Shaul and Tauber (2013) with Rabaa'i (2009) being of the opinion that this factor is, in fact, essential for a successful implementation. This importance is due to user involvement increasing user acceptance of the new system (Amoako-Gyampah and Salam 2004; Chen 2014). This study finds that user involvement is neither an active factor that influences other factors, nor is it a driving factor. However, it does emerge as a factor that is influenced by other factors (because it is in the upper values of passivity) as well as a factor that should be monitored when changes are made to the system to ascertain whether the changes have an effect on user involvement. This signals whether the changes being implemented are having the desired effect. The factors with the strongest influence on user involvement are the understanding of the legacy system and business processes and the change management plan, with the project plan and implementation of the plan having a marked impact on user involvement. It follows that user involvement is affected by the knowledge and understanding that exist of the business processes of the existing system, as well as the quality and implementation of the project plan. With the project plan and the management thereof being two of the driving factors, user involvement is an important factor in terms of its monitoring value. It is a factor that is determined as critical in the analysis (with a low value of 13.8), but its criticality seems more akin to monitoring in the context of on-line registration implementation. This factor is also ranked as a low level precarious factor indicating its possible use for intervention, but, due to its high reactive nature, this is excluded.

5.7 Senior and Top Management Support

The study's findings mirror current literature in positioning support from management levels as a vital factor for any ERP implementation. The literature review revealed that 24 of the 38 articles analysed cited this as a critical factor, with the factor being mentioned as one of the top critical factors by many researchers, including Sarker and Lee (2003), where this was empirically proven. Top management support and commitment is a highly active factor, affecting every other factor in an on-line registration implementation to some degree. With the implementation of a new system, not merely being about the software, but also about the need for business process reengineering and repositioning the institution (Myerson 2001), this often results in conflicts that arise requiring top management intervention (Davenport 1998; Aladwani 2001). This study recognizes senior and top management support as being:

- highly active (80.7);
- ranked first according to driving factors (84.6);
- one of the most stable factors within the system, due to it being close to the AS axis (96.8);

- a factor with a higher than average integration value (41.2); and
- ranked high on the list of precarious factors (30.3).

The researcher is in agreement with the first three discoveries, but, although the factor exists as having a higher than average integration value, a value of 41.2 is not high enough to determine the factor as highly integrated. A precarious value of 30.3 is also not high enough to be classified as a highly precarious factor. Top management support contributes extensively to the stability of the on-line registration system due to it being highly active but not reactive in nature. However, top management also emerges as a factor that is highly integrated, indicating that it has a high number of interrelationships with other factors. On the contrary, this factor is highly active, influencing other factors, but is not influenced by many other factors, as evidenced by the extremely low PS (1.6). In addition, a factor with a high precarious ranking indicates that the factor is not a valid selection for intervention strategies, but this factor has emerged as having high activity as well as high in the driving ranking and a very low criticality. In the same vein, with the factor being higher in integration listings, having a high AS and being a driving factor, it cannot be deemed a factor contributing to the system stability as any changes made to this factor will destabilise the system, affecting all other factors. The researcher, therefore, concludes that senior and top management is not highly precarious, does not have strong interrelations with other factors nor is it a stable factor.

5.8 Project Plan with Clear, Agreed upon Objectives and Goals

A clearly defined project plan is essential for any project being undertaken in any organisational area, not just ERP implementation. The plan sets out the vision for the project, justifies its existence and can include a number of other plans (Finney and Corbett 2007; Ifinedo 2008). Once again, this is a highly referenced success factor in literature with 50% of the papers reviewed identifying the factor as critical. What is established in the current study is the high activity of the factor, with an AS of 43, placing the project plan as the third most active factor in the system for on-line registration implementation. Having an efficient project plan seems to exert the most impact on the two factors in the user category, viz., user training and user involvement.

This could be due to the project plan needing to identify users and acknowledge the areas in which consultation and training must take place. Due to the project plan influencing these and other factors, it is one of the driving factors, ranked in position three, therefore making it an ideal factor to be used when the on-line registration system needs intervention measures. The project plan also emerges as a factor that contributes highly to the stability of the entire system, as with other factors like top management support and project management, the highly influential nature of these factors and the lack of major influences acting on them, indicate their stabilising ability. Although the project plan lies within the upper rankings of precarious values (with a low value of 20.7 due to the low criticality of the factor), the low precarious value and its alignment with a driving factor eliminates it from the high precarious values set.

5.9 Effective institution-wide communication

The importance of communication with the user has already been alluded to and established in a previous section, but some researchers opine that there should exist effective communication across all departments of the entire organisation or institution (Al-Mashari and Al-Mudimigh 2003) with open communication between all stakeholders (Sumner 1999; Shaul and Tauber 2013), resulting in the need for a communication plan to be in place (Yusuf, Gunasekaran and Abthorpe 2004). In the current study, this factor did not present itself as being noticeably important in any of the classifications. Besides, it has a low precarious value, indicating its possible inclusion as a factor to be used for intervention. These findings are in contrast to literature, where this was identified as a critical factor in 50% of the papers reviewed. The discrepancy may be due to the on-line registration system not being a system that affects all stakeholders nor does it affect the entire institution and is only used by those that have direct involvement with the registration of students. Another reason for the discrepancy may be due to some articles not including a separate factor for user involvement and rather having one factor called organisation- wide communication.

5.10 Organisational Culture

Zhang *et al.* (2003) propose that it is not just the culture that exists inside the organisation that affects whether the implementation of an ERP is successful or not, but it is also the national culture that comes into play. With most studies on CSFs for ERP implementation being conducted in non-African countries, it becomes unclear as to whether the national culture, in fact, affects the implementation of an ERP in Southern Africa or whether the national culture affects the implementation of the on-line registration system in Southern Africa. What has been identified as important in all organisations and institutions, regardless of the country, is the need for the institution to have a culture that is open to change and not resistant to the inevitable changes that will occur with any new implementation. Allen and Kern (2001) established that the institutional culture had a major impact on the success of ERP implementations in four universities in the United Kingdom. The findings of the current study indicate that the institutional culture is ranked third in the criticality rankings, with a value of 14.3. This by no means identifies the factor as highly critical for implementation of an on-line registration system, but does present itself as having an effect on other factors (affecting 9 other factors) as well as being affected by factors (18 factors affect organisational culture). Therefore, it might be advisable to use this factor as one to observe and, if changes are seen in this factor, intervention may be necessary.

5.11 Legacy System and Business Processes

The legacy system, or existing systems, as well as current business processes that are in place need to be identified and understood so that any new software that is being implemented, has a planned, seamless integration (Holland and Light 1999). According to Finney and Corbett (2007), it is only through understanding the existing system and business processes that possible problems can be identified and a remedy included in the change plan. This was identified as a critical factor in the study on HEIs by Karande, Jain and Ghatule (2012) and was mentioned as critical in 11 of the 38 papers reviewed for this study. As far as the current investigation is concerned, this factor did not present itself as highly relevant in any of the classifications, except in criticality where it has the fifth highest value (14.3). Although this is not significant in terms of criticality, the CIM presented in section 4.2 does show that this factor impacts on 16 of the 19 other factors and is impacted on by 11 of the 19. It follows that although the strength of the impact is not high, this may be a factor to retain as being one of criticality for the on-line registration implementation and use it for the purpose of monitoring changes to the factor. Should changes occur to this factor during implementation of the on-line registration system, then corrective action would need to be investigated. The factors that emerge as being most affected by the legacy system and business changes are user training and the software testing and troubleshooting, which are both identified as factors to observe when changes take place with the implementation.

5.12 Project Management to Implement the Project Plan

Cost and time overruns were cited as some of the main reasons for the failure of ERP implementations. Effective project management that runs throughout the entire project can assist in preventing these challenges (Zhang *et al.* 2005). It is also through efficient project management, with the use of control and monitoring measures that the project plan will be adhered to, time frames can be met and budget constraints realised (Bingi, Sharma and Godla 1999). With 21 of the 38 articles analysed for this study identifying project management to implement the project plan as a critical factor, this study is in agreement with these findings, identifying project management as being ranked in the top five factors as far as it's driving potential is concerned and being placed fifth in the list of activity levels. Project management, therefore, has a major influence on other factors of on-line registration implementation. Some of the more noticeable influences are those that occur on the user training and user involvement, as well as the influence that project management has on some of the other necessary plans, for example, the change management plan and the data management plan. The researcher is of the opinion that should not enough attention be paid to the important task of project management, this could result in a lack of focus on both user involvement and user training, which ultimately causes resistance to using the software and could quite likely have a negative effect on the success of system implementation.

Additionally, if project management is neglected, this would possibly have a detrimental effect on the plan that is needed for conversion of data between systems and on the handling of change that needs careful consideration. Project management also emerged as having the fifth highest stability value (95.2), thereby contributing highly to the stability of the on-line registration implementation. This high value is the result of higher activity values and considerably lower passivities.

5.13 ERP Strategy and implementation methodology

The existence of a number of approaches for implementing ERPs has been alluded to in chapter 2, with many researchers alluding to the importance of having a strategy, in particular, the use of one of the phased approaches (Scott and Kaindl 2000; Mandal and Gunasekaran 2003). However, ERP strategy and implementation methodology remains one of the factors that is often overlooked (Holland and Light 1999), even though it is identified as being one of the top critical factors by Ngai, Law and Wat (2008). From the results of the current study, the importance of the ERP implementation strategy is recognised in terms of its criticality value (being the highest at 17.5) and the third highest in the precarious rankings. Being in the upper levels of precarious rankings indicates that this factor should not be used for intervention strategies. These findings are consistent with it having the lowest value of the activity (32.2), indicating that it does not exert major influences on other factors. Being identified as having a high criticality identifies the factor as both acting on other factors and being acted on by others. This criticality is evident in the CIM, where it can be seen that, for an on-line registration implementation, the ERP implementation strategy affects 16 other factors and is affected by 12 other factors, so the factor is both active and reactive.

5.14 Business Process Re-engineering (BPR) and Customisation

It is inevitable that, when implementing an ERP, changes will need to be made to current business processes, due to the business processes of the system being incompatible with those used with the legacy system (Nah, Zuckweiler and Lee-Shang Lau 2003). These changes have led to much debate around whether to re-engineer the organisation's business processes or rather configure the ERP to fit the organisation's business processes (Olson and Riordan 2012; Chen 2014), resulting in BPR and customisation being cited as a major factor when considering the success of the ERP implementation. Shanks *et al.* (2000), Sumner (1999) and Light (2001) all contend that this factor is one of the most critical factor, with 16 out of 38 articles perused being of the opinion that BPR is a CSF for ERP implementation. This opinion is in contrast to the findings of the current study that did not identify BPR as a major factor in any of the classifications under investigation. When looking at the actual values from data analysis, low values for the AS and PSs were presented, as well as insignificant values for the integration and criticality. The stability value of BPR was high (90.5) but not high in comparison with the other factors, which were below the average of 92.8. What can be established is that for the on-line registration system implementation, BPR is more a driving factor (42.8) than a driven factor (23.4), but does not have a marked effect on the system as a whole.

5.15 Change Management

For the institution and all stakeholders to be prepared for the changes that accompany an implementation, a formal change management plan is needed (Al-Nafjan and Al-Mudimigh 2011). According to Finney and Corbett (2007), change management is one of the most cited CSFs in literature, which is supported by the number of articles reviewed by the researcher that included change management as a CSF in 18 out of the 38 articles. Although this factor does not present itself as highly influential, it does exert a significant effect on both user involvement and software testing and troubleshooting during the implementation of the on-line registration system. It is evident that the change management plan needs to include a plan for the inclusion of users, so that the success of the on-line registration system implementation is positively affected. Change management has been identified as a factor that has a higher criticality when compared to the rest of the factors. Although low (14.8), the criticality cannot be ignored. However, when looking at the ranking of driven factors, change management is ranked fifth with a value of 56.7. Due to the driven ranking being significantly higher than the criticality value, along with the driven factors being those that are non-critical and the factor not having high active or passive sums, the researcher is going to eliminate change management as a critical factor for on-line registration implementation and rather recommend it be used as a driven factor for observing interventions that are implemented.

5.16 Data Management

With the implementation of a new system, such as the on-line registration system, there is the need to integrate data from the existing system into the new module and into the ERP that is in operation. This is an important aspect requiring plans for data conversion, accuracy, analysis and migration (Shaul and Tauber 2013) that will ensure the data is migrated efficiently and accurately. It has been established by prior researchers (Bingi, Sharma and Godla 1999; Somers and Nelson 2001; Zhang *et al.* 2003) that the degree of data accuracy has a marked, positive impact on the success of the implementation. Even though this factor has been identified by many researchers as being of extreme importance, the criticality is not evident in the implementation of an on-line registration system, with data management having low activity and passivity values of 5.9 and 16.6, respectively, as well as the level of integration being a mere 11.2, and criticality having a value of 9.9. This factor does not present itself as being either driven (23) nor driving (38.7). The only value that is flagged is its lower precarious ranking being sixth from the bottom, indicating that it could be considered for intervention, but due to the driving value being only 23, and the activity value being a mere 5.9, the factor does not conform to the values necessary for consideration as a driving factor.

5.17 Project Leader

The leader of the implementation team needs to lead, motivate and support the implementation team throughout the implementation of the system (Nah, Zuckweiler and Lee-Shang Lau 2003), with other responsibilities including communication with the entire institution and direct reporting to top and senior management (Sumner 1999). With this factor emerging 15 times as critical in the 38 articles reviewed, it might be assumed that this factor is of extreme importance for any ERP implementation. This finding is consistent with the findings of the current study where the project leader is identified as having a high AS (48.6), and is one of the main driving factors. The project leader exerts the most influence on the skilled project team, which could be due to the project leader having an influence on the selection of the team as well as being responsible for the training and motivation of the team. This could be an important factor for intervention strategies as the project leader will influence the team, which, ultimately, is responsible for the implementation of the system. The project leader was identified as having a high precarious ranking, which may indicate that it is not ideal for intervention, but this is negated as the criticality of the project leader is extremely low and the factors that are highly precarious are those with high criticality.

5.18 Skilled Project Team

Having a skilled project team was cited in 20 of the 38 articles reviewed in the literature review, indicating its importance in literature, with two researchers identifying its importance in HEIs. The implementation team needs to consist of the best full-time IT, technical and business personnel from the institution (Al-Sehali 2000; Mandal and Gunasekaran 2003; Finney and Corbett 2007), all of whom demonstrate a deep understanding of the system in terms of IT requirements and business processes. From the CIM presented earlier, this factor exerts significant influence on user training and system testing and troubleshooting. This may be due to the project team implementing the on-line registration system being the same individuals that perform the user training and the testing and troubleshooting of the system. It can also be seen that this study unveiled the high influence that the project leader has on the project team. Thus, any intervention implemented by the project leader should be evident in the project team. Although this factor did not emerge as critical in any area, it was sixth in the ranking of driven factors, and could possibly be considered for intervention, if the need arises.

5.19 Autonomous Project Team

Having a project team that has the authority to make quick, effective decisions as well as having a high level of trust within the team has been recommended as critical by a number of researchers (Kraemmerand, Møller and Boer 2003; Karande, Jain and Ghatule 2012; Ram, Corkindale and Wu 2013). For the implementation of the on-line registration system, having an autonomous project team does not have any significant influence on other factors nor does it appear to be highly influenced. It has low integration and criticality values and is not remarkably driving nor driven. The only classification that needs mention is the level of stability. With a stability value of 96.2, it contributes significantly to the stability of the on-line registration implementation. What is also noticeable is that, due to it having a low integration and a low passivity, this factor is the most stable during implementation and will not be affected by changes made to other factors during implementation.

5.20 Post-Implementation Evaluation

The last factor presented refers to the evaluation that is done after the system is implemented, and is used to evaluate whether the project can be determined a success (Al-Mashari and Al-Mudimigh 2003). This factor is often difficult to assess and involves a number of contributors which may include management, users, developers and consultants (Skok and Legge 2002). It is possibly due to this factor referring to an evaluation of the entire system success that it has emerged that post-implementation evaluation has little to no influence on any of the other factors but has the highest passivity value indicating it as a highly influenced factor. The post-implementation evaluation emerges as having the highest integration, indicating that it has the most interrelations with other factors, but the researcher is of the opinion that this is an inaccurate assessment due to the extremely high passivity sum. For a factor to be strongly connected to other factors, both a high passive and active sum needs to exist. The factor also has a low precarious ranking which might indicate that it can be used for interventions, but, like user training and software testing and troubleshooting, this factor would not be useful for intervention activities. What is highly significant for this factor is its stability value and ranking as a driven factor. With a stability value of 99.8, caused by the high passivity and low activity, the post- implementation evaluation contributes significantly to the stability of the on-line registration system. Lastly, this factor is highly driven, with an influence being exerted on this factor by all other factors. Therefore, any intervention that is imposed will or should be evident and result in a change to the post- implementation evaluation.

5.21 Chapter Summary

Table 5.1 below displays a summary of the findings for each factor with respect to the implementation of an on-line registration system. Classifications have been adjusted according to the discussion presented for each of the factors. The chapter that follows will provide conclusions in relation to the field, limitations of the study and will conclude with recommendations for future research.

Table 5.1: Summary of Classifications relevant to CSFs for Implementation of an On-line Registration System

CSF	Highly Active	Highly Passive	Integration	Criticality	Stability	Precarious	Driving	Driven
ERP ENVIRONMENT								
ERP Vendor Support and Guidance	✓						✓	
Expert ERP Consultant								
Software integration								
Software testing and troubleshooting		✓						✓
ERP USER								
User Training		✓						✓
User Involvement		✓						✓
ORGANISATION								
Senior and Top Management Support	✓						✓	
Project Plan with clear agreed upon objectives and goals	✓						✓	
Effective, organisation / institution wide communication						✓(low)		
Organisational Culture				✓				
Legacy System and the Business Processes								
ERP IMPLEMENTATION PROJECT								
Project Management to implement project plan	✓				✓		✓	
ERP Strategy & Implementation methodology				✓		✓(high)		
Business Process Re-engineering (BPR) and Minimal Customisation								
Change Management								✓
Data Management								
Project Leader	✓						✓	
Skilled Project Team	✓							
Autonomous Project Team					✓			
Post Implementation Evaluation		✓			✓			✓

CHAPTER 6: Conclusion, Limitations and Further Studies

The purpose of this chapter is to provide an overview of the research, a discussion of the results and the implications they have to both theory and practice. There will be a revisit of the research question in relation to the fulfilment of the initial objectives. The research contributions are presented and limitations of the study are then discussed. The chapter concludes with suggestions for future research.

6.1 Overview

The major objective of this study was to determine the CSFs for implementation of an on-line registration system. The motivation for the study was twofold. Firstly, despite the abundance of literature on CSFs for ERP implementation, there exists an alarming shortage of literature specific to HEIs, specifically for implementation of an additional module such as the on-line registration module. Secondly, there is a need to address the shortfall of current scientific evaluation techniques for accurately determining whether a factor was identified as critical for success.

This study aimed at establishing the factors that are critical and can affect the successful implementation of an on-line registration system. The main research question of this study is:

What are the critical factors for successful implementation of an efficient on-line registration system?

Due to the complexity of the question, five objectives needed to be met:

1: To define criticality in the context of successful on-line registration implementation;

2: To establish, refine and categorise a set of factors that are deemed necessary for successful on-line registration implementation through literature for use in the field work;

3: To uncover relationships that exist between factors and establish how each might impact on the on-line registration system implementation;

4: To identify the criticality, stability and integration of each factor; and

5: To determine which factors should be used for intervention strategies by identifying the following for each factor: precarious, driving and driven.

Chapter two presented a critical review of literature that related to ERPs, CSFs and the implementation of ERPs at various organisations. From the review, a number of success factors for ERP implementation were identified with 20 factors being distilled and later driving the fieldwork. The factors were identified and retained using content analysis. Both objectives 1 and 2 were satisfied and the findings presented in chapter 2.

Chapter three presented the research framework underpinning the study. This can be briefly described as a mixed methods study that is placed within the post-positivistic philosophy. The factors gathered during the literature review were presented to the expert participants in the form of an on-line questionnaire using a web application developed by the researcher. Participants interacted with the application that gathered data in the form of preference chains. Thereafter, a CIM was generated and the matrix was exported to a spreadsheet so that the data analysis could be performed on the data via formulae in the spreadsheet developed by the researcher. This chapter also included algorithmic proof that a CIM can be generated from preference chains. The data analysis technique adopted was advanced impact analysis (ADVIAN) tool that gave rise to interrelationships between factors, as well as identifying six classifications for the factors, namely, criticality, integration, stability, precarious, driving and driven.

The results of the ADVIAN analysis were presented and discussed in chapter four, with the remaining three objectives, viz., objectives 3, 4 and 5 being met through data analysis. A summary of the data analysis findings was presented in table 5.1 along with the interpretation and discussion around each factor.

6.2 Answering the Research Question

***RQ**: What are the critical factors for successful implementation of an efficient on-line registration system?*

In order for the primary research question to be answered, it was first necessary to accomplish the five objectives that were suggested. The research findings in chapter four assisted in meeting the objectives and ultimately lead to answering the main research question.

6.2.1 **Objectives**

***Objective 1: To** define criticality in the context of successful on-line registration implementation.*

In chapter 2, section 2.4.1, a discussion ensued as to the meaning of both success and criticality, with particular reference to the study being undertaken. The researcher is of the opinion that, in the context of this study, the *criticality* of a factor is defined as:

"Factors that have a high influence on other factors, are highly influenced by other factors and, therefore, influence the success of the on-line registration implementation".

Objective 2: *To establish, refine and categorise a set of factors that are deemed necessary for successful on-line registration implementation through literature for use in fieldwork.*

During the literature review, 38 articles were reviewed, with 20 factors being identified in four different categories for further analysis in the fieldwork. These factors were obtained through content analysis and were presented in table 2.3.

To satisfy the last three objectives, an on-line questionnaire was developed by the researcher in which expert participants were asked to create preference chains such that the chain would represent which factors had an influence on others for the on-line registration system implementation. From the data collected, the on-line application was able to generate a CIM to be used for ADVIAN data analysis.

Objective 3: *To uncover relationships that exist between factors and establish how each might impact on the on-line registration system implementation.*

The relationships between factors were identified by establishing the indirect interrelationships that factors have on each other, as well as the indirect influence that factors have on each other when an on-line registration is implemented. These were established by calculating indirect active and passive sums, up to order 19 as well as their relative values (tables 4.3, 4.4 and 4.5), with a discussion of these relationships presented in section 4.4.2 as well as the relationships for each factor discussed in chapter 5.

Objective 4: To *identify the criticality, stability and integration of each factor.*

ADVIAN data analysis functions were used in this study to determine the criticality, stability and integration of each factor, the results of which are presented in table 4.6, with graphs for each of the three classifications included in figures 4.12, 4.13 and 4.14. Each of these classifications was discussed in section 4.4.3 and presented in a summary table (table 4.8), with further discussion ensuing for each factor as well as further refinements taking place after assessing each factor and considering all ADVIAN classifications and rankings, with a final table representing the criticality, stability and integration relevant to each factor for on-line registration implementation (table 5.1).

Objective 5: *To determine which factors should be used for intervention strategies by identifying the following for each factor: precarious, driving and driven.*

Using the ADVIAN rankings of precarious, driving and driven, presented in table 4.7 within section 4.4.4 and summarised in table 4.8, it is possible to identify which of the factors have the *most* influence on the success of the on-line registration system and can, therefore, be used for intervention, should the need arise. Other factors that can be used to measure whether these interventions are effective are also identified. A discussion of these attributes exists in section 4.4.4 as well as an interpretation for each factor in Chapter 5. The interpretation section culminates in table 5.1, identifying the attributes that are relevant to each factor for on-line registration system implementation success.

6.2.2 The Primary Research Question

The primary research question that was set to be investigated in this study was***:*** ***What are the critical factors for successful implementation of an efficient on-line registration system?***

It is apparent that all factors presented have an important role to play when implementing an on-line registration system, with each having an important function, but this study aims at determining which are **most** critical. The concept of criticality is highly subjective, as discussed in chapter 2, with the definition for this study being established in objective 1, as the factors that can be used to influence the system and are highly influenced. This study posits that there exist different dimensions of criticality, with some factors being deemed critical due to their ability to drive or influence other factors during implementation, and others being critical as factors to observe as a means of monitoring whether changes made to factors during implementation have the desired effect, and, lastly, there exist factors that can be monitored. Any change occurring to these factors during implementation of the on-line registration system should be identified such that intervention strategies can be adopted.

Current literature often relies on the same data set and variations of the same families of data for analysis. By virtue of the innovative analysis used in this study and the different dimensions of criticality that were identified, it is believed that this research, by some margin, differs from and surpasses existing contributions.

Table 6.1 below summarises those factors that are deemed critical for the implementation of an on-line registration system implementation.

Table 6.1: Critical Success Factors for Successful Implementation of an On-line Registration System

FACTOR	Criticality	Driving	Driven
ERP Vendor Support and Guidance		✓	
Senior and Top Management Support		✓	
Project Plan with clear agreed upon objectives and goals		✓	
Project Management to implement project plan		✓	
Project Leader		✓	
Change Management			✓
Post Implementation Evaluation			✓
Software testing and troubleshooting			✓
User Training			✓
User Involvement			✓
Organisational Culture	✓		
ERP Strategy & Implementation methodology	✓		

6.3 Contribution of the Study

The major contribution to the field exists in the new and innovative data analysis tool that was used. Most research in the area of CSFs for ERP implementation focusses on the criticality of the factors. This study differs from and surpasses prior research contributions by using the ADVIAN analysis tool which allows for the identification of factors according to their criticality, integration, stability as well as ranking of factors according to precarious, driven and driving. Along with offering different dimensions of criticality, ADVIAN provides robust, scientific proof of the criticality of factors, unlike many of the prior studies, which provide taxonomies which are often based on the results obtained from prior research.

The results obtained from the study contribute to the undernourished research area of identifying the factors critical for implementation of ERPs and on-line registration systems in developing countries and at HEI's. They also provide top management of the institution with an empirical set of factors which are critical to the success of an on-line registration system. These factors can be used to influence the success of the implementation as well as for monitoring purposes. The critical factors were identified in all four of the various categories, namely, the ERP environment, the ERP user, the organisation and the ERP implementation project. This implies that equal focus and attention needs to be placed in all categories of implementations.

For the implementation of the ITS on-line registration system, management and the implementation team need to take special note of changes that may take place in the organisational culture and ERP strategy and implementation methodology factors, due to these factors being identified as having high criticality. Any changes observed may have a detrimental effect on the success of the registration implementation and intervention may be necessary.

Should the implementation require intervention measures to ensure its success, a starting point would be for there to be extra focus and commitment from senior and top management, as it is their influence that has an effect on every other factor in the on-line registration system. Management can also institute changes and improvements to the project leader construct, as it was seen in section 5.17 that the project leader has a strong influence on the project team that ultimately also affects the user training and testing and troubleshooting plans which are important factors for any ERP implementation. Both the project plan and the management of this plan are other areas where intervention can assist with a successful implementation, with both these factors having direct influences on user involvement and training. This comes as no surprise, as it has well been established that improvements to user involvement and user training have a direct link to the success of an ERP implementation (Wickramasinghe and Gunawardena 2010). Increased user involvement and training results in users that are less resistant to the registration system, which should assist towards a successful system that is used to its full capabilities. The last factor that management of the institution can use when intervention becomes necessary is ERP vendor support and guidance. The vendor needs to impart all relevant knowledge to the implementation team such that they are equipped with the tools necessary to implement the registration system and have the knowhow to train the users on the functioning of the registration system. Vendor support demonstrates the most impact on the software testing and troubleshooting, with it being well-known in the IT industry that a system that is not fully tested will not be successful.

The project leader and management of the institution need to be able to assess what effect the changes they may have implemented to the critical factors listed above have had on the success of the registration system. These may have a positive or negative effect on the system success. It is the driven critical factors that can be used for monitoring the implications of these changes. As has already been established, user involvement and user training are both influenced by a number of factors (18 out of a possible19). Therefore, changes implemented to any of the driving critical factors, as well as any others, will influence the user constructs. Moreover, the user construct provides an ideal tool for the institution's management as a means of monitoring whether changes made are having the desired influence on the success of the on-line registration systems implementation. Software testing and troubleshooting is another factor that is directly influenced by all other factors, with all the factors that have been suggested as being ideal for intervention having a notable influence on the testing and troubleshooting of the system. The project leaders can, therefore, confidently observe this factor, identifying any changes that take place as a means of assessing whether the changes are having a positive impact on the success of the on-line registration system implementation. Another factor that can be observed for changes is change management. Although it does not present influences from the driving factors that are as strong as those that work on the user factors, it does, however, react to 18 of the 19 other factors, making it an additional factor that can be observed in the assessment of changes implemented. The final factor that is undoubtedly influenced by all other factors is the post-implementation evaluation that takes place after implementation. It is, therefore, not a factor that can be used during implementation to assess whether the changes being made are having the desired effect, but can be a useful factor to assess the improvements that are made post-implementation.

6.4 Limitations

During this study, the researcher made a concerted effort to mitigate all shortcomings that had the ability to result in inaccuracies and falsifications. However, it is normal that, in most studies, there exist constraints which could possibly be out of the researcher's control, with these having the ability to negatively impact the research process and cause some limitations to the findings. These may be limitations that are specific to the sample participants, the data analysis methodology, or the context under which the study is being conducted. The domain of this research study is ERP systems. Of particular interest is the ITS on-line registration system at the DUT. Even though an ERP is an IS, with the on-line registration system being an additional module, there may be disparity that prevents the results from this study from being generalised to all IS implementations and to all ERPs. Much as the study was conducted in a developing country (South Africa). The study was only conducted in one such country, at a single university. This limits the results from being generalized to all developing countries and all universities within South Africa.

Due to the study being limited to a single institution of higher education, and ERP implementation being a highly technical and specialised area of IT, the sample size of the expert participants was small. However, with only 12 experts being identified as experts in the area, the positive response from 10 equates to a response rate of 83%, which is more than adequate. Should this study be conducted at other HEIs, this would increase the sample size significantly? With the majority of the participants of the study being employees of the institution where the investigation was conducted, the possibility exists that human factors such as a participant's attitude to their work, their employer or the actual on-line registration system could have resulted in factors being selected in the questionnaire based on emotion and not on academic value.

When considering data collection methods used, the researcher based the list of CSFs on those obtained from literature. The researcher acknowledges that further CSFs could have emerged if an additional stage of data collection was done. The primary data source was from questionnaires which were completed on-line by the experts. Some limitations that might present themselves could be the order in which the factors were presented to the participants. With twenty factors being presented, if the participant was under time constraints to complete the questionnaire, they may not have given the factors that were lower on the list the attention and time that was given to those that were presented first. Additionally, if a factor was not understood, it would not have been included in any of the preference chains. Both of these limitations would possibly have resulted in a reduction in activity and passivity levels of the factors concerned.

The CSFs that were gathered from the literature were identified by reviewing 38 articles, with a frequency indicator being used to identify those factors that should be taken through to the field. The researcher acknowledges that there are numerous other papers that may also be relevant to the investigation, but, due to time constraints, it is not possible to review all papers that may exist. The frequency of each factor may be slightly skewed as some of the articles reviewed only chose to look at one specific category of CSFs, while others presented CSFs in all categories. Both of these observations are noted as possible limitations of the study.

When considering the data analysis performed in this study, the researcher chose to use the new ADVIAN methodology developed by Linss and Fried (2010). Due to the methodology only being published and available from 2010, at the time of this study, the researcher was only able to identify five other studies that referenced the ADVIAN methodology. This methodology may then have limitations in that it has not yet been adopted as a popular approach by other researchers.

6.5 Recommendations for further study

Several areas of future research were uncovered during the course of the study. The paragraphs that follow will discuss these possible avenues for new research.

This study should be extended to different institutions of higher education that have implemented an ITS on-line registration system, with this study being used as a springboard. The results of further studies would then validate the findings of this research and would, at the same time, address one of the limitations of this research, i.e., the small sample.

With South Africa being categorised as a developing country, this research could be expanded into neighbouring southern African countries, with a view to validating the results and being able to generalise to developing nations in southern

Africa. This would contribute greatly to the undernourished area of ERP research in developing countries.

Focus for the current study was on the ITS ERP system. It would be beneficial to the ERP research area if an investigation were to be conducted into what CSFs are critical for on-line registration system implementation for a variety of vendor products. This would serve to further generalise the findings across all ERP suites. What's more, a comparative study could be adopted that compares the various factors that emerge as critical where different modules are being implemented. This research focussed on the factors for implementation of the on-line registration system. Further studies could be conducted for the implementation of the timetable system, or student fees system.

With regard to the data collection method employed, in addition to using the on-line data collection tool, the researcher could meet with the expert participants in a group situation, where an explanation of each of the factors would be given, and interaction and questioning would be encouraged. The results of the study could be used to validate the current study and determine if the interaction with participants has any effect on the results. The researcher would need to exert extreme caution not to influence the participant's answers, as well as being aware that participants could influence each other.

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